A User’s Introduction to

PAMGUARD

Tutorial version 1.4.03

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Contents

PAMGuard Overview

Many marine activities involve underwater sound emissions. These may be a by-product of the activity (e.g. piling or explosives), or a tool (e.g. air guns used for seismic surveys in oil and gas exploration, or military/commercial sonar). To mitigate against harm to marine mammals, observers are often employed to visually scan the sea surface for the presence of animals. In the event of a sighting, procedures such as suspension/delay of activities may be implemented to avoid harm.

Visual observations play a vital role, but marine mammals are difficult to spot on the sea surface, especially when weather and light conditions are poor. However, many marine mammals produce loud and distinctive vocalisations, which can often be detected more reliably than visual cues. For these species, passive acoustic monitoring (PAM) offers an effective means of detection. Furthermore, the creatures do not need to be on the surface to be detected.

A basic PAM system consists of a number of hydrophone elements (analogous to microphones in air, but used for underwater sound) arranged to form an array, hydrophone signal conditioning/amplification, a signal acquisition device (e.g. a sound card) and a computer running PAM software. Sounds in the water are converted by the hydrophones into electrical signals which are conditioned appropriately and converted into digital signals for processing by the PAM software.

The PAMGuard project was set up to provide a standard software infrastructure for acoustic detection, localisation and classification for mitigation against harm to marine mammals, and for research into their abundance, distribution and behaviour.

PAMGuard is open-source Passive Acoustic Modelling (PAM) software based on a platform-independent (e.g. Windows or Linux), flexible, modular architecture.

This architecture makes it relatively straightforward to incorporate new modules as they are developed to include additional detection, localisation, classification and sound visualisation functionalities. The software offers a versatile software/hardware interface to enable flexibility in the configuration of in-sea equipment (number of hydrophones, sensitivities, spacing and geometry).

PAMGuard is a sophisticated software package that can be used by the expert user to set up industry/research PAM infrastructure. It can also be configured for operational use by MMO PAM operators. Central to the software design is a flexible core architecture which allows the integration of a range of additional plug-ins. For more information on PAM and PAMGuard please visit *www.PAMGuard.org*.

This tutorial provides an introduction to PAMGuard from a user's perspective. This involves exercises in setting up and running the software with a variety of configurations of plug-in modules.

The latest PAMGuard release contains over 38 different plug in modules. A complete list of these is available on the PAMGuard web site at http://www.PAMGuard.org/modules.shtml

Tutorial Learning Outcomes

The purpose of this tutorial is to provide a basic overview of how to use PAMGuard, including adding and configuring plug-in modules.

The main learning outcomes are:

- Loading and running PAMGuard configurations
- Navigating the Graphical User Interface (GUI)
- Basic Map familiarisation
- Running and configuring a Click Detector module
- Adding and configuring User Display panels
- Adding, configuring and running a Whistle Detector
- Using “Ishmael” modules for Energy Sum, Spectrogram Correlation and Matched Filter detectors.
- Overlaying detector graphics on display panels
- Adding and configuring FFT Engines
- Using spectrogram and radar displays to view detection information

These learning outcomes can be achieved through a series of exercises that now follow.

The exercises can be seen as a guide, so you’re encouraged to experiment with PAMGuard as you work through each one.

Exercise 1. Tutorial Installation

During these tutorial examples, we assume you are running PAMGuard on a Windows machine.

In the exercises you will play back sound from a file rather than receive it in through a sound card. PAMGuard will operate in exactly the same way as it would if the sound were coming in through the sound card. If a sound playback module is included in the PAMGuard configuration, then analysis will be in real time. If a sound playback module is not included, then PAMGuard will process data as fast as possible.

EX 1.1 Install data and configuration files

The configuration files used in this tutorial refer to sound and map files at specific locations within a predefined directory structure (shown below). If you put the tutorial files elsewhere on your computer you will have to reconfigure the tutorial example configurations to find the correct sound and map files.

If you have downloaded the files from the PAMGuard website, create the following folder structure and place the downloaded files as shown:

C:\PamguardTutorial – all settings (psf) files should be copied to this folder

C:\PamguardTutorial\TutorialSoundFiles – all sound (wav) files should be copied to this folder

C:\PamguardTutorial\TutorialMaps – any map (asc) files should be copied to this folder

For Tutorials and training workshops it is most likely that you will be given a folder containing all the files you need on a portable hard drive or USB memory stick. If possible, copy the entire Pamguard Tutorial folder onto your C drive (so that it becomes C:/PamguardTutorial).

EX 1.2 Install PAMGuard

The examples in this tutorial will work with the latest PAMGuard Beta version 1.12.00 or higher. If you've not already downloaded it from the website and are taking the training workshop, the latest installer for Windows should be in the PAMGuard Training folder.

Exercise 2. PAMGuard familiarisation

Ex 2.1 Launching PAMGuard

Launch PAMGuard from your Windows Start menu. The first thing to appear will be a splash screen giving version and license information and a tip of the day. Make the tip go away and wait for the splash screen to disappear and you will be left with a dialog like the one below.

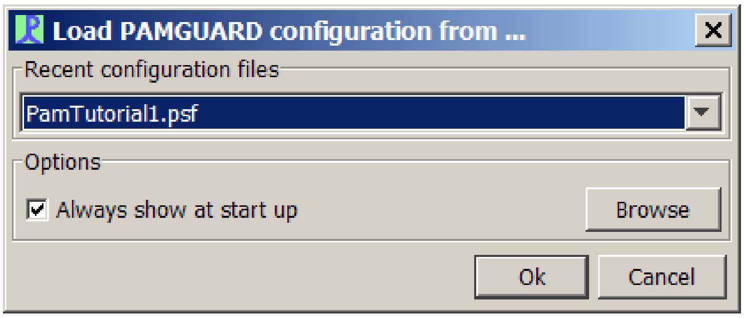


Figure 1. ***PAMGuard configuration dialog***

This dialog allows the user to choose from a selection of PAMGuard configuration files which were either installed with PAMGuard, you created yourself, or were provided by someone else.

Recently used configurations can be selected from the drop down list. If the file you want is not available in the list, press the browse button and find the configuration file on your computer. For this tutorial, press Browse and load the file PamTutorial1 which you'll find in your C:/PamguardTutorial folder.

When *OK* is clicked, the dialog will disappear and the PAMGuard application will launch. During the launch, the following dialog will appear.

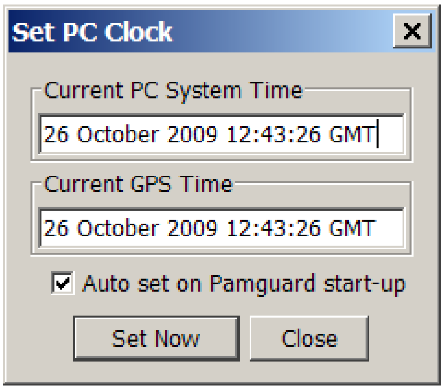


Figure 2. ***Set PC Clock Dialog***

You should ignore this dialog for this tutorial. After a few seconds it will disappear. In real operation this would synchronise your PC clock with the time provided by the GPS system.

Ex 2.2 PAMGuard GUI overview

Once launched, the PAMGuard Graphical User Interface (GUI) will look like Figure 3.

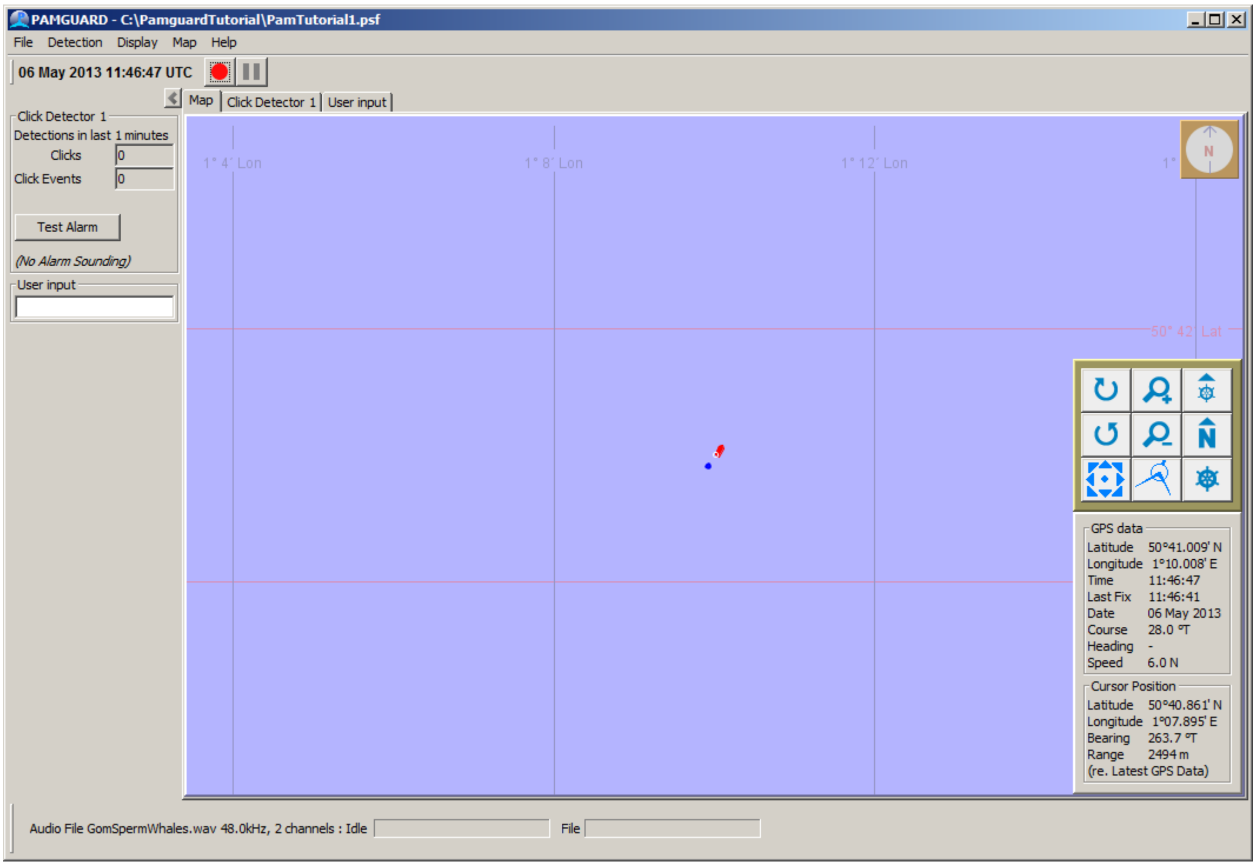


Figure 3. ***PAMGuard Graphical User Interface***

The GUI is subdivided as described in the following table.

Menu bar	This provides access to many PAMGuard settings and controls, as well as access

	to the help system. PAMGuard has a dynamic menu bar system, whereby the menu items change according to the current view and settings.
Clock display	Shows the current time.
Side panel	The side panel gives quick access to information and controls for currently active modules.
Tab panel	Tab panels provide access to the main visual interfaces of many of the PAMGuard modules. In this example the map tab panel is shown, which consists of a map, compass and some GPS data etc.
Status bar	This bar provides information on the current status of PAMGuard, e.g. whether it is running or idle

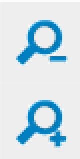
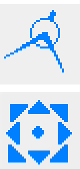
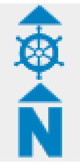
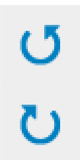
Spend some time investigating the user interface.

Ex 2.3 Using the map

At this point, PAMGuard should be running with the “PamTutorial1.psf” configuration. The configuration file name is always shown in the title bar of the PAMGuard display. If this is not “PamTutorial1.psf”, exit and restart PAMGuard with the correct configuration file.

In the tutorial configurations, the GPS data are simulated and the “vessel” icon will appear on and move over the map display. If you cannot see this, make sure you have selected the map tab panel by clicking on its tab and click on the “centre map on ship” map control button (see table below). GPS data are simulated for demonstration purposes.

Experiment with the map controls, which have functions as described below:

	Centre map on vessel	This control pans the map such that the vessel which supplies PAMGuard’s GPS feed is represented in the centre of the display by the  icon.
	Zoom out/in	These controls allow the user to zoom in and out of the map view. These functions can also be achieved using the mouse wheel.
	Measure/Pan	These controls allow the user to either measure by dragging the mouse across the display or to ‘pan’ or drag the display to view a different region.
	Ship/North orientation	These controls set the map’s orientation to ship’s heading and North, respectively.
	Rotate map	These controls allow the user to rotate the map to a desired arbitrary orientation.

Note the information panel at the lower right hand corner of the map. This shows useful information such as the position of the vessel which is supplied by the GPS feed to PAMGUARD.

Move the mouse cursor around the map and note that the Latitude and Longitude of the cursor position is provided and in addition, the range from the mouse cursor to the host vessel. This is useful for range estimation.

Ex 2.4 Setting up a sound source

First of all you will need a source of sound. PAMGuard modules can acquire sound data in a number of ways, e.g. sound can be acquired directly from the system sound card, from some other digital acquisition device or sound files can be loaded and "re-played".

If you've put the PamguardTutorial folder on your C drive and are running the example configuration files (e.g.PamTutorial1.psf) then the sound source will already be configured for you. If however you've put the tutorial files somewhere else on your computer, you'll have to go through these next stages in order to find the correct files.

To load a sound file, your configuration must contain a 'Sound Acquisition' module. Go to the settings dialog for the sound acquisition module (Figure 4). You will find this in the Settings->Sound Acquisition menu. In 'Data Source Type' select 'Audio File'. Select the file of choice (AIF or WAV format) either using the 'Select File' button or selecting a recent file from the drop down list. The sample rate and number of channels will be read automatically from the file. If you have calibration information you can also enter it here, but this is not required for any of the exercises in this tutorial.

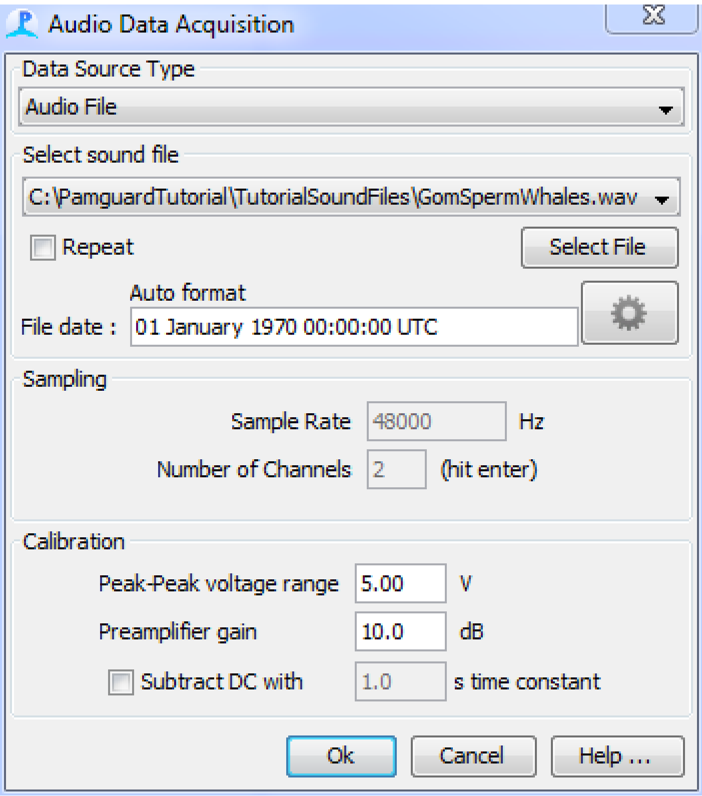


Figure 4: ***Sound acquisition configuration dialog*****.**

Exercise 3. Running the Click Detector

The loaded configuration already has a Click Detector plug-in added. Clicking on the Click Detector module's tab (Click Detector 1) will bring forward the main Click Detector interface panel (Figure 5).

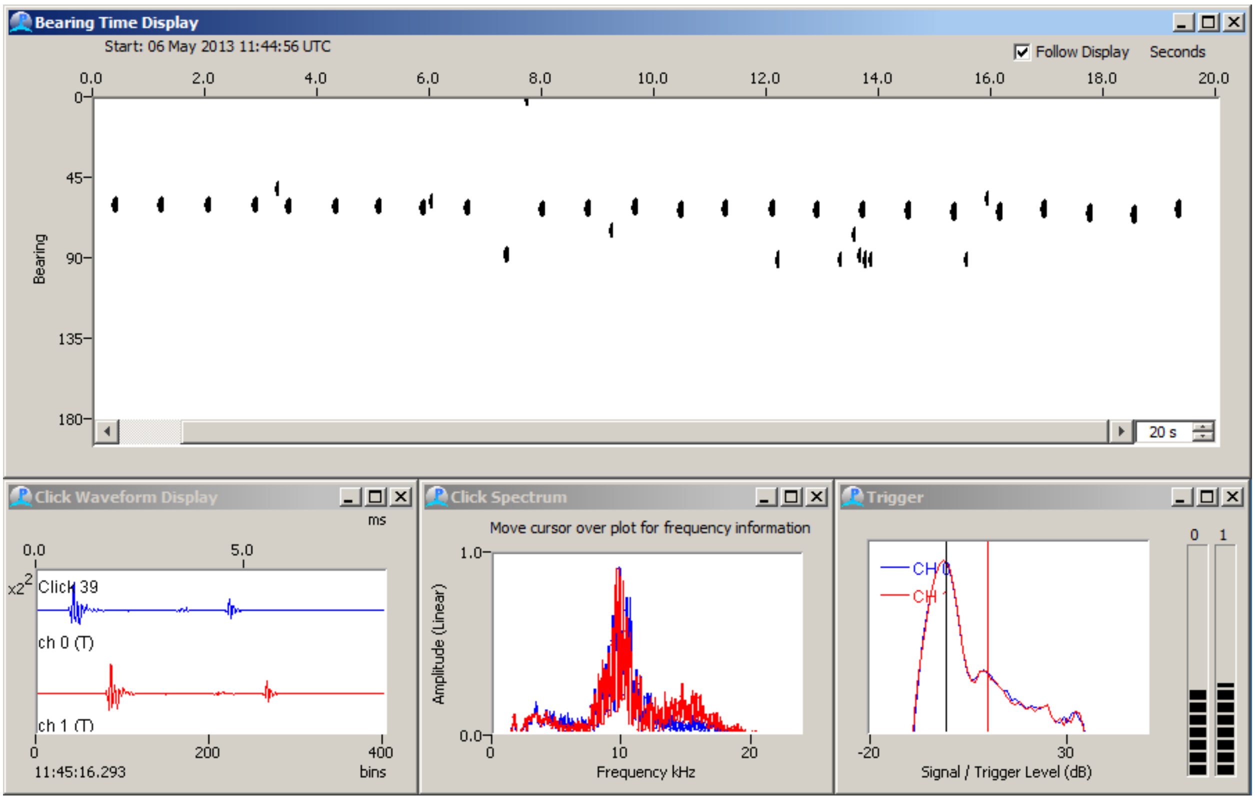


Figure 5. ***Click Detector Tab Panel***

The panel has four main components:

Bearing/Time display	Each detected click is shown as a circle or ellipse on the scrolling display. The toolbar at the top of the display can be used to select the type of vertical axis - bearing, amplitude or inter click interval.
Click waveform display	The waveform of each detected click appears on the display as it is detected.
Click spectrum	The power spectrum of each click is displayed as it is detected.
Trigger display	The trigger window shows the amplitude of the signal on each channel as a decaying histogram. The vertical red line represents the trigger threshold set in the detection parameters dialog (cross reference). Level meters for each channel are also shown on the right hand side of the trigger window.

You can change the duration of the bearing/time display using the arrows in the bottom right corner of the displays scroll bar.

Start detection by clicking the Record button ( ) in the toolbar. You are now running PAMGuard.

Ex 3.1 Tracking clicks manually

The bearing time display scrolls with time and detected clicks are displayed as ellipses. As clicks appear on the bearing time display, the Click Detector's side panel display (Figure 6) updates the number of clicks detected in the last 1 minute.

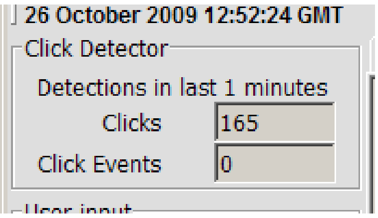


Figure 6. *Click Detector side panel display*

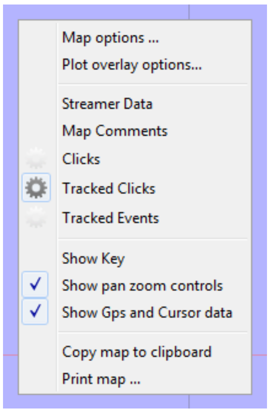


Figure 7. *Map Panel drop-down menu*

To track detected clicks manually, select a click in the Bearing Time display by right-clicking on it (in fact you can right click anywhere, which will pause the display, then release the mouse over the click you want to track). A pop-up menu should then appear where you can select an id or colour for the whale you are tracking. This will draw a cross on that click **+** to confirm its status as being tracked. Next, click on the map panel tab to bring forward the map display. Using the right mouse button (or for Macs, hold the ctrl key and click) click on the map display to bring up the map detection drawing options. This provides a selectable list of items which are suitable for drawing on the map. An example is shown in Figure 7.

Make sure that "Tracked Clicks" is selected. This will draw the bearing lines for that click on the map panel, as indicated in Figure 8:

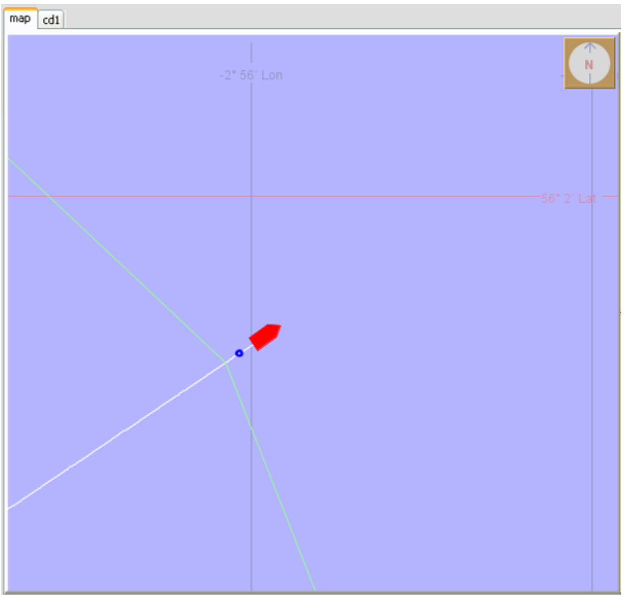


Figure 8. *Tracked click bearing lines plotting on the map panel*

If no bearing lines are visible on the map, the overlay settings may need adjustment. Right click on the map display to bring up the map detection drawing options and select "Plot overlay options…". This will show a new pop-up menu that controls how long objects are displayed on the map (Figure 9). Ensure that the *Plot* check-box beside Tracked Clicks is checked. The time in the text box to the right of the check defines how many seconds the object should stay on the screen before disappearing. Checking the box under *Fade* causes the object to slowly fade away, as opposed to abruptly disappearing. The *default* button sets the Time to the typical value, and checking the box under *All* will keep the object on the screen at all times.

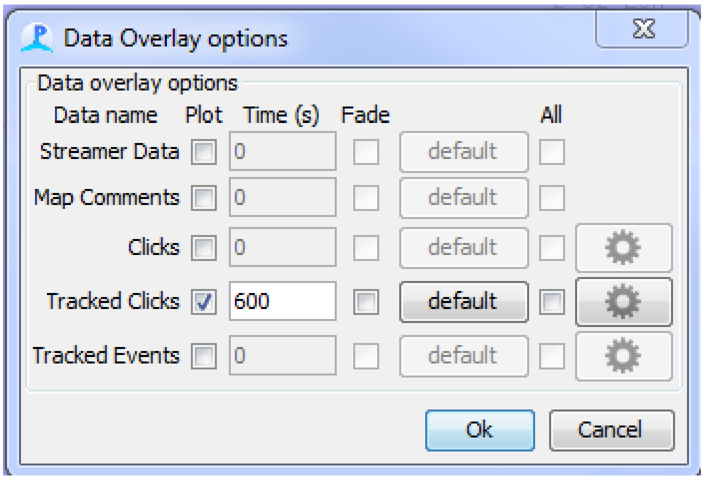


Figure 9. *Plot Overlay Options*

Ex 3.2 Tracking clicks automatically

The Click Detector can automatically detect sequences of clicks on a consistent bearing with a consistent inter click interval. Clicks that satisfy these constraints are referred to as *Click Trains*.

To enable this feature, select the Click Detector tab panel. Then select *Click Detection ⇒ Click Train Identification…* from the menu bar. This will bring up the following dialog:

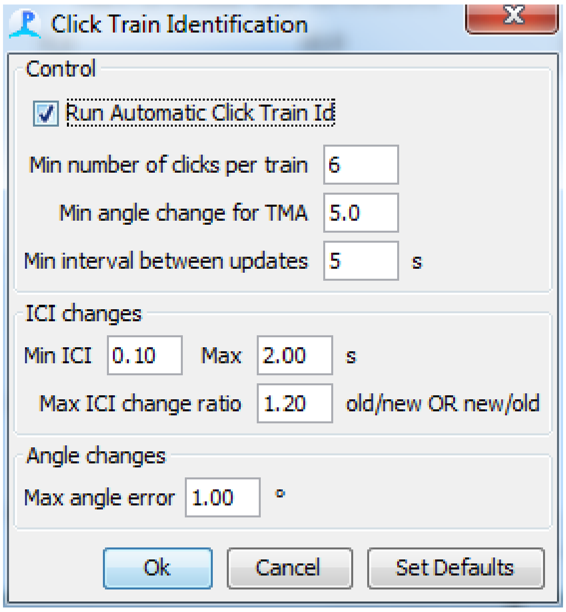


Figure 10. *Click Train Identification Dialog*

Click on the *Run Automatic Click Train Id* check box and select *OK*.

Note that access to the same dialog is also possible by selecting

Settings ⇒ "Click Detector Name" ⇒ Click Train Identification

from the main menu – where ***"Click Detector Name"*** is the name given to the particular Click Detector module running. For this exercise this will be "Click Detector 1".

Now look at the Bearing Time display. Identified click trains are indicated by coloured ellipses, as in the Figure 11.

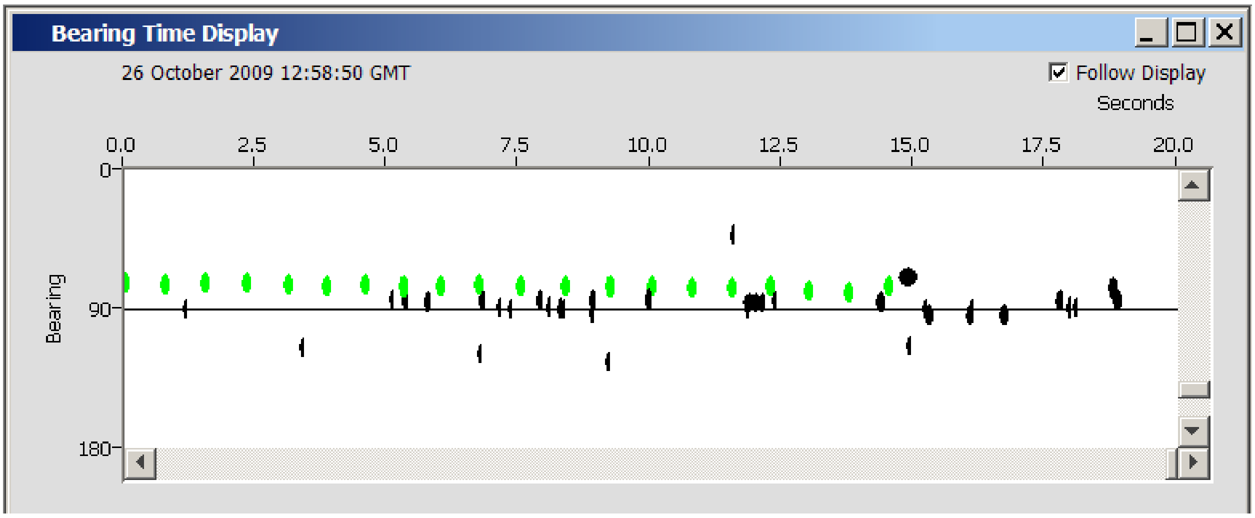


Figure 11. ***Click trains plotted on the bearing time display***

Now switch to the map view.

Position the mouse somewhere on the blue map area and press the right mouse button to display the drop-down detector selection box and make sure that "Tracked Clicks" is selected.

If a click train reaches sufficient length and the bearing change is adequate, target motion analysis automatically calculates a range and bearing to the sound source. The first and last bearing lines associated with this click train sequence are also automatically displayed on the map. An example is shown in Figure 12.

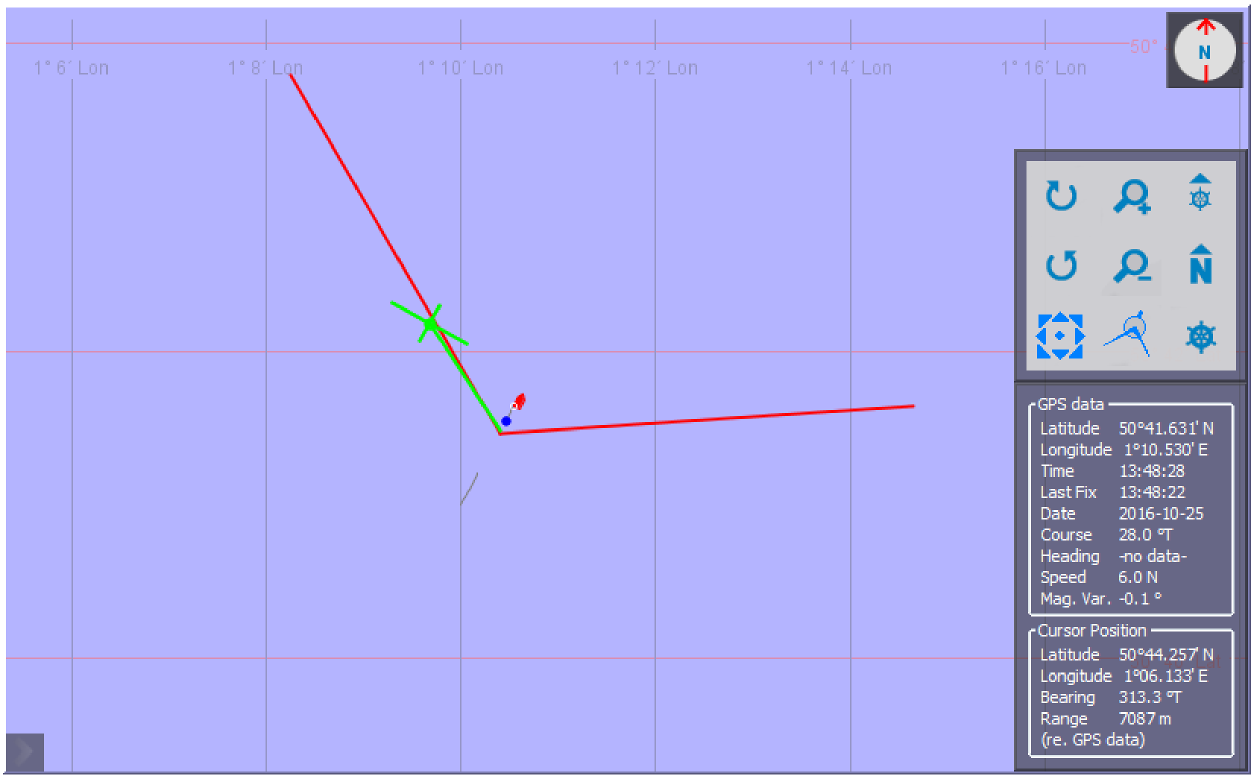


Figure 12. ***Click Train range estimates drawn on the map***

Note that the lines terminate at the point of bisection, indicating the range estimate. Now hover the mouse cursor over this point and observe the Vessel-cursor range and bearing on the map information panel.

Take some time to experiment with the Click Detector and map views.

Try the program with the file “SpermSurvey.wav”, a recording made in the course of a real seismic survey from a survey vessel of Australia.

Click on the Pause button (▌▌) in the toolbar to stop the detector.

Think about the advantages and disadvantages of automatic detection compared to manual detection of click trains and other events.

Exercise 4. Adding a Spectrogram Display

Detections can be viewed in a number of PAMGuard graphics modules. For this exercise you will firstly use a Spectrogram Display. Spectrogram Displays are placed on a generic User Display panel, so first of all you have to add a User Display panel to PAMGuard. To add the new User Display panel, you will now use the Data Model display. Select ***File ⇒ Show data model***… from the main menu. This will open the Data Model display window.

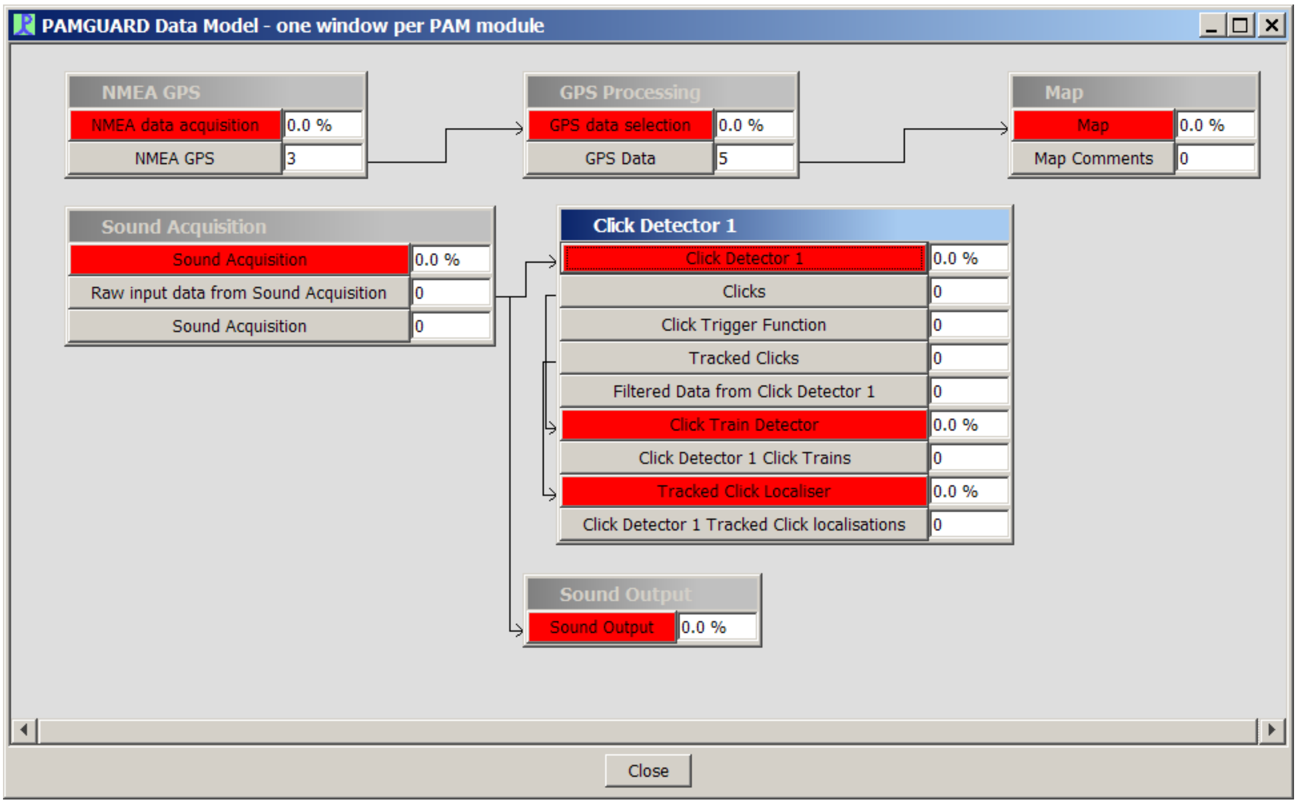


Figure 13. ***The PAMGuard Data Model window***

Place your cursor anywhere on an empty space on the data model display area and, clicking the right mouse button, select ***Add Modules… ⇒Display⇒ User Display*** from the drop-down menus. Enter "User Display 1" as the name of your panel in the new module dialog and click OK. Note that the User Display module does not appear as part of the data model. This is because the user display cannot receive or produce data, and acts merely as a canvas for other displays. Click *Close* at the bottom of the Data Model display window.

To add the Spectrogram Display to the new User Display panel, select the User Display tab on the tab panel selector. Notice the main menu items change as you select the various tabs. Select **User *Display ⇒ New Spectrogram***… from the main menu. The spectrogram display requires spectrogram data in order to work, so the following dialog will appear:

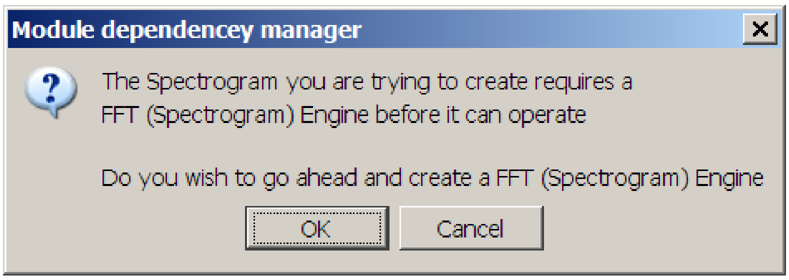


Figure 14. ***FFT Engine creation dialog***

Click Ok to create the FFT module and Ok again to set the module name (or enter a different one).

The Spectrogram configuration dialog will then appear:

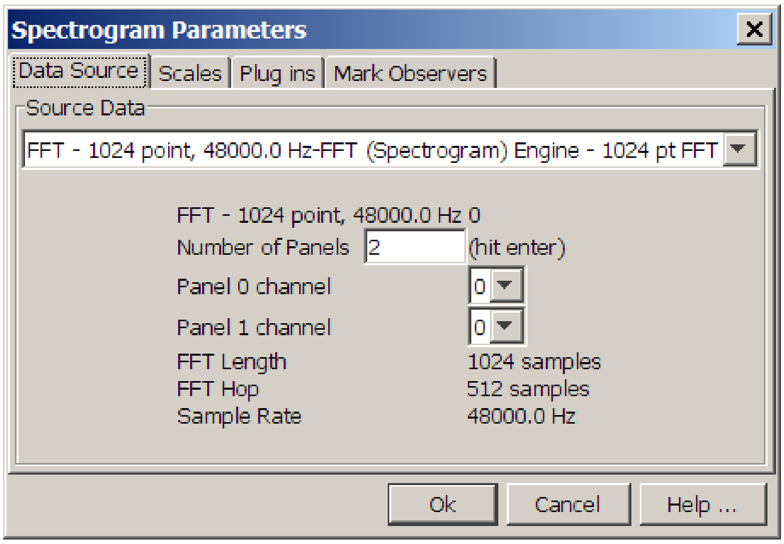


Figure 15. ***Spectrogram configuration dialog*.**

Enter “2” in the number of panels box. Hit the *Enter* key on the keyboard to confirm the value and select channel 0 and 1 from the two channel selection drop-down lists. Click *OK* and the new Spectrogram Display will appear on the ***User Display 1*** panel. Expand the spectrogram window to fill the entire User Display pane. The FFT Engine will appear in the model view (Figure 13) connected to the sound acquisition module.

Start the detectors again and you will see a spectrogram scrolling across the screen. Sperm whale clicks will appear as vertical lines along the display. You may wish to experiment with different FFT lengths and other parameters in the FFT Engine configuration dialog. The spectrogram configuration dialog shown in Figure 15 can be accessed by right clicking anywhere on the spectrogram display and selecting ‘Settings’.

Ex 4.1 Changing the scales

To change spectrogram time, frequency and amplitude scales, go back to the dialog (right click and chose “Settings …”) and go to the “Scales” tab (Figure 16. *Spectrogram Parameters*).

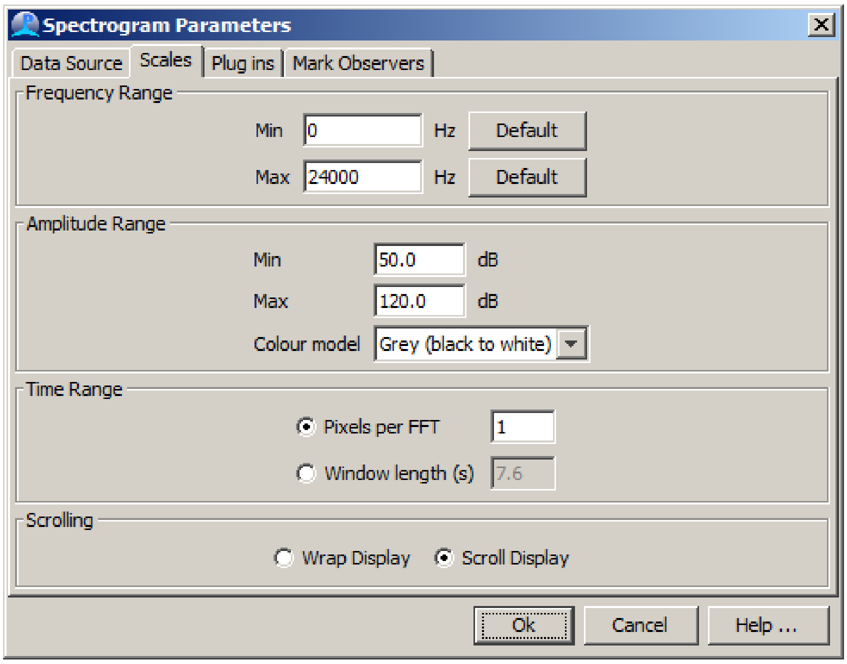


Figure 16. ***Spectrogram Parameters – Scales tab***

By default, the displayed frequency range will be from 0Hz to half the sample rate (refer back to the lectures and remember that we can only process sound data at frequencies up to half the sample rate of the data, so if the sample rate is 48 kHz, we can process sounds up to 24 kHz).

The amplitude range required to get a reasonable resolution on the amplitude (colour) scale will depend a bit on the hydrophone sensitivity and the amount of noise in the system. If you set the values too high or too low, then you may end up with a completely black or completely white display since many of the values to be displayed will be outside the range you have specified. You can change the display colours – but while the coloured spectrogram might look nice, it will be harder to see the detections which are drawn on top of the display once we start to add detection data in later exercises.

By default, it's best to use a single pixel of the display for each FFT slice in time. For a 512 point FFT and a 48kHz sample rate, this generally means less than 10s of data per screen. Increasing the time range beyond this will force the software to compress the spectrogram image and short transient sounds may no longer be visible.

In the latest PAMGuard version (V1.12 or later), you can chose to scroll or wrap the spectrogram. Scrolling looks better, but if you're using a module which requires you to mark or select parts of the spectrogram with the mouse, then it's almost impossible to mark the right bit when it's scrolling, so the wrapping option is easier to use.

Ex 4.2 Add plug in displays to the spectrogram

Many PAMGuard modules have plug in displays which attach to the bottom of the spectrogram displays. Right click on the spectrogram to access the spectrogram configuration dialog. Go to the 'Plug ins' Tab (Figure 17) and select one or two of the available plug in displays. Start detection and you will see additional display units at the bottom of the spectrogram display. Some plug ins have additional options which can be accessed by right clicking on specific plug in panels.

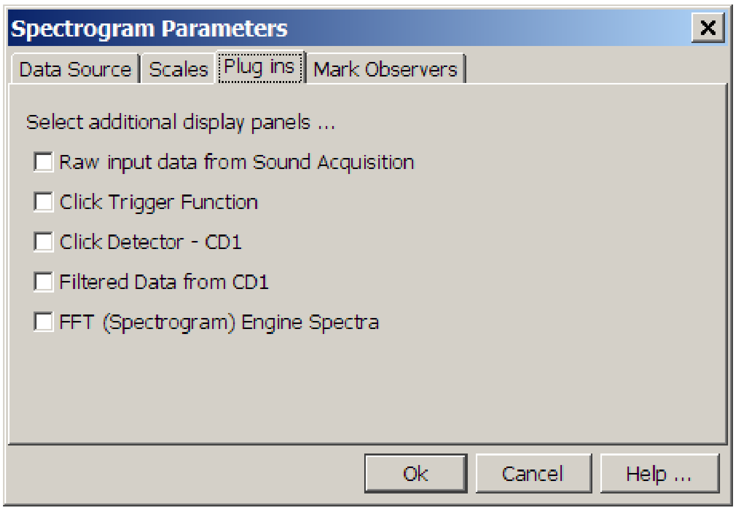


Figure 17. *Spectrogram plug ins configuration*.

Exercise 5. Detecting Whistles

PAMGuard contains two different detectors that can be used to detect Whistles – tonal calls from a variety of Odontocete species. The first is called simply the "Whistle Detector" and the second the "Whistle and Moan Detector". The Whistle and Moan detector is a lot better than the older Whistle detector at detecting calls, so you should always use that one. We've left the older module in though, just in case anyone has it set up perfectly for a particular purpose and doesn't want to change it.

As its name implies, the Whistle and Moan detector can be used to detect both odontocete whistles, which are generally at frequencies of between a couple of kHz and the low 10's of kHz and also low frequency moans from baleen whales.

Ex 5.1 Configure PAMGuard

Start from the settings file used for click detection 'PamTutorial1.psf'. The module will already have the click detector in it, but that's OK – PAMGuard can run multiple detectors at the same time.

First, ensure that Detection mode is not active (hit Pause button to stop).

Load the sound file "whistles.wav" (See exercise 1.4).

Next, we will add a Whistle and Moan Detector module to PAMGuard. Select ***File ⇒ Add Modules…⇒ Detectors ⇒ Whistle and Moan Detector*** from the main menu.

Whistle detector modules require spectrogram data to work. FFT modules provide spectrogram data and PAMGuard knows whether or not FFT data producing modules are present. The following dialog will appear if an FFT module is not already included in the configuration:

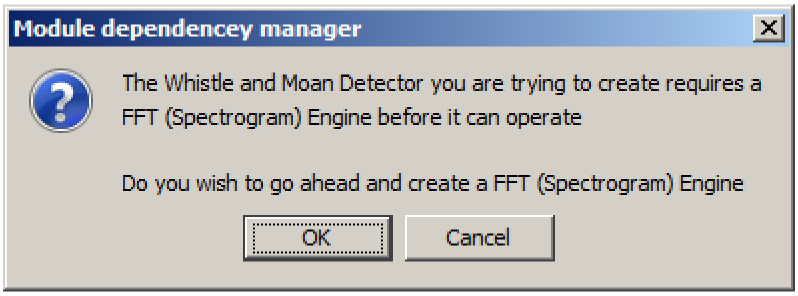


Figure 18. ***FFT Engine creation dialog***

Click *OK*. A new dialog will appear asking you to name the FFT Engine module. In this dialog, enter ***FFT1*** as the name for the new FFT Engine and click OK.

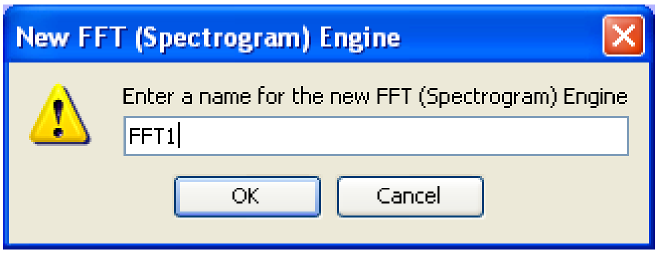


Figure 19. ***Naming the FFT Engine module***

It will then ask the name of the new Whistle and Moan detector:

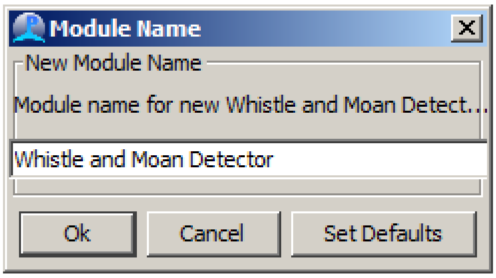


Figure 20. ***Naming the Whistle and Moan Detector module***

Click OK (or change the name if you want to !).

Ex 5.2 Configure the FFT

Next you need to configure the FFT module so that it's providing exactly the right type of data to the Whistle and Moan Detector. It needs to be set up quite carefully for the Whislte and Moan detector to operate correctly.

From the Settings menu, select ***Settings ⇒ FFT1 Settings*** and the following dialog will appear:

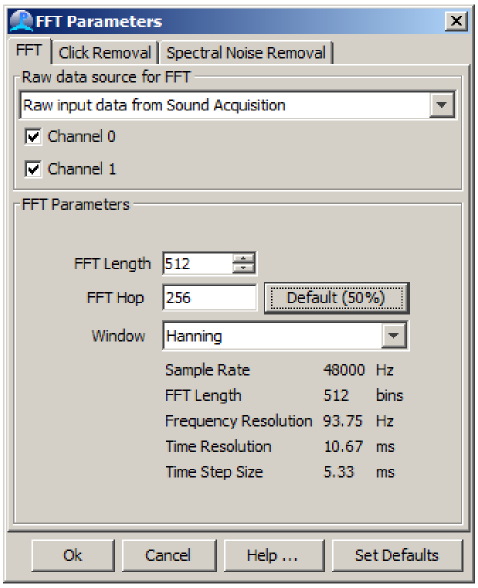


Figure 21. ***FFT Parameters Window***

On the first tab, make sure that it's connected to the correct sound source (Raw input data from Sound Acquisition), that both channels are selected and that the FFT length is set to 512 points and the FFT hop to 256 points (when you adjust the FFT length and hop, note how the Freqeuncy and Time resolution values change !).

Next, you need to set up some noise reduction methods, which operate on the Spectrogram data before it can be used to detect the sounds. On the other two tabs, select everything !

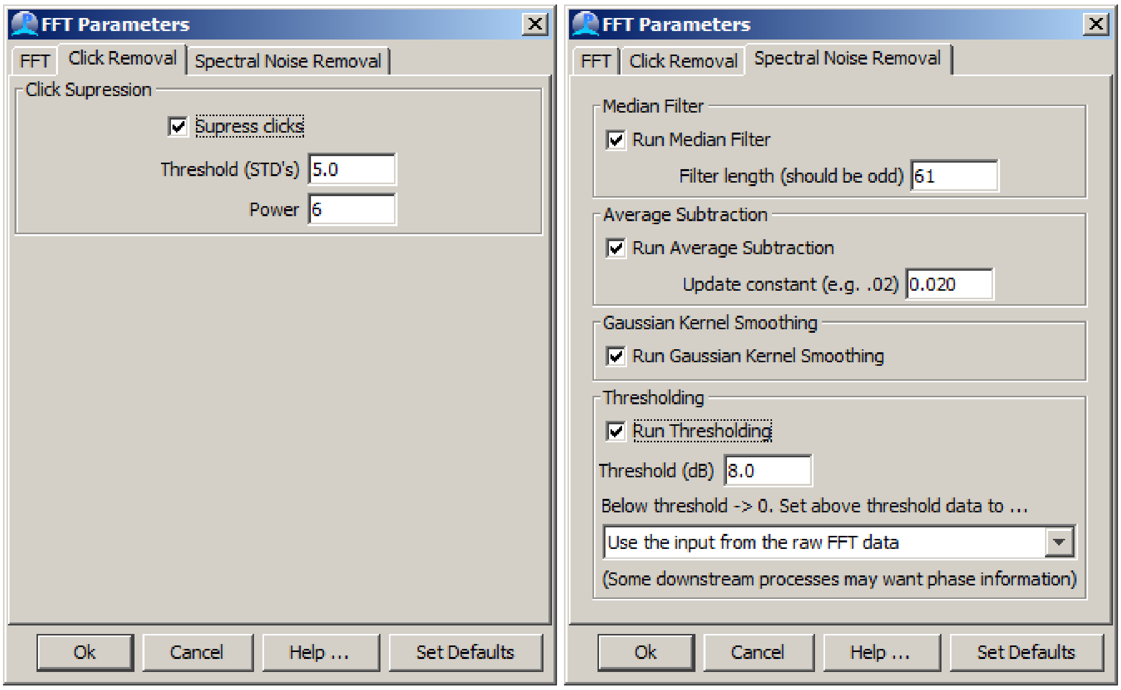


Figure 22. ***FFT Parameters – Noise Reduction tabs***

Once you've done this, you can hit *OK* to close this FFT dialog and proceed to setting up the Whistle Moan detector itself.

From the Settings menu, select ***Settings ⇒ Whistle and Moan Detector***.

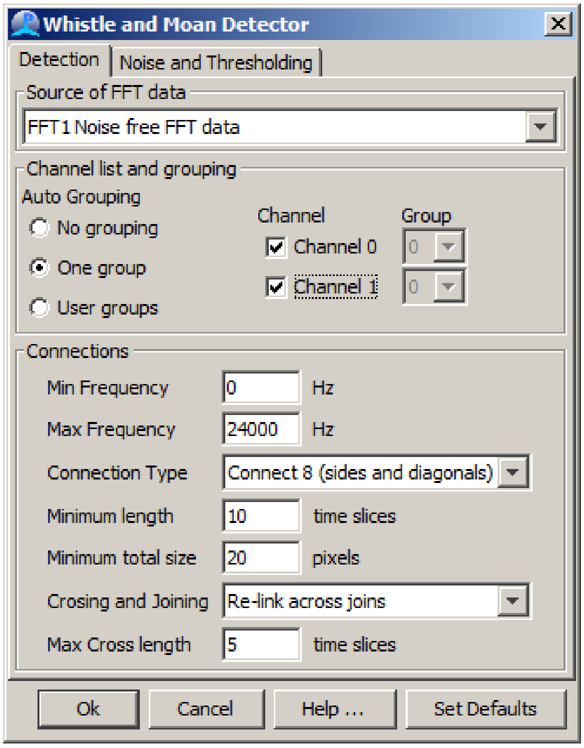


Figure 23. *Whistle and Moan Detector Settings window*

There are several things you'll need to change on this dialog.

First set the source of FFT data to be "FFT1 Noise free FFT data". This is the FFT data utilizing the noise reduction methods set in the previous step. Selecting simply FFT1 (or *FFT Spectrogram Engine* in some versions of PAMGuard) would force the Whistle and Moan Detector to use the raw FFT data, prior to any noise reduction.

Select one channel group, and include both channels in that group (for more on channel grouping and how channel groups are used to measure bearings to detected sounds, see the help file).

Set the Max frequency to 24000Hz (24kHz).

And click Ok to save the configuration.

Now that you have changed the PAMGuard model configuration, click

File ⇒ Save configuration as*…* and save the configuration as "clickAndWhistleDetectors.psf"**.** Close down PAMGuard **(*File ⇒ Exit*)** and re-launch the application. Choose "**clickAndWhistleDetectors.psf**" from the ***Load PAMGuard configuration from****…* dialog and click *OK*.

> Note: This closing down operation is not necessary for PAMGUARD to operate with the new configuration – it's just to give you practice!

Ex 5.3 Viewing whistle detections

You've probably already got a Spectrogram display from Exercise 4. If not, go back to Exercise 4 and add one now.

Start detection by pressing the Record button () and the two spectrogram panels will show the spectrogram data in real time.

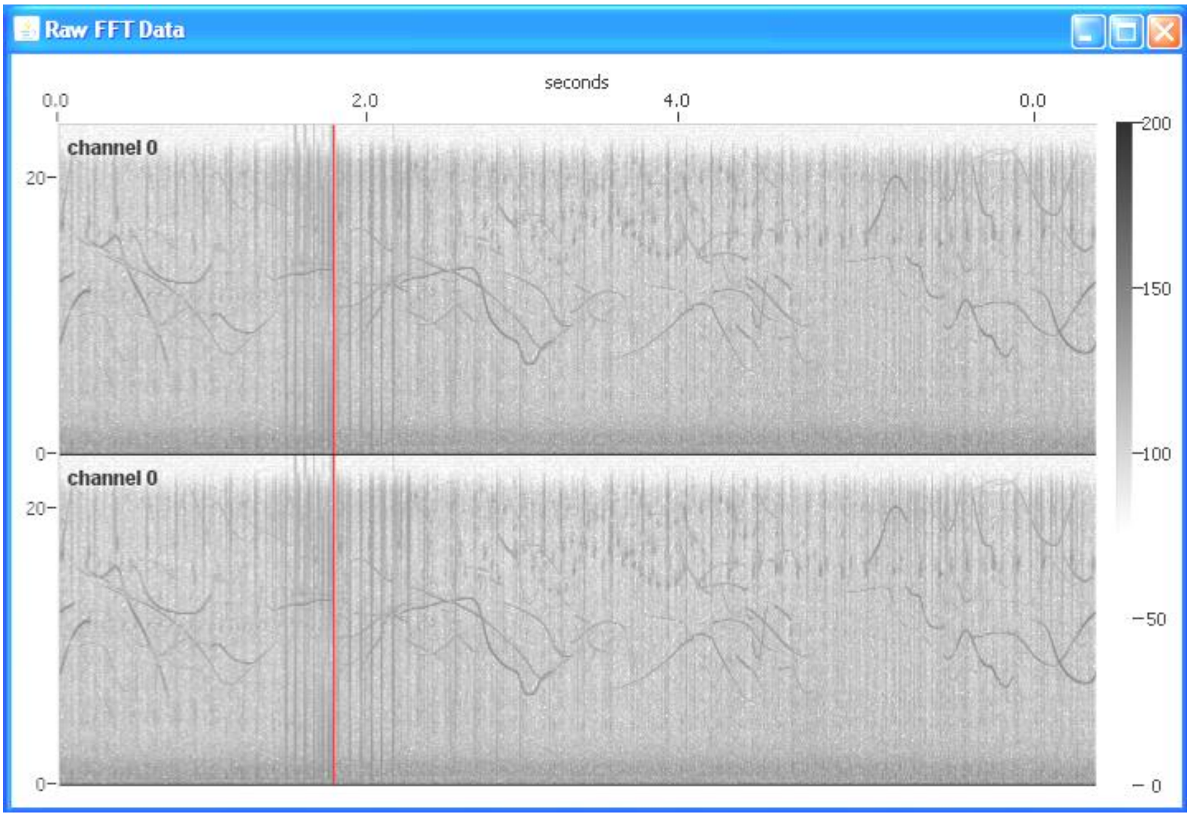


Figure 24. ***A Spectrogram panel display***

To view the whistle contours on the display, right click anywhere on the spectrogram and select “Whistle and Moan Detector Connected Regions”.

Run the detector again and you should get something looking like this:

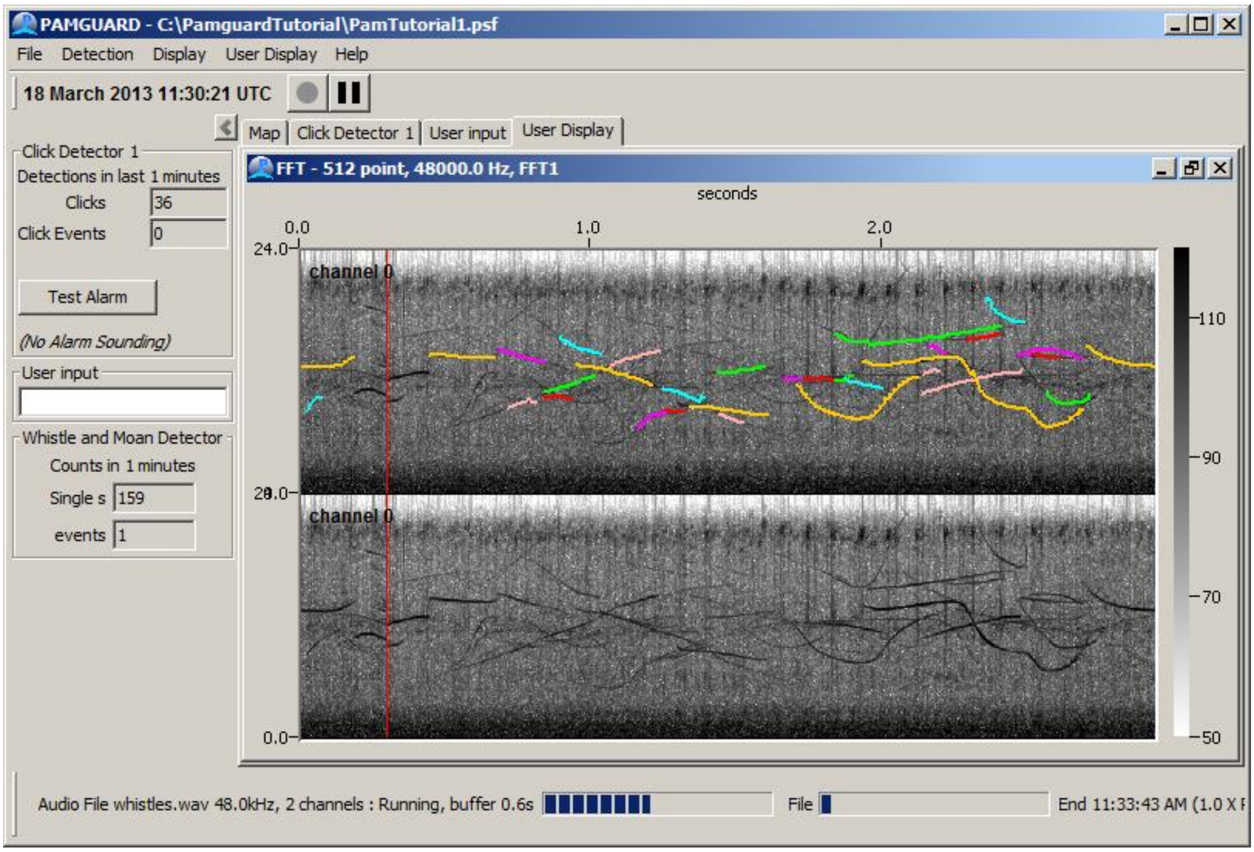


Figure 25. ***Spectrogram Display with Whistle and Moan Detector contours***

Exercise 6. Mysticete Detection

This set of exercises will demonstrate three different detectors which have been ported to PAMGuard from Dave Mellingers Ishmael software.

1. Energy sum
2. Spectrogram Correlation
3. Matched Filtering

The energy sum detector takes a spectrogram and sums the energy in a given frequency band. It's sensitive to any sounds in that frequency band and would not, for example, be able to tell the difference between an upsweep and a downsweep. Energy sum detectors are extremely simple, but are good for making a first pass through a data set, highlighting areas that deserve closer scrutiny. (Low Processor Gain)

Spectrogram correlation also uses the output of a spectrogram, but rather than simply adding the energy in a given frequency band, the spectrogram 'image' is convolved with (multiplied by) a spectrogram image of a sample sound. The closer the match of the image to the sample sound, the higher the detector output. Spectrogram correlation detectors should be able to tell the difference between an upsweep and a downsweep. (Moderate Processor Gain)

A matched filter uses the raw data, which is convolved by a template of a sample sound. The better the match of the sample sound, the higher the detector output. Matched filters are in fact the optimal solution for the detection of a known signal in random (Gaussian noise). However, if the template is not an exact match, they perform poorly. (High processor gain).

To start this series of exercises, exit PAMGuard, then restart it and load up the configuration file PamTutorial2.psf. This contains a basic configuration containing a sound acquisition module (which will read the sound files), FFT Engine and a spectrogram display. During the exercises you will add the three detectors and then run them on a variety of sounds.

All exercises start by using the file Blue Whale-Atlantic.wav file. This should be automatically loaded when you start the PamTutorial2.psf configuration. PAMGuard can analyse this low frequency sample file extremely quickly. To slow it down, so that you can see what's going on on the screen, a playback module has been included in the configuration which plays the sounds at 2000Hz – 20 times real time for the 100Hz sample file.

Ex 6.1 Energy Sum Detector

From the ***File ⇒ Add Modules…⇒ Detectors*** menu, add an **Ishmael energy Sum detector**. Accept the default name. From the ***Settings ⇒ Energy Sum settings*** menu item, configure the module as shown in Figure 26.

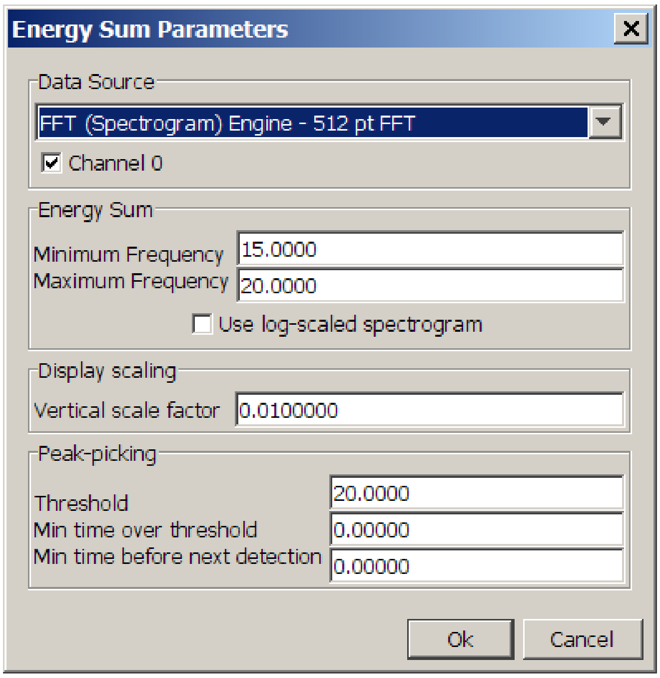


Figure 26. *Energy sum configuration dialog*.

From the spectrogram plug-in options (right click on the spectrogram display, select Settings and navigate to the Plug-Ins tab), select the 'Ishmael energy Sum Graphics' and start detection. You should see the detector output displayed below the spectrogram as shown in Figure 27.

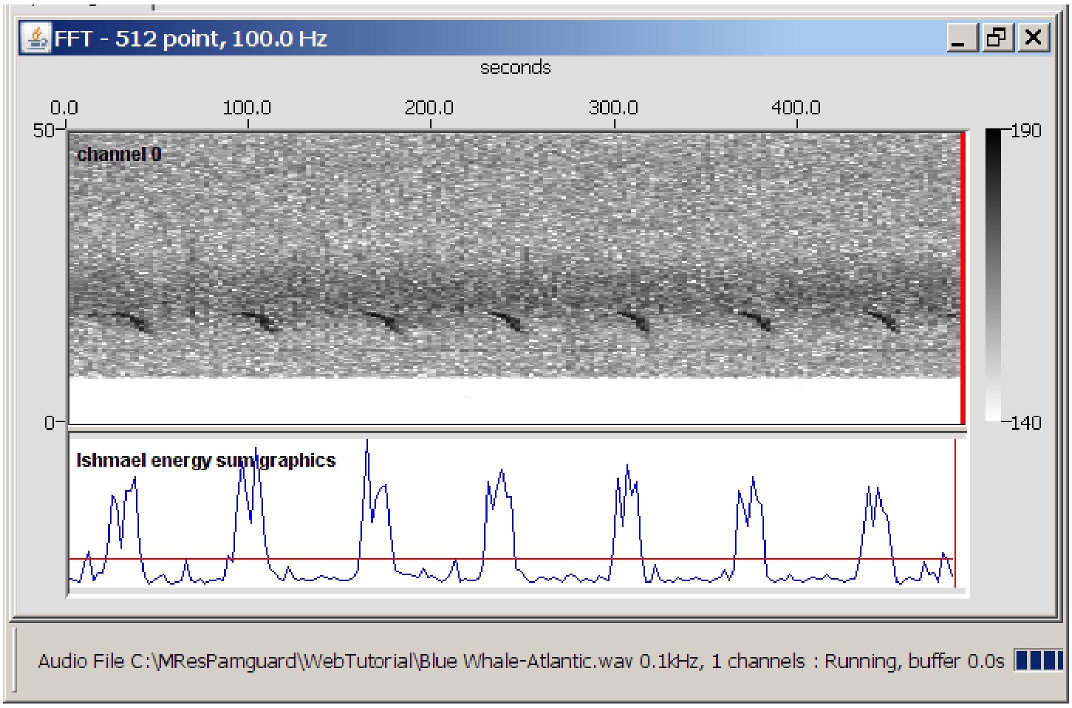


Figure 27. *Blue whale calls and Ishmael Energy sum detector output*.

Ex 6.2 Spectrogram Correlation Detector

From the ***File ⇒ Add Modules…⇒ Detectors*** menu, add an **Ishmael Spectrogram Correlation detector**. From the settings menu, configure the module as shown in Figure 28.

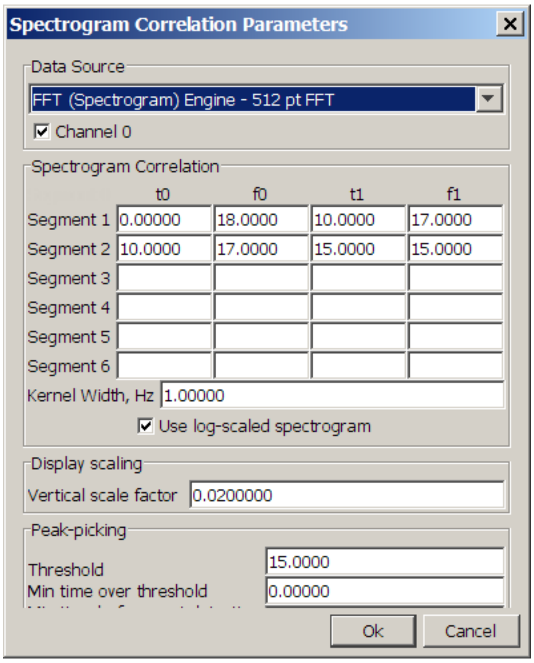


Figure 28. *Spectrogram Correlation configuration dialog*.

Select the appropriate plug in for the spectrogram display and run the detector again (Figure 29).

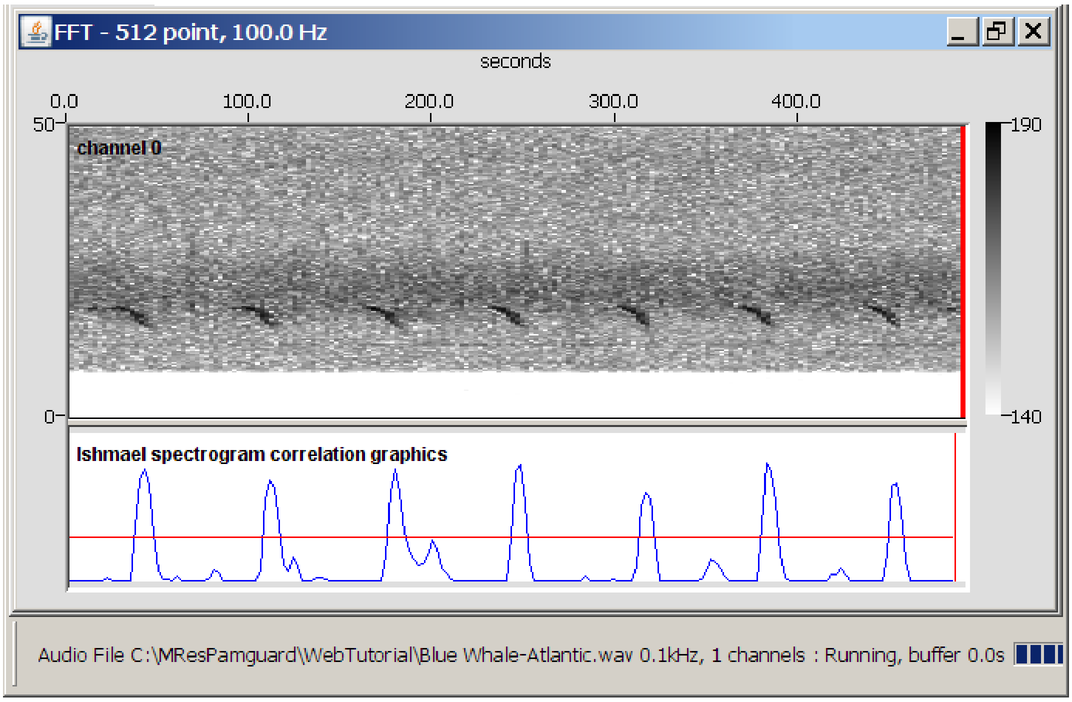


Figure 29. ***Blue whale calls and Ishmael Spectrogram Correlation detector output*.**

Ex 6.3 Ishmael Matched Filter detector.

From the ***File ⇒ Add Modules…⇒ Detectors*** menu, add an **Ishmael Matched Filtering detector**. From the settings menu, configure the module as shown in Figure 30. Note that the name of the kernel sound file is blueTemplate.wav and is included with the tutorial dataset.

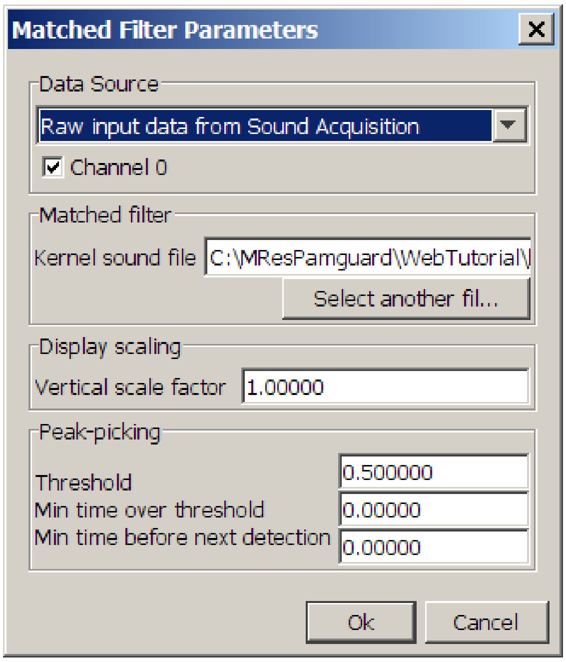


Figure 30. ***Matched Filter configuration dialog*.**

Select the appropriate plug in for the spectrogram display and run the detector again (Figure 31). The output of the detector is a number varying between 0 and 1. Note that the peak detector output corresponding to the second call reaches this value. This is because the template for the matched filter was taken from this second call, so the match is perfect !

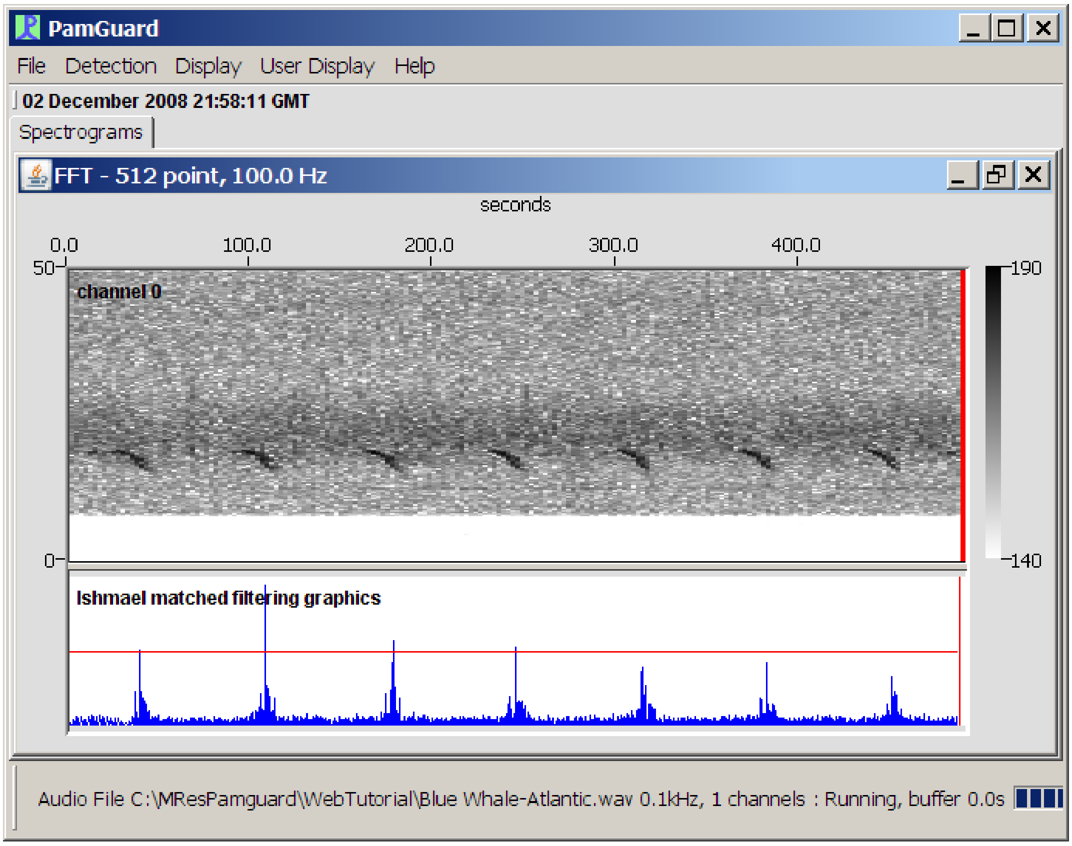


Figure 31. ***whale calls and Ishmael Matched Filter detector output***

Ex 6.4 Compare the three detectors

You should easily be able to run all three detectors simultaneously and display the plug ins for each at the bottom of the spectrogram. Which detector is best ? The answer is that it's impossible to say unless you test them with multiple sound files containing both blue whale calls and a variety of noise sources, count the number of false detections and the number of missed detections for varying detection thresholds and create ROC curves for the three detectors.

Ex 6.5 Set up the detectors for different species

Try the detectors with some of the other blue whale and humpback sound files. Try to reconfigure the energy sum and spectrogram correlation detectors for some of the other sounds files. You will be able to test the matched filter on other sound files, but will not be able to reconfigure it since the creation of a suitable template file is beyond the scope of this tutorial.

Try to configure energy sum and spectrogram correlation detectors for some of the sperm whale and whistle files in the tutorial dataset.

Exercise 7. Use the Whistle and Moan Detector to detect Baleen whale calls.

Go back to one of the configurations you were using to detect Baleen whale sounds with the Ishmael detectors and try to set up the Whistle and Moan detector to find these sounds as well.

Exercise 8. Advanced display features

There are more display types available in PAMGuard which will be explored here.

Ex 8.1 Adding further displays to Spectrogram Panels

It is often useful to view multiple data and detection types simultaneously. For example, various detector modules active in PAMGuard can draw detections on the Spectrogram panels. While detection is running, right-click over a spectrogram panel and choose "Clicks". Detected clicks will now be plotted on the panel as red circles or black/white triangles (depending on the version of PAMGuard) on the top of the plot.

In addition, plots can be added to the bottom of the Spectrogram panel. Right-click over the spectrogram display and choose *Settings…* from the menu. Now click on the ***Plug-in*** tab. Select additional plug-in display panels by clicking on the check boxes for ***Raw input data from Sound1*** and ***Click Detector ⇒ Click Detector 1*. Click *OK*.**

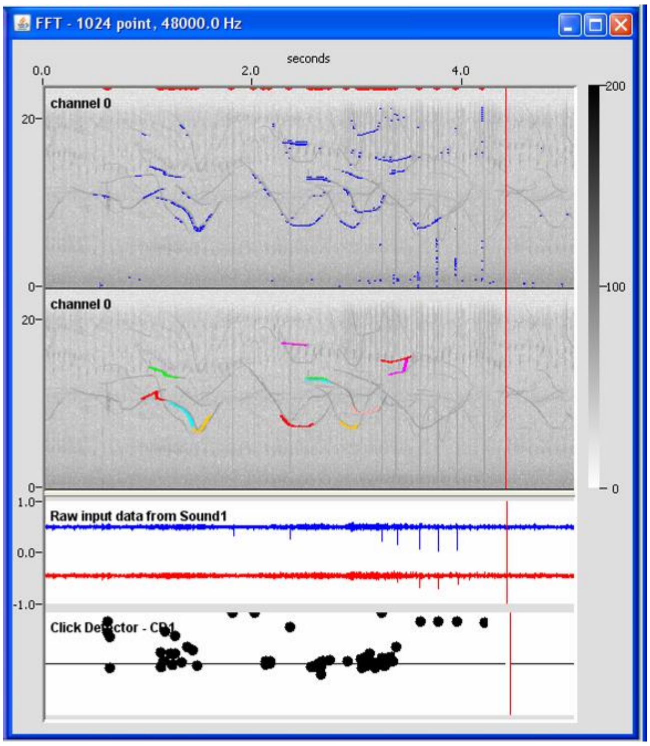


Figure 32. *Raw data and Click Detector plugin panels added to a spectrogram display*

As illustrated in the figure above, the raw sound waveforms are plotted and also a compact version of the Click Detector display is shown.

Ex 8.2 Adding a Radar Display to the User Display panel

We will now add a "Radar" type display to the User Display. Radar display windows can be used to display range, amplitude and bearing information to detected sounds. To add the Radar Display to the User Display panel ***User Display 1*,** select **the *User Display 1*** tab on the tab panel selector. Select ***User Display ⇒ New Radar display****…* from the main menu.

Since many detectors, particularly those using simple linear hydrophones, produce ambiguous bearing information, it is possible to display either the full display or only one half of the display. We will display a half display called *RD1*, so type in the name and select ***Right half only*** from the Style option drop-down list. Hit *OK*. Once the Radar Display is on User Display 1, select, ***User Display ⇒ Arrange Windows… ⇒ Tile Vertical*** from the main menu. The display should look something like Figure 25.

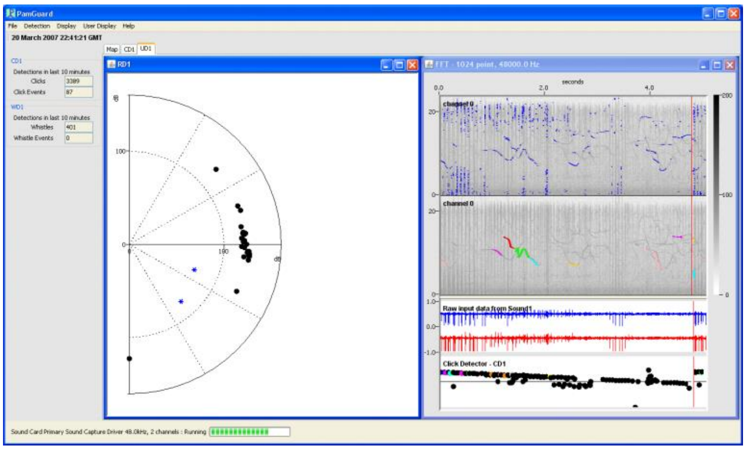


Figure 33. ***A Radar display added to the User Display Panel***

Right-click over RD1 and choose **Settings**. Navigate to the Detectors tab (Figure 34).

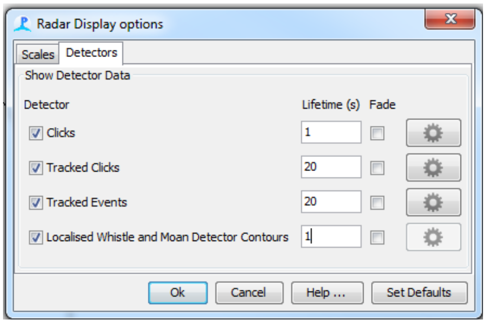


Figure 34. ***Detector selection and lifetime settings for Radar Display***

Click ***OK***. This will set the radar plot to display Clicks, Tracked Clicks/Events and Whistle detections for 1, 20 and 1 seconds respectively. If no detections are displayed, then individual settings may need to be changed. Click on the gear buttons located beside each Detector and make sure the check boxes in the *Event Type* area are checked appropriately.

Experiment with the plot settings and, when you have finished, hit the Pause button ( ) in the tool bar in preparation for the next exercise.

Exercise 9. Detection during seismic source operation

Ex 9.1 Loading the sound file

First load the sound file “spermWhalesPlusSeismic.wav”.

This is a recording of sperm whale vocalisations taken during an active seismic survey. The presence of a significant sound source, such as firing air guns has implications for the operation of detection algorithms.

You will notice an artefact on the central axis (indicting no time delay between channels). This is noise picked up after the seismic pulse which has been gated out.

Here we will investigate changing the Click Detector settings in an effort to reduce the adverse effects of the unwanted noise.

Select ***Detection ⇒ Click Detector 1 ⇒ Detection Parameters****…* from the main menu. Click on the Set defaults button to restore the detectors settings to their default values. Start Detection (Record button) and observe the Click Detector tab panel displays. You should see something like this:

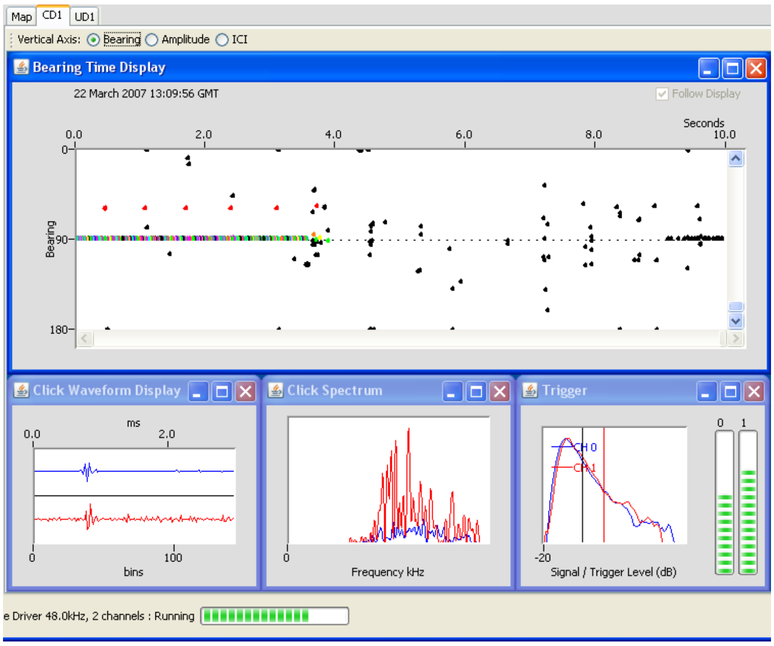


Figure 35. ***Click Detector display example for noisy seismic data***

Notice the rapid click detections associated with the electrical noise on the 90° bearing.

Ex 9.2 Adjusting click detection parameters

Right click on the ***Click Detector Bearing Time Display*** and select 'Amplitude/Time' This changes the Y-axis of the plot to represent the amplitude of detected clicks. Notice that the rapid clicks consistently appear at lower amplitude to the majority of the rest of the click detections (Figure 36). If all of the clicks appear at the top of the display, you may need to adjust your computer's mixer settings to reduce the amplitude of the captured sound. You can also adjust the amplitude scaling of the display by right clicking and invoking the settings dialog (Figure 37).

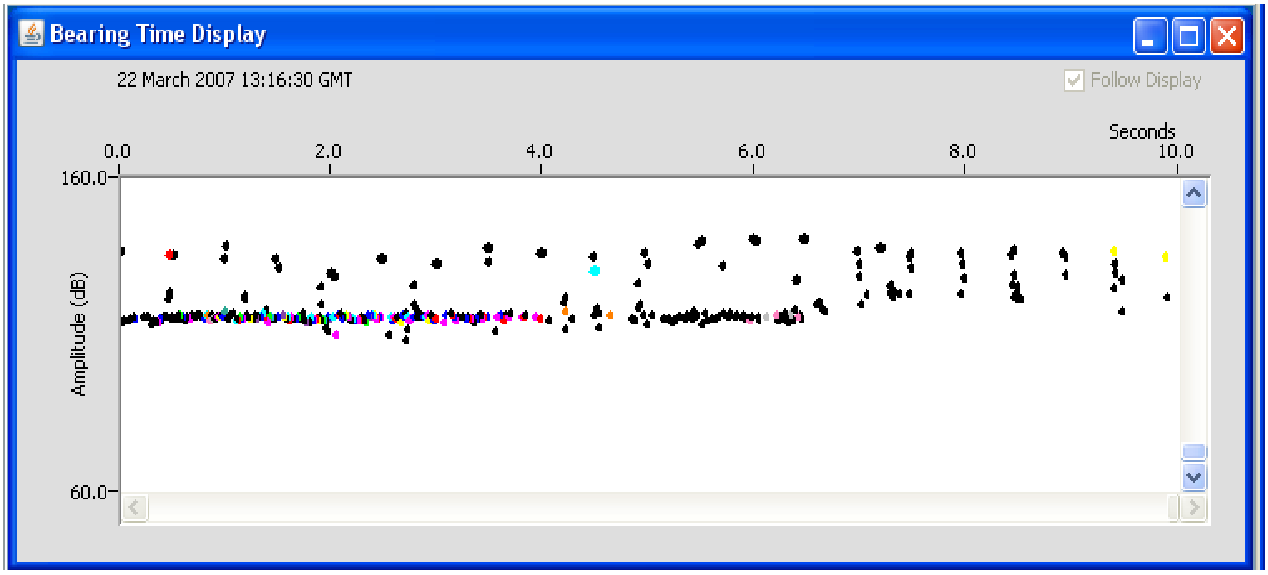


Figure 36. ***Plotting click amplitude versus time***

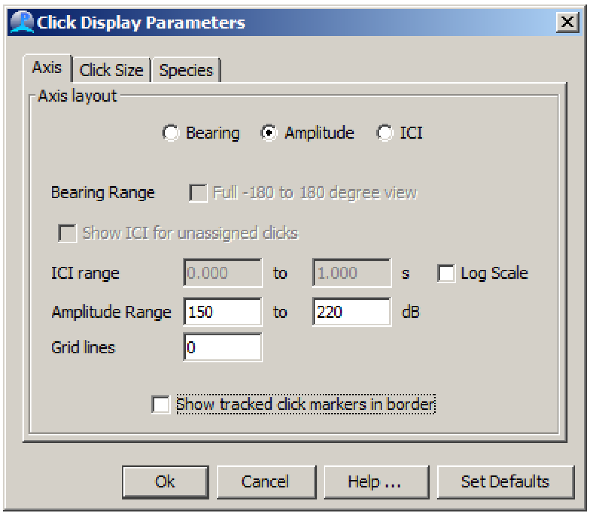


Figure 37. ***Adjusting the amplitude scaling for the Click Detector Amplitude display***

We will now adjust the click trigger threshold such that the Click Detector will not trigger for these lower amplitude clicks. Again select ***Settings ⇒ Click Detector 1 ⇒ Detection Parameters…*** from the main menu. This time, increase the *Threshold* setting above the default setting of 10.0 dB. This will increase the level above the measured background which must be exceeded by clicks to become detection candidates.

Click ***OK*** and observe the Click Detector display. Wait for the algorithm to settle down with the new settings (up to 10 seconds).

If your setting is too high, then genuine clicks may not be exceeding the threshold and the click display will look rather sparse. If the setting is too low, you will still be seeing the interference clicks. Experiment with this setting until you are happy with the results.

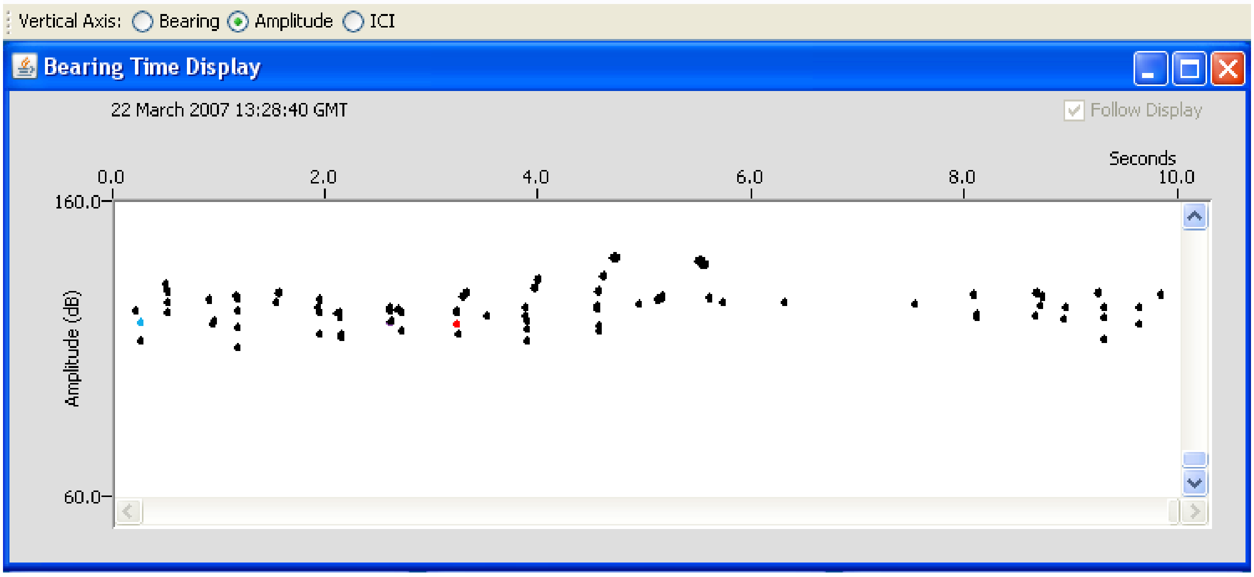


Figure 30. ***Results of adjusting Click Detector trigger threshold***

Exercise 10. Don't stop now!

This tutorial has given you a brief introduction to setting up and using PAMGuard. There are more PAMGuard plug-ins and features for you to try out.

Here's some ideas to get you going:

- Set up a Sound Recorder module and trigger recordings from click trains.
- Use a decimator to provide lower sample rate data to a second spectrogram.
- Display smoothed spectral data on a spectrogram.

Try these out with the other example sound data files.

The PAMGuard developers are keen to know what you think of the software, so any comments (good or bad!) are very welcome. Also, if you think this tutorial can be improved in any way, please let us know at feedback@PAMGuard.org.

Thanks for taking the time to do this tutorial. Hopefully you've enjoyed this and learned some more about PAMGuard. You can contact us and keep up with PAMGuard news through visiting www.PAMGuard.org.