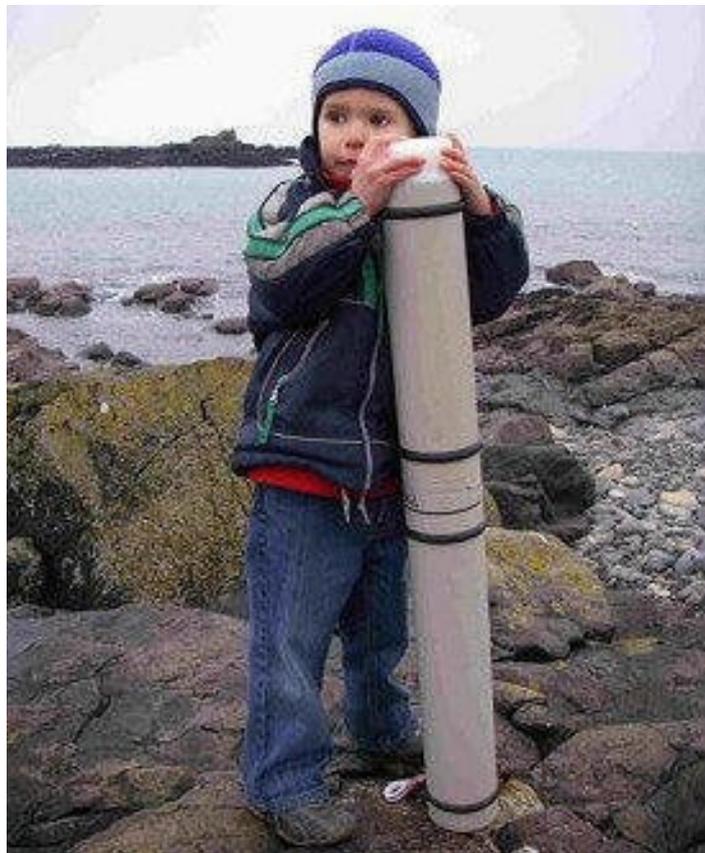




Chelonia Limited
Cetacean Monitoring Systems

T-POD

Reference Guide



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1 Introduction

This *Reference Guide* contains more advanced information about using TPOD.exe and analysing your data.

For basic information about setting up and maintaining T-PODs, refer to the *T-POD User Guide*.

Three tutorials are also available on the *T-POD CD*, in the **Reference** folder:

- Analysing_data_quickly.doc
- Answering_the_question.doc
- Does_your_file_look_good.doc

The above tutorials use sample Microsoft Excel and Microsoft Access files and therefore these application need to be installed on your computer.



If you would like to discuss your project requirements with us, please contact us for free advice (see below).

Here to help

Your T-POD purchase entitles you to free email support and future software upgrades.

We also supply a range of additional services, including project planning, project management, data analysis and interpretation.

For more information, please visit our web site at www.chelonia.co.uk or contact us using the details below:

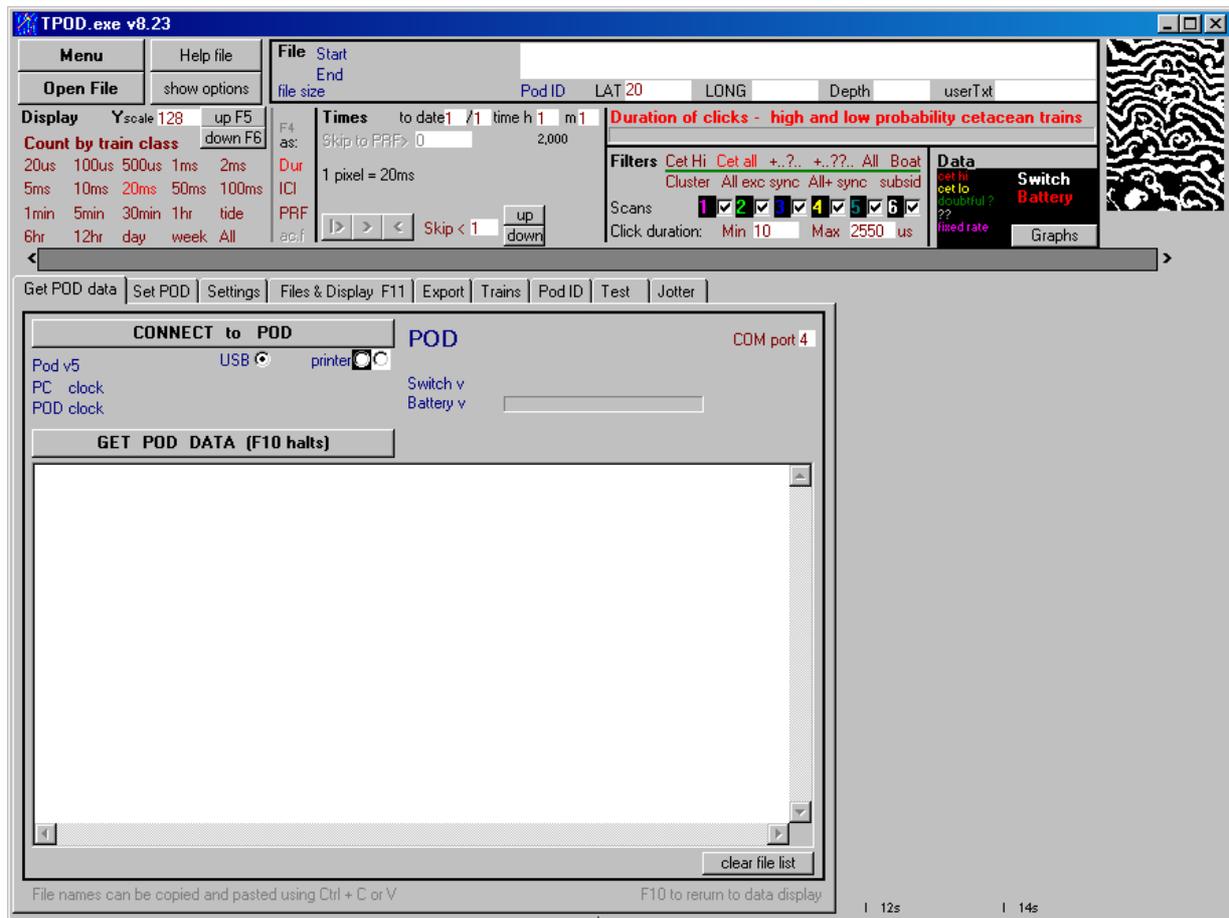
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2 Using TPOD.exe

Display basics

When you run TPOD.exe, the main window is displayed.



The upper part of the window shows options that you normally use when displaying data.

The lower part of the window displays the menu area, which consists of nine tabs. Each tab displays a different page with appropriate functions, depending on your current task

The menu area can be hidden or displayed by clicking the **Menu** button. You normally hide this window when you are looking at data and show it when you want to use a menu option.

Tip: Many items will show a help tip if you put the mouse pointer over them for 2 seconds.

The colour of text in the program means:

- Maroon: clickable
- Red: selected
- Blue: mostly data
- Black: general information

When the Menu is hidden, the main graphical display can show:

- up to 3 data files at the same time. It only shows time they have in common. Files are opened from the **Files & Display** page of the Menu.
- different time scales set in the **Display** section of the main window:

Display	Yscale 128	up F5
Count by train class	down F6	
20us	100us	500us
1ms	2ms	
5ms	10ms	20ms
50ms	100ms	
1min	5min	30min
1hr	tide	
6hr	12hr	day
		week
		All

Scales with a unit of 1 minute or above show counts of clicks in the time period selected.

Time scales of 100ms and below show individual click data as click durations, or inter-click-intervals, or the pulse repetition frequency, with 1 pixel representing various time durations from 20 microseconds up to 100 milliseconds.

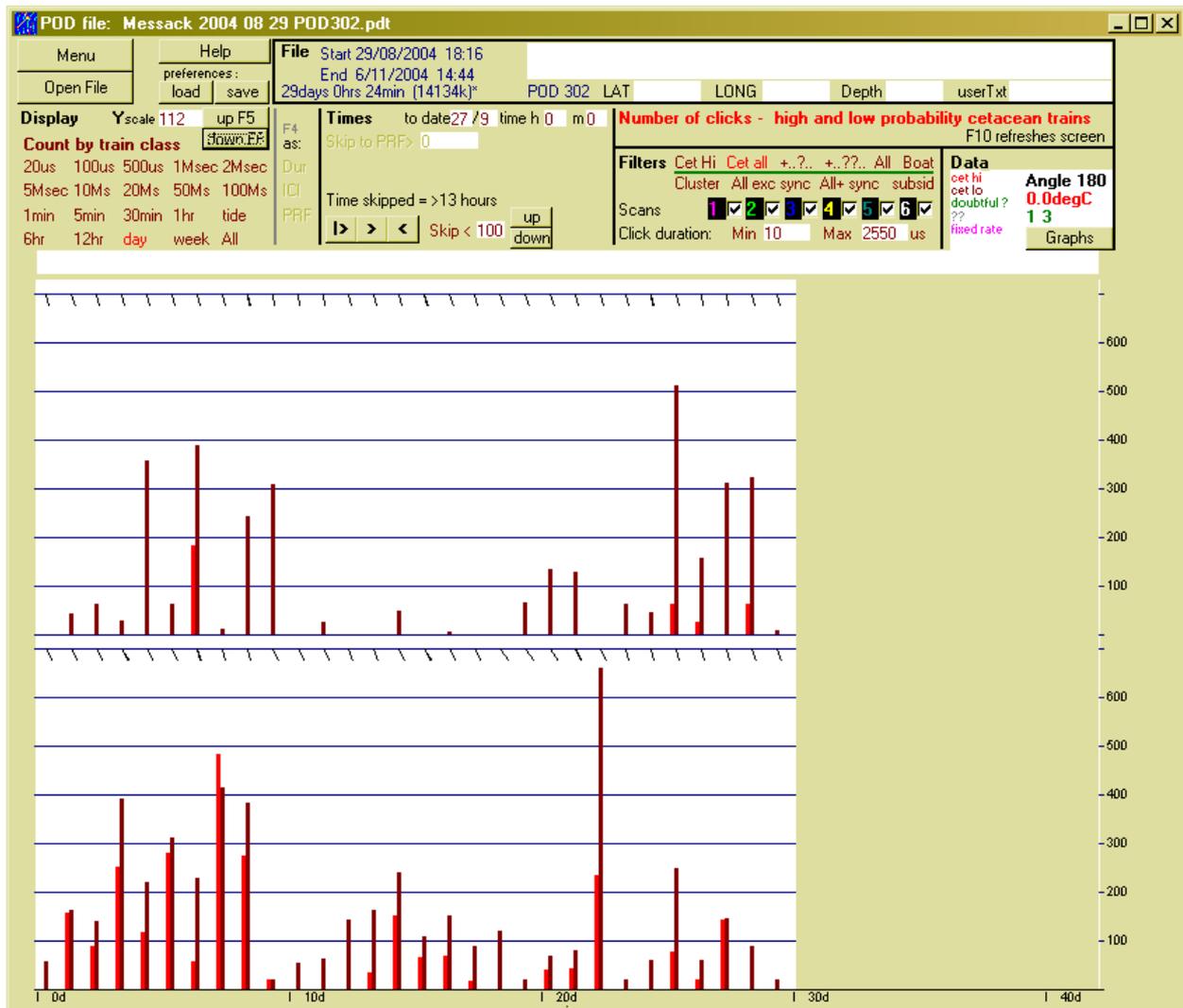
- different Y axis scales, changed by clicking the **Yscale up/down** buttons or by pressing the **F5/F6** keys, or by entering numbers into the edit box.
- data filtered to show all clicks, or clicks in trains of different classes, short clicks, long clicks, etc.

The example below shows PRFs (pulse repetition frequencies) from a porpoise approaching a large navigational buoy.



In the example below, the **Display** scale of one day shows counts of only those clicks classified as being in trains, colour coded by train classification. Data from two PODs is shown.

The angle of the POD (graphic above) is shown by the small lines at the top of the white area.

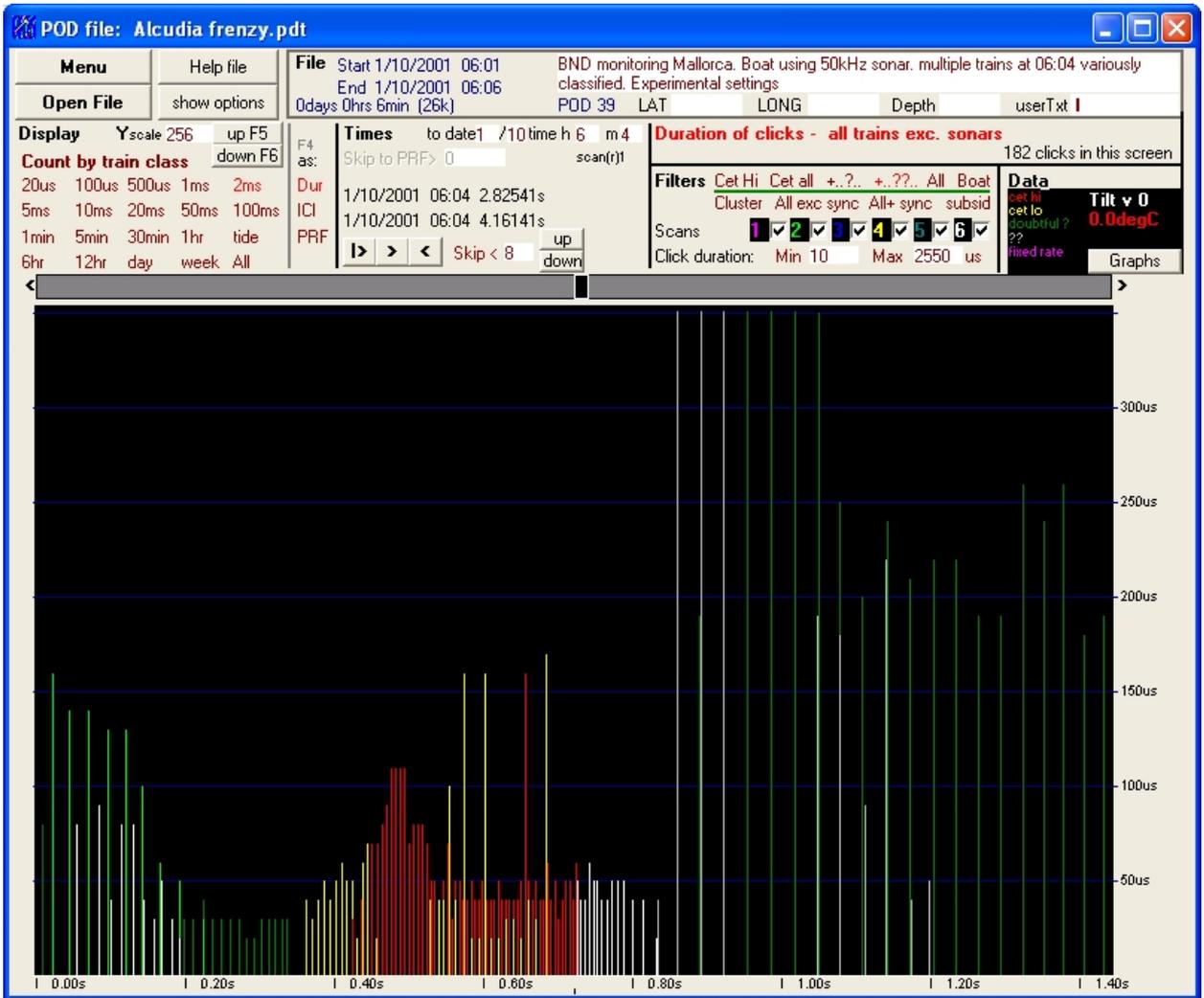


Viewing data

This section describes the areas of the features that are available when you view data.

The main display of click data is in the lower part of the main window. The window can be resized.

The example below shows overlapping trains from feeding bottlenose dolphins. The colour of each train is slightly different from the last if more than one of the same classification (Cet Hi etc., in the Filters section) occurs in a single scan:



The red 'activity' label, above the **Filters** area of the window, gives a brief description of what the program is currently doing or showing.

Duration of clicks - all trains exc. sonars
182 clicks in this screen

File section

This section shows the start and end times, and the duration and size of the file.

File Start 1/10/2001 06:01 BND monitoring Mallorca. Boat using 50kHz sonar. multiple trains at 06:04 variously classified. Experimental settings
End 1/10/2001 06:06
Odays 0hrs 6min (26k) POD 39 LAT LONG Depth userTxt |

Text boxes for notes, latitude, longitude and depth show any text that was entered before the data was downloaded from the T-POD. You can changed the text at any time and save it in the file using the **Save text to files** button on the **Files & Display** menu page. Make a habit of entering deployment info here before you download data.

The userTxt box text is also saved in the file but is different in that it is sent to the POD when you set it to log, and is recovered when you upload the POD data.

Display section

Count by train class

Indicates that currently the display is in default mode, showing click counts colour coded according to their train class:



This gives a good view of how the different classes cluster together in 'encounters' or fail to do so.

In very quiet locations all trains come from the animals and all classes are clustered together.

As conditions get noisier (random sources and boat sonars) the ?? very doubtful trains break ranks and appear scattered through the data and are increasingly derived by chance from random noise, or by degradation of the timing of regular sources – boat sonars – along a pathway that usually includes the moving sea surface. Then doubtful ? and finally **cet lo** trains may cease to be clustered with the **cet hi** trains and consequently need to be excluded or viewed with caution.

Click **Count by train class** to change low resolution displays to show clicks counted by scan (see below).

Count by scan

Count by scan is useful where different scans are listening for dolphins and porpoises as encounters then show up in different colours for the two groups of species.

Horizontal axis

The time resolution on the horizontal axis is selected by clicking the ranges from 1 pixel = 20 microseconds to the whole data set shown at once.

The settings are:

High resolution (20 μ S to 100mS) – shows clicks and their duration, or inter-click intervals (ICI), or pulse repetition frequency (PRF). In the duration display a click is a vertical line (you can change the line width in the Files and Display page).

Where 2 or more clicks occur within a period, the longest is shown. The click duration is represented by the height.

Use the **F4** key to toggle between viewing click durations, or inter-click intervals (ICI) or pulse repetition frequency (PRF), or select these directly by clicking on **Dur**, **ICI** or **PRF**. When trains are being viewed as PRF or ICI nothing is shown where trains overlap.

- 20 μ s = 20 microseconds per pixel along the horizontal axis. No clicks can overlap within 20 μ s as 10 μ s is the limit of resolution of the T-POD. This setting is useful for looking at the fine structure of clicks which may be split by echoes arising within the body of the cetacean or multipath propagation through the water. Eight weeks of data on this resolution requires a total screen width equal to the circumference of the Earth. This is why TPOD.exe skips blank screens.
- 100 μ s = 100 microseconds per pixel. This is useful for looking for feeding trains with PRFs of over 200/s.
- 1ms = 1 millisecond. same. Also useful for looking for feeding trains.
- 2ms, 5ms, 10ms, 20ms are the most useful resolutions for viewing click trains.

- 50ms, 100ms resolutions show several scans per screen enabling comparison between them where different settings are used and for a longer view of click trains. Sonars with their low PRF may show up well on these resolutions.

Low resolution (1m to All) – shows click counts over periods of time.

The 'by train class' tick box allows you to see the data with either each scan count or each train class count in a different colour. This is useful if you are trying to work out which of a range of different scan settings is best at picking out species of interest. You can exclude the data from any scans by using the tick boxes in the **Filters** area of the screen.



- 1min = 1 minute count
- 5min, 30min, etc. show counts within these time periods. These are clock times (e.g. from midnight), so the first and last period in a file are likely to be incomplete.
- tide (186 minutes) – is one quarter of a full lunar tidal cycle. To look for tidal patterns the starting point for aggregating counts into these half-tidal groups can be varied using the tidal or diurnal **offset - mins** box on the **Files & Display** page of the menu. The tides do shift backwards and forwards over the lunar cycle, so the axis is not accurately synchronised throughout a lunar month. The mean tidal cycle is actually 1 minute longer than 4x186. However, this feature does provide an easy way to get an idea of tidal influences. For accurately you should use local tide tables.
- 12hr – this can also be offset by any number of minutes to look for diurnal patterns.
- day – like all these time categories, the start and end are set by the clock, not by the file start time. So 30 hours of logging at a uniform rate can show as 3 days each with very different click counts.
- All – provides a quick view of how counts from different scans vary. All counts from the last displayed data in the file. To view all data you must click > after selecting **All**.

Vertical axis

Y scale up/down buttons or shortcut keys **F5/F6** – higher values magnify the vertical height of the displayed bars/lines. The spin button changes the scale up or down by a factor of 2 but you can put in intermediate values or add or delete the last digit to jump by a factor around 10.

DUR (duration), ICI (inter-click interval), PRF (pulse repetition frequency)

You can select the duration, inter-click interval and pulse repetition frequency options by clicking the **Dur**, **ICI** or **PRF**, or toggle through them using the **F4** key.

Dur shows the duration of the click on the vertical axis with its time on the horizontal axis. The duration profile of a train often represents the tail beat frequency of the cetacean. The trains are colour coded and the colour is changes a little if a second train of the same class occurs in a screen. This allows overlapping trains to be identified.

ICI (inter-click interval) represents each click duration by the length of a horizontal line with its left hand end at the time of the start of the click. The position of this line on the vertical axis represents the time elapsed since the start of the preceding click. The length of line does not correspond to the time scale on the horizontal axis as few clicks would be more than one pixel long and hard to see. Clicks can be duplicated by multipath propagation through the water creating small clusters of clicks with very low inter-click intervals. These appear very close to the origin and mostly don't greatly affect the real inter-click interval.

PRF (pulse repetition frequency) shows a line graph drawn in train displays showing the PRF represented by the preceding inter-click interval. Echoes can create a second train displaced a little in time from the first. The PRF of each train is shown so that two or more PRF lines may follow similar paths.

The maximum **range** (R) at which an animal can get an echo before making the next pulse can be calculated using the formula:

$$R = 0.75 * (ICI - 20)$$

Where the units are milliseconds and metres, and 20 ms are allowed for the processing time of the animal. So at 500 clicks per second, or $ICI = 20$ ms, the range is zero!

ac.f produces a graph of the autocorrelation, and a list of values in the Jotter page of the menu. They can be selected and copied into a spreadsheet.

No-shows

Low-resolution displays of counts do not skip empty screens.

High-resolution displays of clicks normally skips empty screens as there are millions of them. It may sometimes stop without showing any clicks, even though the label showing the number of clicks on the screen claims that some are shown. This can happen because if ICIs are on show and trains are interspersed with each other, nothing will be shown, or if only the ends of trains are on this screen. Displaying duration is less likely to miss these clicks as it does not require multiple clicks to compute an ICI or PRF, and is not affected by overlapping trains.

Times section



Current date/time boxes show the time of the last point on the current view screen. If you change the values while viewing data and then click the **>**, go on button, the display jumps to the time you entered.

In high resolution displays, blank screens are always omitted, as there can be many thousands of them. When the next click is found in the data stream it is shown at the left hand edge of the screen.

Time at pointer is shown when the mouse pointer is in the data display area of the screen. This label can show the PRF if you right-click on any two clicks while in a high resolution mode. It then shows the number of clicks per second at the time spacing of your two click positions, and the two way travel distance for underwater sound in that period of time. After a single right-click on the screen it shows the time of the last screen point in 10microsecond units since the start of the minute.

Moving through data



|> (start button) – shows data from the start of the file (or from the selected start point).

> (go on button) – moves onwards from the time at the right hand end of the screen.

< (go back button) – takes you back to the previous minute or screen. Change any display setting first to see higher time resolution.

To move to an approximate time, drag the black slider on the bar above the display area to your approximate time destination and then click the **>** button.

To move to an exact minute, enter the time in the boxes at the top of the **Times** area and then click the **>** button.

Keyboard arrow keys – if the mouse pointer is in the display area of the screen you can use the keyboard left and right arrow keys to see the data to left or right of the mouse pointer position. The up or down arrow keys contract (zoom out) or expand (zoom in/drill down) the data, putting the data at the mouse pointer position in the centre of the screen.

skip to PRF > – When viewing train data as PRFs, you can set **Skip to PRF>** and the display will do just that. However, at low time resolution scales and limited Y axis scales the data may just be a single pixel at the top of the display. Also, trains alternating with other trains (often echoes) don't get picked up at all. Use the **Esc** key to escape if the search is taking too long.

Skip < – Skips screens with less than N clicks. This can be useful to find fast trains: for example, you might set the horizontal axis to 100µs and skips to 16, so that the software skips through screens until it finds one with at least 16 clicks. Similarly you can use this feature to examine times when a lot of trains are being received over a short period. These occur during active group feeding and during the approach of porpoises to large marine features where the T-POD is located.

Filters section



This section allows you to choose the *classes* of clicks that are displayed:

Cet Hi, Cet all, +..?.., +..??.., All, Boat – show those clicks that *are in trains*.

Cluster, All exc sync, All+ sync, subsid – also show clicks that *are not in trains*.

The colour coding of trains shows the classifications attached to each click by the train detection algorithm:



For most monitoring purposes the **Cet All** category, which includes Cet Hi and Cet Lo is the most useful and is the best option to use when exporting data for analysis.

Clicks are also classified into:

Clusters – These are sentinel clicks chosen to mark tight clusters of clicks. The rest are **subsid** (subsidiaries). The sentinel clicks are the only clicks used in the identification of trains. Clicks identified as belonging to trains are shown as dotted lines in displays that show non-train clicks.

All exc sync – shows all clicks logged except those with the duration characteristic of the time marker clicks exchanged between linked PODs.

All+ sync – shows all clicks logged including the time markers. Time markers are synthetic clicks generated by the POD itself. They can be sent to other PODs by wire to give accurate time registration between PODs to allow stereo processing, but the software to process this has not been written. However, sync clicks are useful as a test of the digital module in the POD.

subsid – shows the clicks that fall into a cluster but are not the sentinel click. There are no gaps longer than 50 microseconds between the sentinel click and any other click in the cluster. In **All** displays they are shown as grey lines. They are never classified as in trains, although they often do show clear trains when they arise as echoes or refracted clicks from a real train.

Viewing trains in their context

If you are viewing a train using the click duration display, most options in the row below the green bar in the **Filters** section display the train clicks as dotted lines and all the other clicks as solid lines. In PRF and ICI displays, train clicks are shown in red.

Tip: The keyboard key **F2** toggles the display between showing all clicks and all train clicks.

Tip: **F3** toggles the display between showing all clicks in trains and those in cetacean trains (Cet All). **Shift+F3** shows Cet Hi only.

Tip: When the filter is set to any choice in the lower row in the **Filters** section, you can set the skip value to zero and a small **to trn** (to train) notice appears. Now when you click on the **>** button the display will move on until a train is found.

Scans

The six check boxes with coloured numbers allow you to select or exclude any of the scans.

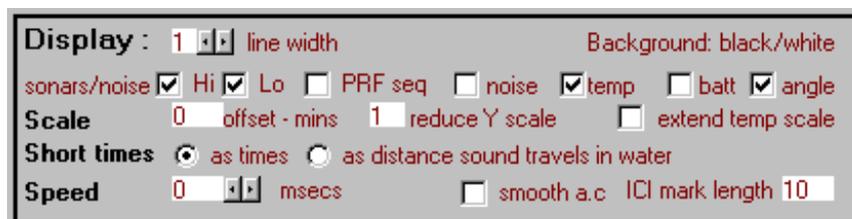
Data section



The coloured labels show the colour coding of the display of clicks. Some data on the T-POD's angle to vertical and temperature may also be shown, depending on settings in the **Files & Display** page of the menu (see below).

Display options

Display options can be changed from the **Files & Display** page of the menu.



Display line width – Higher values draw thicker lines on the display, which may be useful for presentation slides, printable images, or during very fast viewing (see *Speed* below), or on computers with dark screens. Thicker lines suppress the dotted line effect that is used to identify clicks in trains in displays of click duration that include non-train clicks.

Black / white background – can be clicked to set the data display background to white or black. A white background is usually better for printing.

Sonars/noise – shows scan-specific detections of boat sonars as bars at the top of the file screen. Hi = boat sonar likely. Lo = some suspicion of boat sonars. The trains however, may actually be from animals.

PRF seq (rate ramps) – shows detections of progressively rising or falling PRFs in a moving two minute window at the top of the file screen. Rising rates match theoretical models of the sonar pulse rate of an animal approaching a static sound-reflecting object of interest to it so closely that these may be considered to be approach sequences. They are seen mainly in porpoise data when the POD is close to a large feature (e.g. deployed from a large buoy) or is in a relatively featureless area. They are rarely seen in dolphin data. Falling rate ramps are rarely seen and may be chance groupings of trains. Files can be processed for this via the options form Microsoft accessed from the Trains page of the Menu.

Noise, temp, battery, angle – noise is a scan-specific measure of the B filter output and mostly shows the electronic noise level as this is usually above the ambient acoustic noise. Approximate ambient temperature is recorded and can also be displayed. Battery voltage is not the operating voltage of the T-POD electronics, which is regulated, but is the voltage supplied by the battery through one or more diodes depending on the battery configuration used. Angle displays the angle of the T-POD to the vertical.

Scale offset (tidal and diurnal offset) – tidal cycles are divided into four sections with the start of the file being treated as on one of the quarter points in the tide cycle. In reality that is unlikely to be the case by chance, so values in this box can be used to offset the start by the number of minutes entered. This may allow a sharper view of tidal detection rate patterns by making the quarters of the cycle coincide with the actual cycle. The demarcation of the 12 hour display is normally at midnight and midday but this offset can be used to alter that, perhaps to get a better fit with daylight patterns.

Reduce Y scale – allows very large click counts to be shown. It is here because TPOD.exe runs using integers only, except for a few minor instances, and that limits the scale available.

Short times – the default display shows fine resolution times as the distances sound travels, as this makes it easier to think about the route the sound may have taken. This can be changed back to times using these radio buttons. Distances are based on a sound speed of 1.5mm/ μ s.

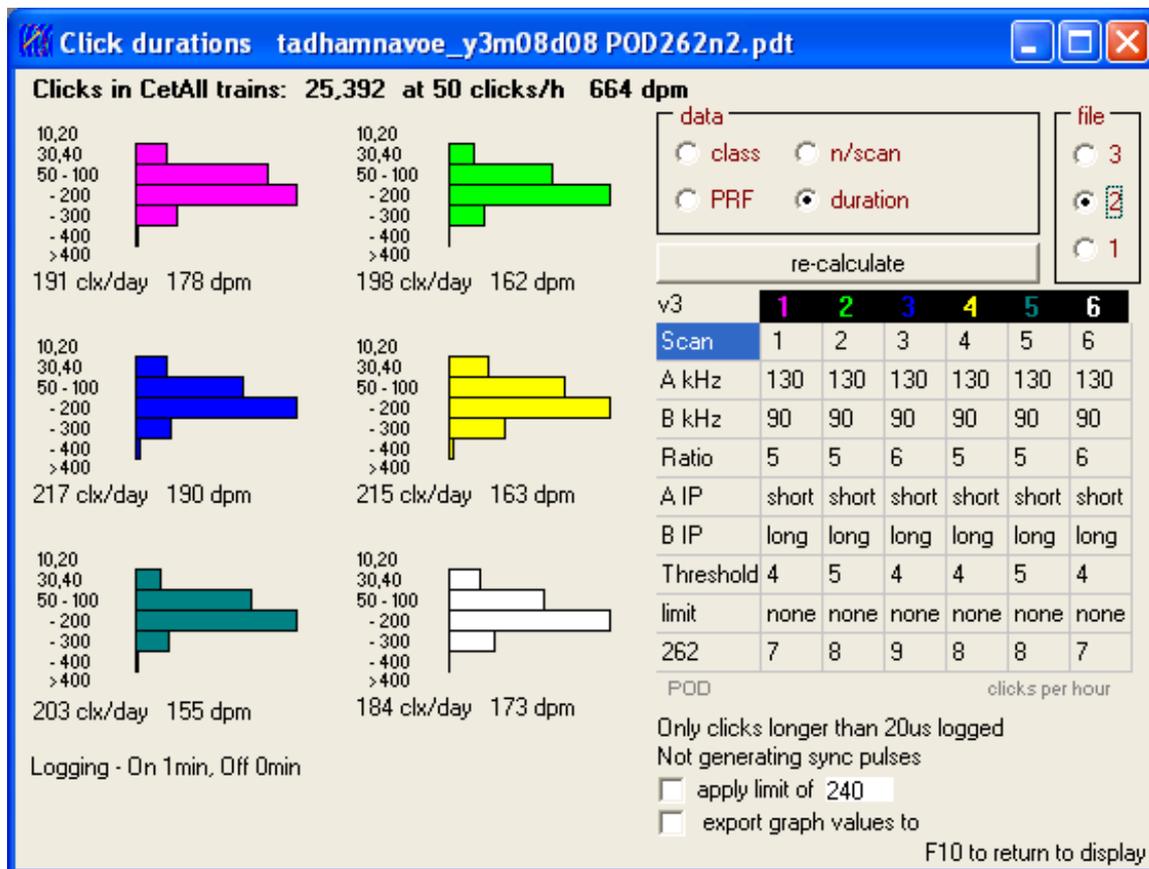
Speed – allows you to impose a small delay between screens. You can then move very quickly through large files at a high time resolution looking at PRFs for example, and get a momentary glimpse of interesting patterns you might otherwise have never discovered. A thicker line can help this process.

ICI mark length – set higher values to show shorter duration lines in ICI displays.

Graphs

Some simple analysis of the file data is available via the **Graphs** button.

1. Click the **Graphs** button to display the **TPOD data analysis window**.
2. Click the **Recalculate** button in the window to see a quick analysis of your data.
3. If more than one file is open, select which file to analyse.

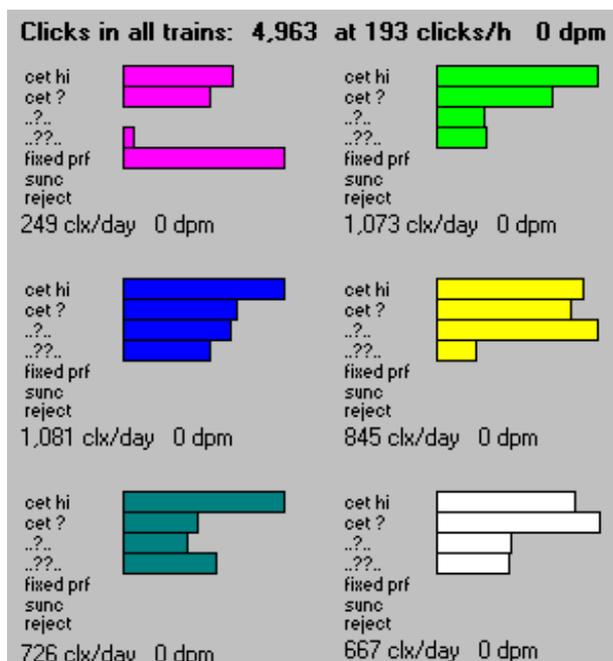


Four different analyses are available as buttons in the **data** area of the window: class, number per scan (n/scan), PRF (pulse repetition frequency) and duration.

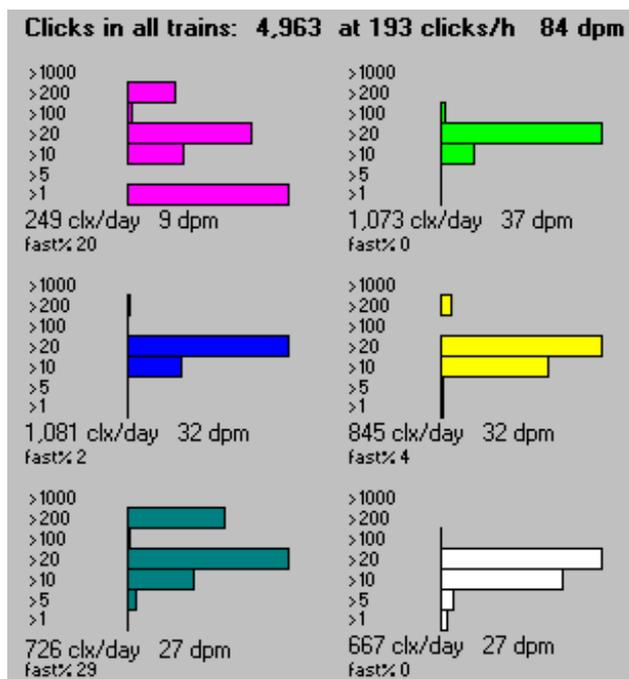
The display also shows the POD settings in use when the data was gathered.

Class

This is the train class and shows the number of clicks in each class of train.



PRF (pulse repetition frequency)

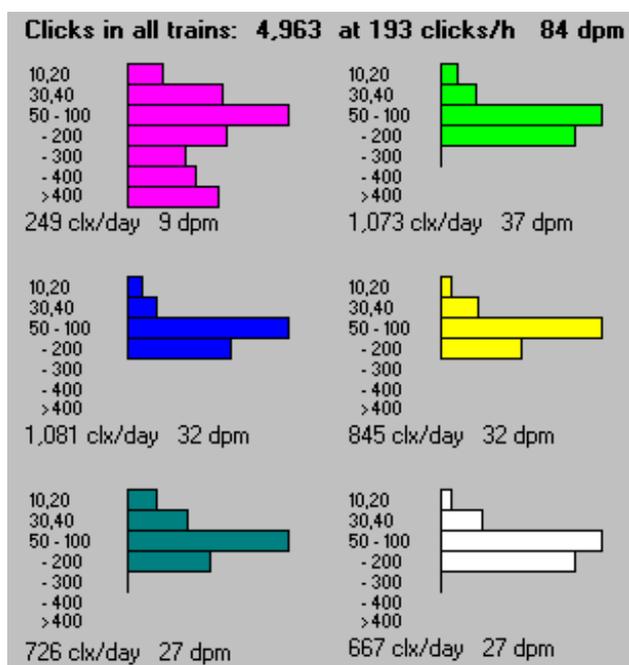


The **fast%** value shown for each scan is the number of inter-click intervals at PRFs above 200/s as a percentage of those above 10/s. It may be higher where feeding is occurring.

If the **Export graph values to** box is checked, the counts for each scan are copied into the **Jotter** page and can be copied from there into a spreadsheet.

These values are not quite accurate because wherever a click in a different train (within the filters in force) is present between two clicks in a train the inter-click interval is not calculated or included.

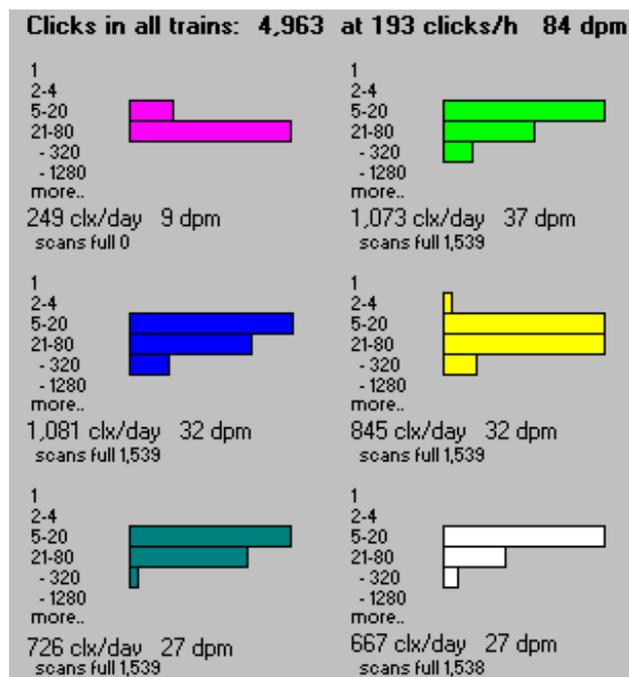
Duration



Scan values are click durations in microseconds. Bimodal duration distributions are common where cetaceans or boat sonars are present.

This is, of course, not the real duration produced by the animal but the duration of *detectability*, which gets shorter as the click gets quieter.

N/scan



Scan values show the total number of clicks logged in each 9.3-second scan. This also reports the number of scans in which the limit set for number of clicks in a scan was actually reached.

dpm is the number of detection positive minutes per day with the filter settings in force. It is counted for each scan independently.

Clicks of all durations/Only clicks longer than... indicates whether a time parameter has been set for the clicks displayed. This value is set in the **Settings** menu page.

Apply limit of... allows you to see the effect on memory use of setting a limit on the number of clicks logged. A click limit can be set before deployment when you set up a T-POD in the **Settings** page.

Export graph values to... the Jotter. If this box is checked, the POD settings in the Graph window are copied to the Jotter. To copy the POD parameters to the Jotter, clear the Jotter page and then, in the Graphs window, click anywhere in the POD settings table. To copy the Class, N/scan, PRF or duration data, clear the Jotter and then click the **Recalculate** button.

Click selection

Cetacean sonar clicks are selected from the myriad marine sounds by the comparison of the outputs of 2 filters. Each filter blocks all frequencies except those around its centre frequency. When the incoming sound gives a ratio between the target filter output and the reference filter exceeding a set ratio the digital hardware times this condition and logs the start and finish. V5 PODs will have two reference filters.

A target of 50kHz with a reference of 90kHz could detect anything below the 70kHz midpoint between them. If the reference was at 30kHz you could detect anything above 40kHz. But it's not 'anything' as the sensitivity falls off when you are more than about 10% above (or below) the A filter centre. So the graph of sensitivity against click frequency is very skewed, being zero midway between the filters, peaking a bit beyond the A filter centre and then falling off in a long tail out beyond that.

Bimodal clicks are a bit more complicated as a peak in the click off that isn't at the target frequency may be at the reference frequency, in which case it will tend to block click detection. You really need to try to put the reference filter in the notch between peaks or beyond them. Two PODs with different settings can actually both detect the same train with each detecting different peaks. This is done by using the notch between them as the reference value. Having the reference frequency between the two target frequencies confirms that this is in a notch in the spectrum as if there was no notch the level in the reference filter would equal or exceed the target levels and block click detection. Bimodal clicks may be the off-axis spectra of clicks that are actually unimodal on-axis.

Porpoise sonar clicks are around 120 - 150kHz in pitch. This is the quietest part of the marine sound spectrum. A porpoise click about 1m ahead of a porpoise will occupy about 9 cm of water in its direction of travel, and will extend sideways to about the width of a dinner plate. Within it there are about 9 wavefronts (roughly like a stack of dinner plates on its edge). It has a much wider spread of sound of lower intensity, but the intense area only subtends an angle of about 15deg horizontally and 7deg vertically. Porpoises, and perhaps all species producing long narrow-band high-frequency clicks, do not show this bimodality off-axis.

Multi-path propagation

Variations in the physical characteristics of water, especially temperature and solutes, affect the speed of sound waves through it. The salinity is continually varied by surface evaporation, rain, rivers and mixing processes. Thermoclines can have major effects on conduction pathways. So as a wave propagates it reaches more distant points by more and more diverse paths and interference occurs between waves arriving with different delays along different paths. The sound reception become more and more uneven – like the twinkling of stars. This signal degradation affects both frequency and phase characteristics. It results in a single click being received as more than one click at the hydrophone. To avoid processing all these clicks as distinct one click at the start of a tight cluster is selected as the sentinel click and the rest are suppressed, although they can still be viewed by selecting 'subsidiaries' in the filters.

However, where 'split clicks' come from is not obvious. The possibilities are:

1. multipath propagation through sea water that is not perfectly homogeneous. (refraction rather than reflection)
2. reflection within the porpoise.
3. porpoise generated pre-clicks (as described by Teilmann *et al*)
4. reflections from structures such as the airspace within the POD, the water surface, deployment gear, especially if nearby, or if large and air filled.
5. interference between an incoming sound and transducer resonance that it generates.

6. saturation of the electronics. When a cetacean is very close to the POD the loudest part of the click may not be detected. The start and end of the click fall within the POD's dynamic range while the middle does not. This effect may not apply to V4 PODs because their noise adaptation is likely to block the second click.

In considering which might apply in a particular case it is useful to know that sound in water travels at about 1.5mm per microsecond and the X axis of the click display can show times as distances on that basis. This is selected on the Files and Display page.

Other noise sources

Above porpoise sonar frequencies underwater sound is dominated by thermal noise – pressure waves generated by the random jostling of water molecules. At lower frequencies breaking waves, rain, moving sediments, and biological noises dominate, with ships and other man-made noises being major sources in many places especially at low frequencies.

There are about 80 species of cetaceans (whales, dolphins and porpoises). 14 species are the baleen whales (Mysticetes) and do not use high frequency sonar (echo-detection) while most of the rest are toothed whales (Odontocetes) and produce sonar clicks at 40kHz or above, with sperm whales being lower at 9-10kHz. V4 PODs cover the whole range.

Porpoise clicks are particularly distinctive in being high pitched, of narrow band width (= pure tone) and low power. Delphinids generally produce shorter, higher power clicks. Short clicks inevitably appear to be spread over a wider band.

Sensitivity

The following parameters increase the sensitivity for clicks -

- setting the upper filter (A) at the centre frequency of the click spectrum. (see below)
- setting the lower filter (B) away from the centre frequency of the click spectrum (see below)
- setting the sensitivity high.
- setting the minimum duration low. (e.g. zero)
- setting the click bandwidth high.
- allowing sufficient soak-time for the transducer sensitivity to become maximal. This effect is small with dark grey transducer housings and can be up to 3 hours with pale grey housings.
- ambient noise is not as big a factor as you might expect because the electronic noise floor of the POD mostly exceeds the ambient noise level at the high frequencies of interest. Cetaceans, and especially dolphins, are very noisy.

Specificity

False negatives include all clicking porpoises that are out of range, so it really equates to detection range and is reduced by all the factors listed above.

False positives – for porpoise clicks, which are both high frequency and narrow band, false detections mainly come from:

- surface noise – bursting bubbles and landing droplets produce pulses of ultrasound at a wide range of sound frequencies.
- moving sand in strong currents.
- propellers which are cavitating (generating extremely low pressure bubbles which collapse violently).
- cetaceans of the wrong species! Odontocetes are very noisy things.
- shrimp clicks. These are generally broad band clicks but a very small percentage of these can resemble porpoise clicks.

- echo sounder pulses – these are long and regular in timing and will be logged. A third filter will be added to V5 PODs to reduce detection of these clicks that are so loud they are often detected despite being well off the target frequency.

Signal Detection

In signal detection processes the false negatives must be balanced against the false positives. The balance chosen can be described as 'sensitivity', which is high when false negatives are low, versus 'specificity', which is high when false positives are low. The best balance between the two is strongly related to the other sources of high frequency sound present during logging so the best balance could vary with time, place, and the requirement of the user.

Specificity and sensitivity are essentially the parameters that define a 'receiver operating characteristic' curve, a much quoted cornerstone of signal detection theory which does not really apply to the POD as the noise level that limits sensitivity is not Gaussian receiver noise but is ambient noise with characteristics that vary greatly over time and place. Further the signal is complex, being both the click and the train, so that increasing sensitivity to clicks can depress sensitivity to trains. 'ROC' curves in relation to marine mammal detection have little meaning unless the noise source and level are defined, which is not an easy task for systems that are more impaired by some weak tonal sources than louder broadband sources. Also the 'false negative' concept applied quite well to radar receivers from which ROC curves came, but for the POD would have to be translated into detection range. Some very revealing work has been done on this by Jacob Tougaard and colleagues in Denmark, who have produced a detection function curve by detailed tracking of porpoises moving over a POD location. They used standard DISTANCE methods which gave a nicely fitting detection function curve.

The balance between specificity and sensitivity has to be assessed against the cetacean **train detection function** of the POD, so the aim is not to limit clicks to true positives, but to keep false positive clicks down to a level at which they are not so numerous as to significantly reduce the detectability of trains, or exceed the memory size. For dolphin detection the fraction of clicks logged that are classified as in trains is commonly below 5%. The highest classification rates are seen with porpoises in quiet environments and may reach 45%.

Porpoises v. Dolphins – Porpoise sonar is high frequency, very narrow band, not very variable, and at frequencies where other tonal clicks are relatively few so it is ideally suited to this method of detection, and highly specific settings are practical. Dolphin sonar is mostly of variable frequency, mostly broader band, louder and still comes in sequences – click trains – that make verification of the source possible, as without train classification it is very difficult to confidently identify individual clicks as coming from dolphins. Where both dolphins and porpoises are present a scan with a 50kHz target frequency and a higher reference frequency will not detect porpoises. Use of a narrow band setting, such as a click bandwidth of 3, will reject all but a few dolphin clicks even when they are centred at porpoise frequencies i.e. around 130kHz.

Dolphins v. Dolphins – Species of small delphinids cannot be distinguished in POD data.

Train filtering

Trains are defined as sequences of clicks in which the variation between successive intervals is constrained.

The level of constraint defines the regularity of the train. The TPOD train filter comes from an algorithm that uses 38% increase or decrease in interval as the constraint. The true value for small odontocete trains is occasionally much higher but cannot be implemented in practice without very complex processing and/or a high level of false positive trains.

The software filter for trains requires hard work from the computer and TPOD offers to do this whenever a .pdc file is opened. At sea with a slow computer and other issues users may wish to defer this. The process can be done via the 'Find Trains in open files' button on the trains page, or the 'Find trains in batch of files' button on the Files and Display page.

Trains come from:

- cetaceans – clicks made for echolocation purposes.
- other biological sources. Herring (*Clupea harengus*) are known to produce trains of FRTs (fast repetitive ticks) at comparatively low frequencies (mostly < 20kHz) but within the lower range of the T-POD. the existence of other sources cannot be ruled out as published knowledge of marine ultrasound is still very limited.
- sonars – highly regular long sounds are used by boat sonars for depth detection, fish finding etc. They mainly appear on the POD as regular bunches of clicks as they are often received as echoes because the source itself is highly directional.
- chance trains – clicks arriving at random from non-train-producing sources have a definite probability of falling into trains by chance alone.

A period of time with many random clicks will contain a much larger number of trains meeting the criterion above. To deal with this the train filter uses a **probability model** that calculates the probability of trains arising by chance if clicks were arriving at the prevailing rate from non-train sources. At high click rates the filter will inevitably fail to extract 'real' trains or give an unacceptably high rate of false positives, so it is temporarily suspended.

Clicks very close together are treated as a cluster of echoes or multi-path duplicates and only the first of the cluster is processed.

Train classification

TPOD.exe should ideally give a simple and reliable YES/NO answer to the question 'Does the data contain trains from a cetacean'. TPOD.exe is a bit less definite and actually classifies trains into one of five classes:

CET HI – these are trains with a very high probability of coming from a true train source (a cetacean or boat sonar) and a high probability of coming from a cetacean. They are show in red. They are generally reliable as cetacean sonar but where boat sonars are numerous and cetaceans are rare the false-positive rate may be serious and data does need to be examined closely.

CET LO – these are less distinctive trains. They are show in yellow and the colour changes in each successive train in a scan so that overlaps can be seen. If you have only Cet Lo trains you should wonder if they are correctly classified as cetacean trains. You can switch from viewing trains to viewing 'All+' and you will get a view of their context and with a bit of experience a feel for how 'real' they are. If you log a lot of noise clicks there will be many very doubtful (??) trains found in this, having arisen by chance, and a few doubtful and low probability cetacean trains too (Cet Lo, and ?). So don't believe in Cet Lo detections if you don't see any Cet Hi trains.

..?.. Doubtful trains – These are often cetacean trains but are sometimes unreliable. Some contain multiple clicks in clusters and these multi-path clusters are more often non-cetacean in origin. If your data comes from a quiet area with few sonars and you need every detection possible it may be worth including these by selecting the ..?.. filter, but you should look at the PRF display to get an idea whether they look 'good'.

..??.. Very Doubtful trains – These are less often cetacean trains and often come from boat sonars or are chance sequences arising from random sources.

Fixed rate / Boat sonars – These are inevitably logged in many situations because boat sonars can be at the same pitch as cetacean sonar. Some cetacean trains get classified as boat sonars because they are so regular and slow. True boat sonars are mostly reflected sounds and often come in huge clusters of echoes from which a number of trains in step with each other are detected by the software. The reflections introduce some irregularity into these trains and leads to a low level of false classification as cetaceans. A V5 POD with better sonar rejection is being developed.

The **trains classification process** uses the probability value mentioned above (see *Train filtering* on page 21), and various statistics of the train, e.g. longest click duration (high values suggest boat sonars), variance of inter-click-intervals (low values suggest boat sonars), etc. These numerical descriptors inter-correlate in various ways, so that some parameters derived from combinations are highly significant at one end or other, or in the middle, of their range, and the functions may involve 2 or three parameters. The effective discrimination achieved by these parameters can be assessed, during the development process without visual confirmation data by using the clustering of categories in time – boats or cetaceans produce distinctively different encounters, while chance trains are clustered only with rate of click detection (or really eligible ICIs), although this correlation is not a linear one. The train classification in use has been derived from analysis of large data sets from diverse locations. Full optimisation of train classification is a theoretical goal as the task is very large. The present version is inevitably suboptimal, but has been optimised to give very low rates of false positives in Cet Hi trains logged in a wide range of environmental conditions.

Train classification is, surprisingly, actually sensitive to variation in individual components in the analogue processor (i.e. the variation in value of specific op-amps, capacitors, resistors etc.) and there is consequently some variation between PODs from this source. This is larger where PODs are used to monitor dolphins. The only calibration technique that can address this is inter-calibration at sea in an area with high densities of animals.

Limitations of train classification: in estuaries and harbours the combination of numerous boat sonars with shallow waters, relatively calm sea states and often very low densities of animals can lead to false positives arising from boat sonars exceeding true positives – which may, of course, be nil. Such locations are currently outside the capabilities of the POD using 'TDA version 1' filters, but is much more satisfactory with 'TDA version 2' in TPOD.exe version 8.0 and above.

TPOD.exe can be applied to all existing data sets and provides graphic and numerical Microsoft access to the output of a boat sonar filter that is designed to identify the presence of boat sonars without using train classification.

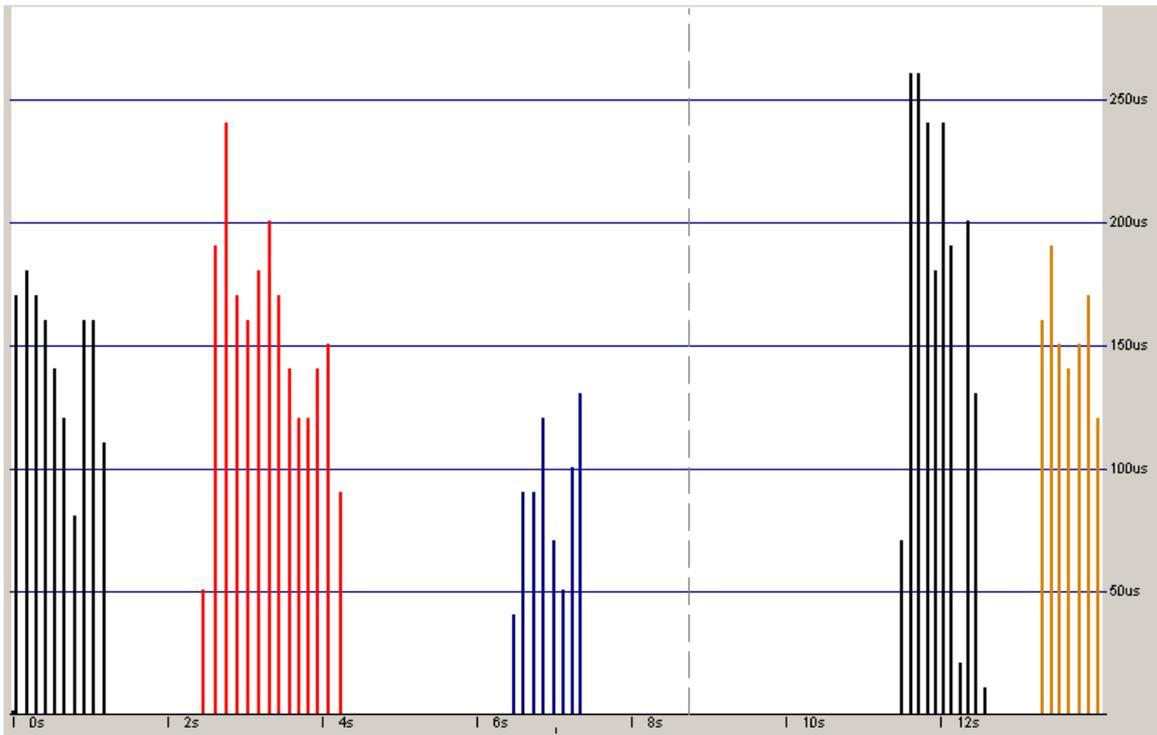
Improved hardware is also under development to give more effective rejection of boat sonars, and better inter-species discrimination. Improved transducer designs are also in progress to reduce pick-up of low intensity sounds and bio-colonisation of the transducer.

Which should I use?

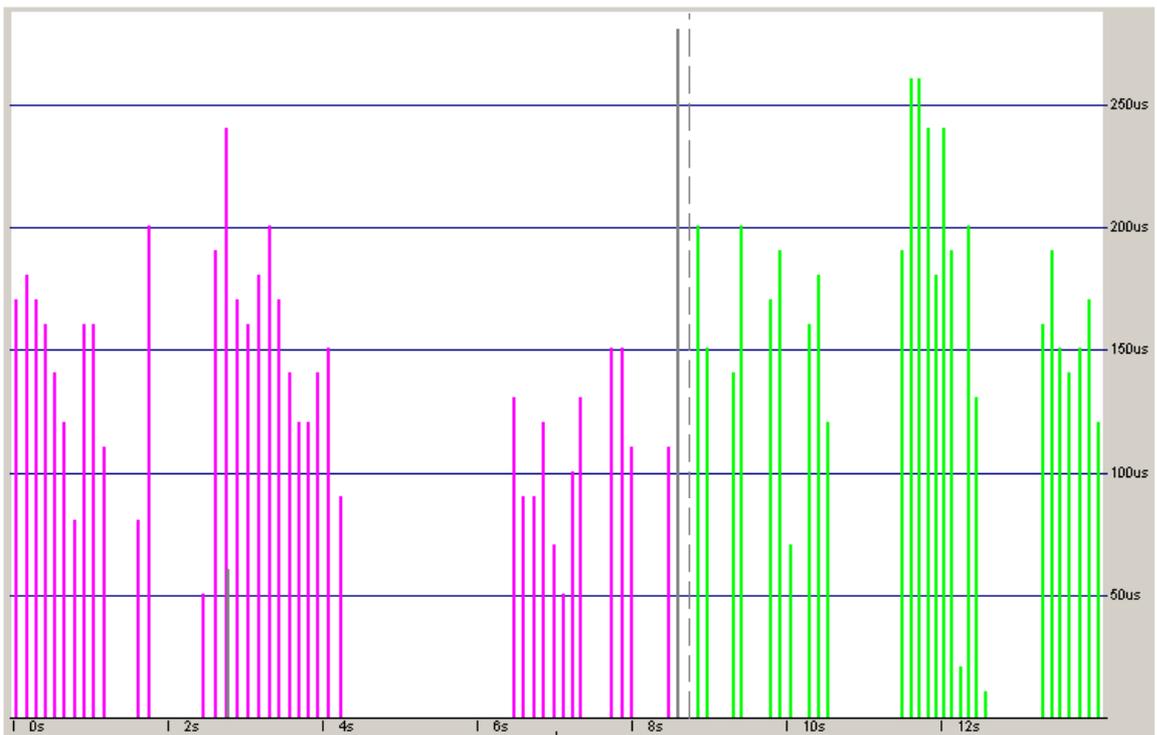
For **habitat monitoring** use **Cet All** – then you will be able to use these same settings across all conditions – storms and boat noise included.

For **researching behavioural responses** you will be working where cetaceans are reasonably common and real trains will outnumber spurious ones so you can include ..?.. (doubtful) trains – this gives both more valid data and is better at including short, low PRF, trains from animals that are not feeding.

Here you see trains that are evidently from the same source but get variously classified for the reasons mentioned above.



When you look at 'All' clicks you see this:



4 Species discrimination

PODs have detected trains satisfactorily from all species attempted. These are:

- Harbour porpoise (*Phocoena phocoena*)
- Bottlenose dolphin (*Tursiops truncatus*)
- Common dolphin (*Delphinus delphis*)
- Hector's/Maui dolphin (*Cephalorhynchus hectori*)
- Humpback dolphin (*Sousa chinensis*)
- Boto (*Inia geoffrensis*)
- Tucuxi (*Sotalia fluviatilis*)
- Risso's dolphin (*Grampus griseus*)
- Indus River Dolphin (*Platanista minor*)

Using low frequency PODs:

- Short-finned pilot whale (*Globicephala macrorhynchus*)
- Long-finned pilot whale (*Globicephala melas*)
- Cuvier's beaked whale (*Ziphius cavirostris*)

Discrimination of species, or groups of species, can be achieved in some circumstances:

- Where one species does not use part of the frequency range used by the other.

Where dolphins and porpoises co-exist, settings of 50kHz with 70kHz or 90kHz as a reference will never detect porpoises. So encounters with 50kHz clicks include dolphins.

It cannot be said that encounters with narrowband 130kHz clicks do not include dolphins, but such clicks are produced by dolphins (*Delphinus* and *Tursiops* at least) much more rarely than lower frequencies. A bandwidth of 4 gives good discrimination here, while 5 admits more dolphin clicks. So encounters can be characterised by the ratio of 50kHz to 130kHz clicks, with a distinct segregation into dolphin and porpoise encounters appearing, plus a few mixed encounters. The key here is that the reference filter is between the major peak frequencies used by the two species or groups so that 50/70kHz and 130/90kHz would be used to collect (only) dolphins, and (mostly) porpoise clicks.

- More subtle approaches using more of the data on trains are possible, e.g. if 40kHz/22kHz is used to collect beaked whale or short fin pilot whale clicks at 1000m depth, it may also detect dolphins far above at the surface using 50kHz clicks. The trains will differ greatly in click duration (much shorter in dolphins) and click rate (much lower and more stable in beaked whales).

5 Handling files

File types

When dealing with POD files on your computer, it's helpful to see the file extensions in Windows Explorer. To view file extensions:

1. Open Windows Explorer and click Tools > Folder Options > View >.
2. Clear the box 'Hide extensions for known file types'.

POD click data files *.pdc

POD data files appear on your computer as *.pdc files. If you open one these files in TPOD, you are asked whether you want to process it to identify any trains in it. If you click Yes, TPOD creates a copy of the file with information attached to each click record identifying which train, if any, it belongs to. The copy is a click-train data file (see below).

POD click-train data files *.pdt

Click-train data files are created by processing *.pdc files to detect trains.

A click-train data file contains all the data in the *.pdc file from which it was derived and is a valuable back-up of your data.

To reprocess a data file with different criteria use the **Find trains in open files** button on the TPOD **Trains** tab. A temporary copy of the file is created (with the .tmp suffix) during this process and is deleted at the end.

POD settings files - *.pds

A set of standard POD settings files is provided with the TPOD software. These files correspond to the different settings on the **Set POD** page.

Settings files are very useful for ensuring that several PODs are set to the same parameters.

You can create your own settings on the **Settings** page and save them via the **Save settings** button.

POD Identifier files - *.pdi

POD Identifier files are text files that contain the various numbers each POD needs to tell your computer about its characteristics.

Each file is specific to one POD and can be used to restore these data to the POD if it is corrupted by faulty communication. They are saved or used via the **POD ID** page.

TPOD preferences files - *.ini

TPOD preferences files are text files that allow you to save and reload your preferences for TPOD.exe. These include the settings for the display, filters, export and upload, but they do not include the logging settings that go to the POD.

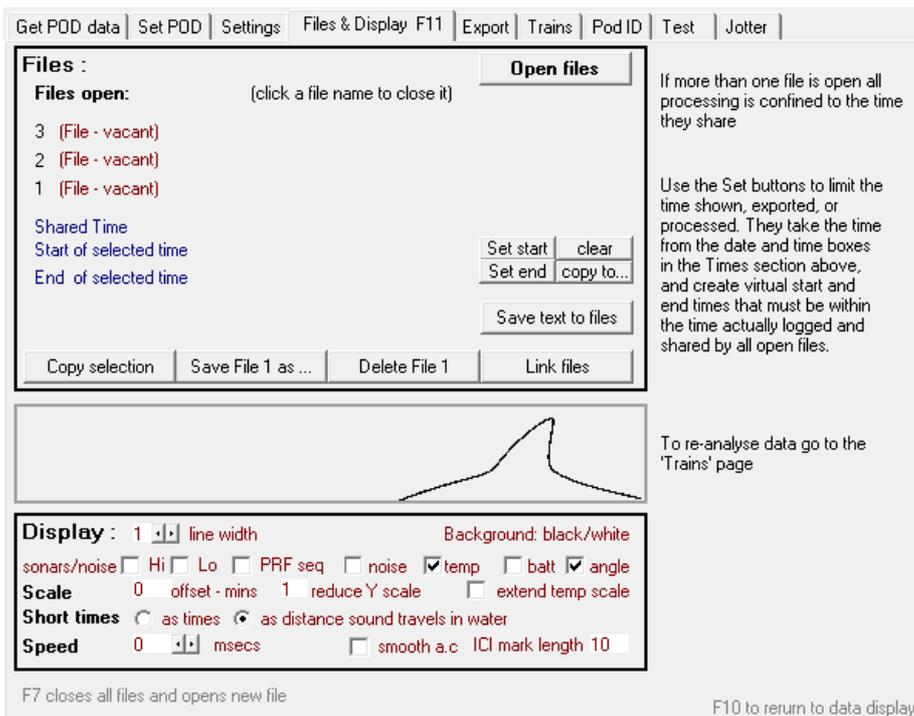
You can save other sets of preferences under other names - if you want to return to viewing a file with the same preferences you can save these in a specific .ini file, perhaps using the data file name with the .ini suffix to identify it. Exporting data can be frustrating if you forget a setting, so try a preference file to reload these quickly.

Data Files

During data upload the POD takes the name you enter at the start of the upload process and adds the date and POD identification number to it for each separate stretch of logging. If a POD logs two or more periods in a day each successive file is given an additional file number.

Tip: When downloading data files, simply type the POD location - the TPOD software adds the date and POD number to the file name. Files stored on your computer can be sorted by name and will appear for each location in chronological order (of time of logging).

The **Files and Display** page is the main location for selecting data files:

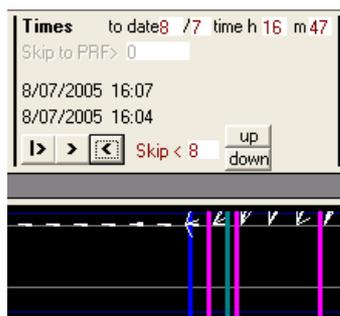


Close data files by clicking on the name in the list.

Start and End points in files

If you set a Start or End point in a file, the software excludes all that is before, or after, that point.

In the example below, you can see the first minute in which the POD was upright after lying on the deck of the deployment vessel and then being moved around for 4 minutes during deployment. You might want to insert a start point to exclude this period.



To set a Start and End point:

1. In the data area of the screen, move the mouse to the START point position, but *do not* click the mouse button.

The date and time corresponding to the mouse position is shown in the **Times** section just above the **|>** button.

2. Make a note of the date and time of the position.
3. Click the **Menu** button.
4. Select the **Files and Display** page.
5. Type the start time in the **Times** boxes. For example:

6. Click the **Set start** button.

TPOD displays the start time as well as the length of time you have selected in the file.

7. Repeat the procedure to locate the END point you want to use and in the **Files and Display** page, click the **Set end** button.

Now if you view the whole file you only see the time between the start and end points.

8. Close the file by clicking on the name.

You are prompted to save the start and end point information.

9. Click **Yes** to save the information. The start and end points are saved into the file, and can be used, changed or cleared as you wish in the future.

To clear Start and End points in a file:

1. Open the file and in the **Files and Display** page, click the **clear** button.
2. Close the file.

To copy Start and End points another file:

1. While your file with start or end points is open in the **Files and Display** page, click the **Copy** button.
2. Locate the file to which you want to copy the start and end points.
3. Click **Open**.

Save text to files

The **Save text to files** button saves the text in the boxes in the File section of the main screen into the file headers of all open files.

File	Start 12/10/2002 13:11					
	End 12/10/2002 17:24					
	0days 2hrs 1min (1056k)	POD 189	LAT	LONG	Depth	userTxt

To save this text:

1. Open the files you want to edit.
2. Enter the text you want to save in the headers of the files.
3. Click the **Save text to files** button.

When you subsequently open any of the files, the header information is displayed.

Copy Selection

Sections of T-POD data files, .pdc or .pdt files, can be copied as a new smaller file using the **Copy** button if start and end points have been set. If they have not been set, the whole file is copied, using the same file name, with the prefix **Copy of**.

There are several situations where copying selections is useful:

- Creating a set of files that have only one species of animal present, as established by visual observation. Many sections can be cut and copied out of one file without any changes to the original file.
- Removing time at each end of a deployment when the POD was not in the sea or the boat was on top of it. Then start and end times can be imposed on the file for more interesting reasons if needed.
- Making a short file for emailing to others or archiving as an interesting piece of data.

Save File 1

This button allows you to save a copy of the file.

Delete File 1



This button destroys the file currently open in position 1 – it does not send it to the Recycle Bin.

Linking data files

T-POD data files, .pdc or .pdt files, can be linked together after upload into a single file if they came from the same POD.

There are two situations where you might want to link data files:

- If the files were split at the month end they can be rejoined.
- Files with a time gap between them can be linked. In this case the gap contains no clicks and the angle sensor shows the POD as facing vertically downwards - the opposite of the normal deployment position.

The **Link files** button closes any open files and asks you to select files to be linked. Up to 30 files can be selected. Any with a different year from the first file are ignored. Others are linked so that the earliest is first, followed by whichever follows most closely, and is longest if several are possible. The name created by TPOD is the name of the first file with 'linked' added to the end.

6 Managing and Exporting data to Microsoft Excel, Microsoft Access, Microsoft Word

Longer tutorials are available from Chelonia Limited. Please contact us for more information.



Always back up your data files immediately after upload. Although you will work on click train files (.pdt), keep the original click files (.pdc) safe as an extra backup.

The section refers to click train files (.pdt), which are created when you process the click file.

Analysing your project

Follow the steps below to prepare your data files:

1. Store the files you want to analyse in one or a few directories.
2. Run TPOD.exe and display the **Export** page of the menu.

Data Export use endpoints, if set

A

data

- click times
- N of clicks
- N of clicks by train classes
- DPM
- DP10M/day
- DPH/day
- encounters / day

period

- 1 min
- 10 mins
- hours
- 1/4 tides
- days

to

- text file .txt
- Jotter

Batch tabulate v Julian day sum identical scans sum all scans

omit negative time periods omit header put data in 1 file

angles degC sonar

minimum encounter gap in minutes: 10

time formats exported

- text
- minutes in year
- both formats
- none

Export data from first open file Export data from batch of files

B Train details - mean PRF, number of clicks, duration, scan, classification, etc. Export train details

Utilities: **List settings** use endpoints as set above **List files** **List days** **List click totals**

Minute n translator: Year 2005 minute 0 = 01/10/2003 F10 to return to data display

The current filter settings are used in both A and B

Exporting to the Jotter allows you to copy the data and paste it into a spreadsheet more easily than via a file that you have to find and open.

These options are a bit tricky and it's a good idea to save your standard export format in an options file for easy recall. See the 'options' page ... button top left..

Exported data are in text format that can be imported or - more easily - pasted into a spreadsheet, imported into Access, or viewed and edited as text

3. Use **List files** to help identify any delete any duplicates or useless short files. Copy and paste the results into Microsoft Excel where they are easy to view.
4. Review each file and in the **Files & Display** page, set end points where there is logging out of the water, noise from the deploying vessel, etc. You can copy the real data section into a new file if you prefer, by setting endpoints and then using **Copy Selection** and then process these files without setting any endpoints.
5. Closely inspect any files with few detections, especially if none are **Cet Hi**. This is necessary to verify that they are good.
6. Scan quickly through all files using PRF view and 20ms or 50ms, perhaps with thicker lines (on the **Files & Display** page) and perhaps set a delay between screens so that they don't flash by too quickly. This gives you a useful sense of how much boat sonar is around, any feeding frenzies or rate ramps and the general pattern of rates.
7. In the **Export** page, use **List settings** to see the settings from all files at once, again copying and pasting the text into Microsoft Excel. This shows if files are actually comparable.
8. Use **List files** to verify that you have correct values in place.

You now have a purged and appropriate set of files in one directory and you can start to process millions of clicks an hour while drinking tea.

Next

1. Select which filters to use first as this determines the subset of data you get. In particular, decide whether to use **Cet Hi**, or **Cet All** (or others, if your location was very quiet) and if you want to deselect certain scans, for example dolphin scans.
2. Decide if you want to run the data from many files into one export file. This is useful for moving data to Microsoft Access, but can create files that are too large for Microsoft Excel if you are exporting train details.
3. Decide on creating a file or putting the data into the Jotter. Shorter data sets are best in the Jotter as you can copy them (click Copy All) and paste them into Microsoft Excel. It is easier to import a file into Microsoft Access.
4. As there are a large number of possible options, it is useful to save your preferred settings in a preference file that can be named according to its use and recalled when needed. Click **show options** on the main screen, then display the **Preferences** page and click the **Save present TPOD.exe settings** button.

What do you want to export?

For studies of habitat use and changes over weeks or longer, number of detection positive minutes per day is likely to be most useful. Export these to a spreadsheet.

For studies of behaviour, e.g. diel patterns, number of detection positive minutes per hour is useful, plus train detail data to reveal changes in click rates in trains. This requires a spreadsheet and a database.

For short term Environmental Impact Assessments (EIAs) you may need to look at the data in relation to each impact event. This may be easier in TPOD.exe without using the Export function. The time of recorded trains can be obtained by right-clicking on them.

The text files created by the Export function hold delimited data fields with a tab character as the field end marker.

Microsoft Excel

Data from the Jotter can be selected, copied and pasted into a worksheet.

The choices you are offered by Microsoft Excel when you open a .txt file require Delimited, Tab, General, Finish in succession. As these are the defaults for Microsoft Excel you can just hit Return four times and you're singing.

Microsoft Access

Importing train data into Microsoft Access allows you to analyse data.

Open a blank database and click **File > Get External Data > Import**.

Choose the following options: Delimited, Tab, In a new Table, Change field names = Next, Add Primary Key = Yes, Name Table = enter a name, Finish.

Microsoft Word

Microsoft Word and text editors read the files directly. If you prefer to use a text editor, EditPad from JGsoft is recommended.

Options

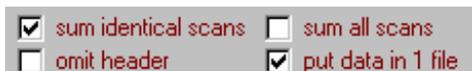
Option A – The data exported depends on the filters set

The choices for export include:

- click times - in microseconds. Don't export from too big a chunk of data.
- N of clicks
- N of clicks by train classes - each minute, each scan, each class lots of columns.
- N of detection positive minutes - practical stuff. DPM, DP10M, DPH (see below) can be exported to the Jotter and the easiest option is to 'tabulate whole year' for a batch of files, then 'List days' to get a comparable list of how many hours were logged on each day.
- encounters / day - defined by gaps of the length you specify without any click in a train in any of the selected classes.



Time can be exported as text, which Microsoft Excel will read as a date, if the cell is formatted as a date, or as the number of the minute in the year. That may seem strange but is quite convenient to work with and is very economical in memory use (a Microsoft Excel file version of a POD file is about 10 times as big). Some notes on how to do that are given below.



Sum identical scans is useful if you have some identical scan settings for porpoises and different, but identical, settings for dolphins. If you select this option, two columns are produced, one for each group. If you want the data exported in one column that ignores any differences between scans, select the **sum all scans** box. If neither **sum identical scans** nor **sum all scans** is checked, each scan will shown as a separate column of counts.



Omit negative time periods reduces the volume of data exported a lot when you use shorter durations as the time unit.

Put data in 1 file is a quick way of getting a lot of data into Microsoft Access or Microsoft Excel. Each can read large text files, or they can be opened, e.g. in Edit Pad, copied and pasted into Microsoft Excel. Microsoft Access can create a new table based on the text file with the field names already set in the first row, and in moments you have info on millions of clicks Microsoft accessible for analysis. To do that you should select **omit header** as well. Putting the data into the Jotter can be even quicker – right click in the **Jotter** and select **select all**, then use **Ctrl+C** to copy the data to the clipboard. Then you can paste the data directly into Microsoft Excel without having to open any file.

Angles works with counts of clicks and gives you a column with the mean angle logged in the time periods selected.

DegC is similar for temperature.

Sonar exports an estimated risk of a boat sonar being present in the record during each scan of each minute.

Option B – details of individual train characteristics

This option can be use on batches of files. The column headings are:

File	
YrDay	
YrMin	
Scan	
TrClass	
Start	in 10microsecond units
TrDur	total duration of train
NofClx	
MaxICI	
MinICI	
PRF	clicks per second
TotalDurClx	summed duration of all clicks in the train
IClup%	% of ICIs that are shorter than the preceding ICI.

These data are primarily intended for export to a database, e.g. Microsoft Access, where they can be analysed efficiently. As every train generates all these data values it is liable to become too large a file for Microsoft Excel.

Names for POD data

The following terms are recommended:

- **Detection Positive Minutes** DPM – a measure of presence.
- **Detection Positive Ten Minutes** – DP10M
- **Detection Positive Hours** – DPH
- **Detection Positive Days** – DPD

Terms such as “frequency” and “intensity” are best avoided where possible because they are commonly used to describe sounds.

Specifying “train” or “detection” makes it more clear that raw counts of clicks are not being used.

Working with MinuteNinYear ('YrMin') in Microsoft Access

Some useful functions that can be copied and pasted are described below:

INT() is a function that converts a number into an integer – the number of whole units. So $\text{INT}(5.93) = 5$.

Square brackets [] are used by Microsoft Access to identify data fields from a table. **[YrMin]** is the field name of the **MinuteNinYear** exported by TPOD.exe in the Train Details.

All these start with the first time unit as 0:

WeekInYear: $\text{INT}([YrMin] / 1440 / 7)$
DayInYear: $\text{INT}([YrMin] / 1440)$
Hour: $\text{INT}(([YrMin] - [YrDay] * 1440) / 60)$
TenMinofDay: $\text{INT}(([YrMin] - [YrDay] * 1440) / 10)$
MinofDay: $\text{INT}([YrMin] - [YrDay] * 1440)$

The same calculations in Microsoft Excel use the cell identifier instead of [YrMin] etc.

Putting PRF values in classes

PRFclass: $\text{INT}([prf] / 10) * 10$ gives categories of 10/s with the lower limit as the value for trains in that PRF class.

Alternatively:

PRFclass: $\text{INT}([prf] / 10) * 10 + 5$ gives categories of 10/s with the central value of that PRF class.

Larger classes can be produced by substituting 20 or 50 for 10 in the expressions above and changing 5 to 10 or 25.

Tidal phase:

Position in cycle, as a fraction of 1:

$((\text{YrMin} + \text{offset}) / \text{CycleMins}) - \text{INT}((\text{YrMin} + \text{offset}) / \text{CycleMins})$

CycleMins = the duration of the tidal cycle = approx 744 minutes.

Offset = minutes between file start and the start of the tidal cycle.

Microsoft Excel stores dates as a number of days since 01/01/1900 and the time as a fraction of one day.

This can be converted to a Microsoft Excel Date/Time in three steps:

1. Take the Days number for the year from this table

Year	Days
2000	36526
2001	36892
2002	37257
2003	37622
2004	37987
2005	38353
2006	38718
2007	39083
2008	39448
2009	39814
2010	40179
2011	40544
2012	40909
2013	41275
2014	41640
2015	42005
2016	42370
2017	42736
2018	43101
2019	43466
2020	43831
2021	44197
2022	44562

2. Add 'minute in year'/1440.
3. Format this result as a date or a time and it will be correct.

If required, the time within the minute can be added as a fraction of a minute/1440.

Working with Microsoft Access

Some useful functions are listed below:

MeanClkDur: $10 * [\text{TotalDurClx}] / [\text{NofClx}]$

Criteria for daytime: (uses Hour as above):

Daytime - Hour (>5 And <18)

Nighttime - Hour Not (>5 And <18)

Criteria to select trains by class

Exclude very doubtful and boat sonar train:

Not (Like '??' Or Like 'Fxd')

Use Cet all trains:

Like 'Cet*'



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