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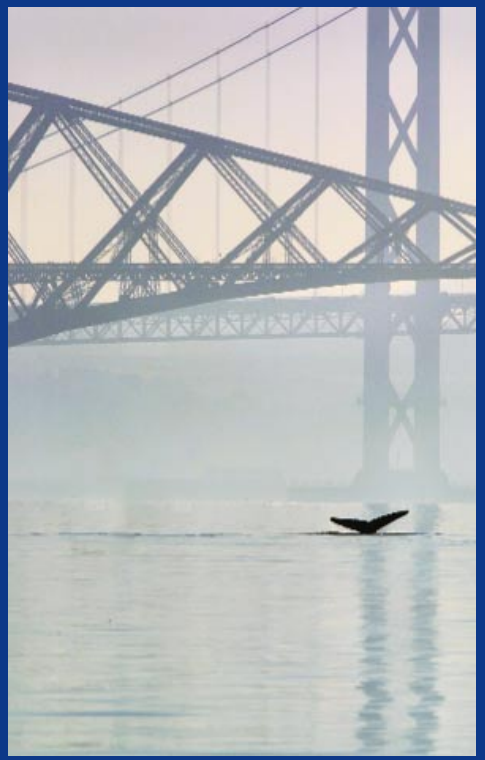

Forth Estuary, Scotland

Monitoring of Marine Mammals: PAM and PamGuard Software

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Ocean Systems Laboratory

Electrical Electronic and Computer Engineering

School of Engineering and Physical Sciences

Heriot-Watt University

Edinburgh

(a) Monitoring of Marine Mammals for Research and Mitigation

Visual versus passive acoustic
PAM for operational Mitigation and Research

(b) PamGuard software

Where did it evolve from?
What does it do?
The Technical bit: Introduction to the software infrastructure
"Open-source" so how do I get PamGuard?
The future?

The PamGuard Team and acknowledgements

(a) Monitoring of Marine Mammals for Research and Mitigation

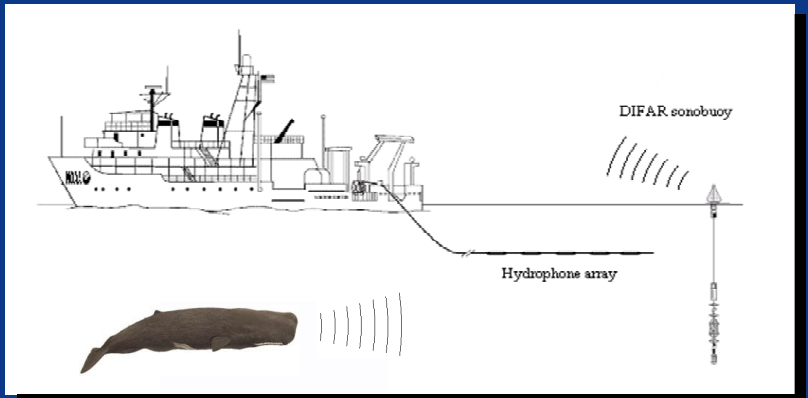
Marine mammal studies are traditionally done visually

- *Cetaceans are hard to spot even in the best conditions*
- *Some spend long periods submerged*
- *Need to monitor day & night*

(a) Monitoring of Marine Mammals for Research and Mitigation

Acoustic monitoring methods are now becoming common

- *From a ship using a towed array or sonobuoy*
- *From fixed hydrophones – either cabled or autonomous*



Detection of marine mammal vocalisations

(a) Monitoring of Marine Mammals for Research and Mitigation

Acoustic monitoring methods are now becoming common

Advantages

- *Monitor 24 hours a day in poor visibility*
- *Acoustic detection distance can be ≥ than visual range*
- *Acoustic detection can be less tiring and onerous*
- *Permanent record & auditable*

(a) Monitoring of Marine Mammals for Research and Mitigation

Acoustic monitoring methods are now becoming common

Advantages

- *Monitor 24 hours a day in poor visibility*
- *Acoustic detection distance can be ≥ than visual range*
- *Acoustic detection can be less tiring and onerous*
- *Permanent record & auditable*

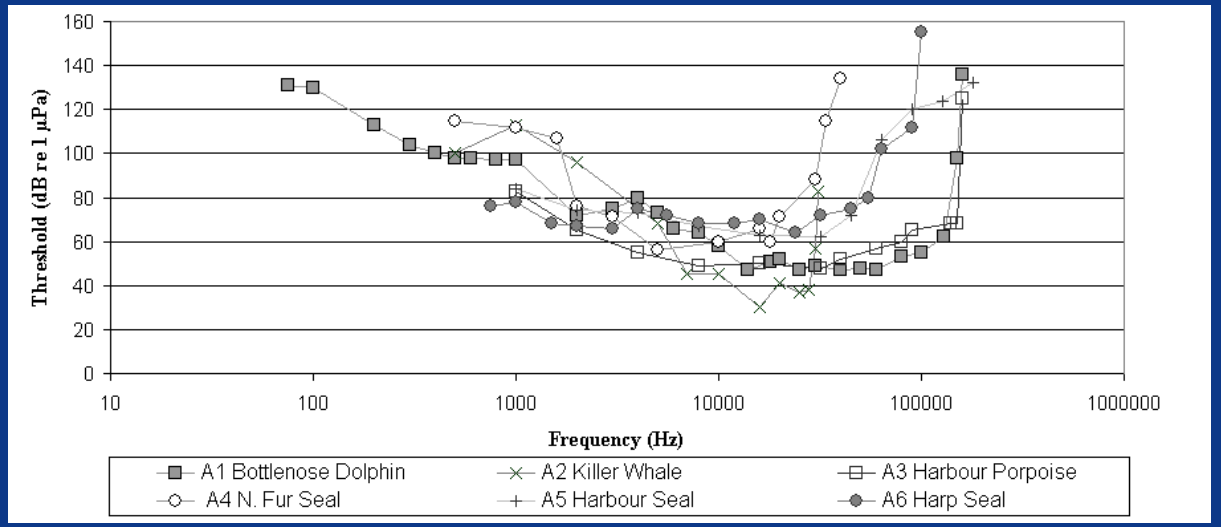
Disadvantages

- *Some species rarely vocalise*
- *Noisy vessels can mask vocalisations/ affect range capability*
- *Anthropogenic noise may affect vocal behaviour*
- *Array limitations including ambiguities and accuracy issues*

(a) Monitoring of Marine Mammals for Research and Mitigation

Cetaceans come in all sizes & make a broad range of vocalisations

- *Have to cover a variety of wide frequency ranges*
- *Click*
- *Tonal*



Marine mammal auditory thresholds (J Gordon)

(a) Monitoring of Marine Mammals for Research and Mitigation

PAM for survey and strategic mitigation

- *Presence/ absence – need a knowledge of species vocalisation types & behaviour*
- *Index of abundance – need to understand detection probabilities*
- *Density and abundance – detection probability a function of range*
- *Consistent detection probability most important*

(a) Monitoring of Marine Mammals for Research and Mitigation

Mitigation practices

Regulatory requirements vary between geographic areas

- *adopt a precautionary approach*
- *very species dependant*

Generic mitigation measures

- *soft - start or ramp-up source firing procedure*
- *exclusion or warning zones*
- *continual monitoring*

(a) Monitoring of Marine Mammals for Research and Mitigation

Mitigation monitoring – an ideal system (seismic air-gun example)

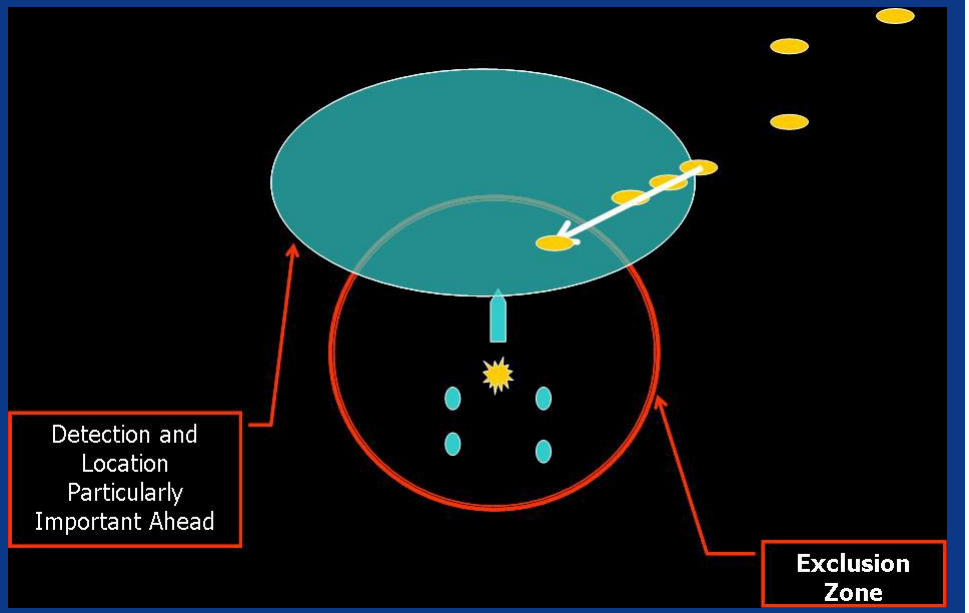
Aim –to reduce the risk of animal exposure to sound.

Continue for the duration of the operation

Location accuracy vitally important

Quantification and real-time prediction of detection efficiency is really important

Real time – detection/localisation



Main vessel/Guard vessel ?

(a) Monitoring of Marine Mammals for Research and Mitigation

Standards, standards, standards……

- *We need to have a consistent PAM performance*
- *Common reporting methods*
- *Regulators need to support PAM (or not) and be aware of its limitations*
- *PAM is a total system / PamGuard is a software package / PAM is only as good as the array to which it is attached*
- *Without standards will PAM ever really be a credible tool?*

(b) PamGuard software: Where did it evolve from?

There are of course a number of existing PAM software packages available (some of these are free)

For example:

IFAW suite

Ishmael

Cornell Labs (Raven) …. Military (MMADS) ….. etc

PamGuard can be thought of as a fusion of IFAW suite and Ishmael as it has all the key functionalities of these two software packages

(b) PamGuard software: What does it do?

*IFAW**

Click detectors (medium/high frequency)

Tonal (whistle) detectors

Interface/detection log/annotation/GPS

Calculates bearing/maps

*Ishmael**

Spectrogram viewer

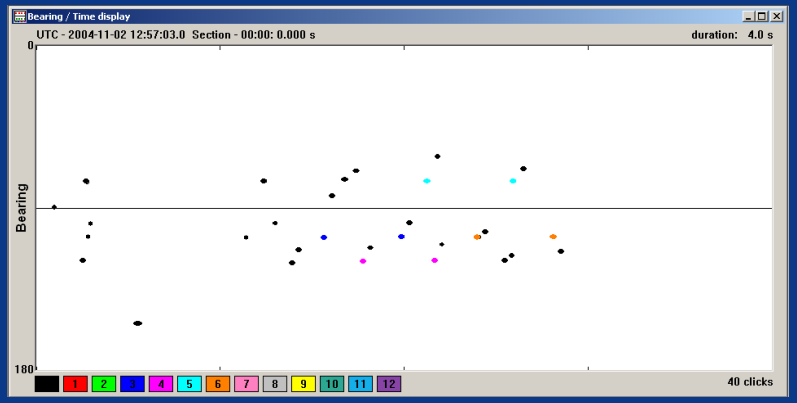
Multi-element localisation methods

Automatic generic call detection/energy summation/matched filter/spectrogram correlation

log file annotation

** and many more functions*

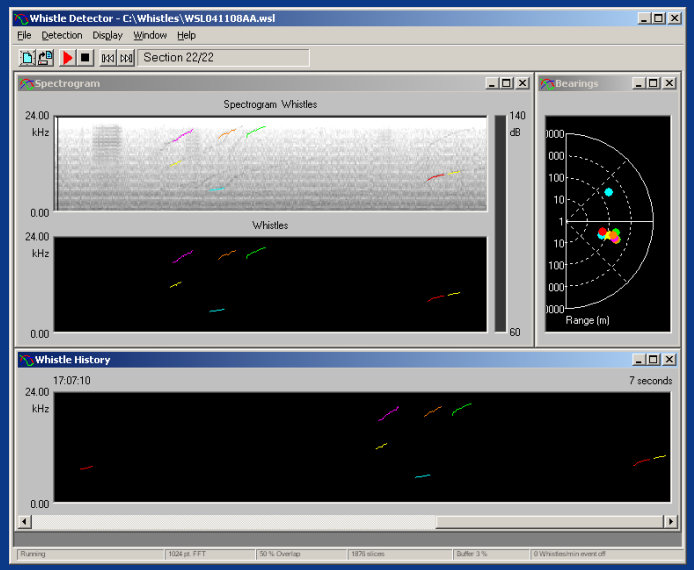
(b) PamGuard software: Like IFAW



RainbowClick time-bearing

The vertical position of an eclipse corresponds to an ambiguous bearing, horizontal position relates to time click was received.

Width and height of the "eclipse" is proportional to the duration and amplitude of the click.

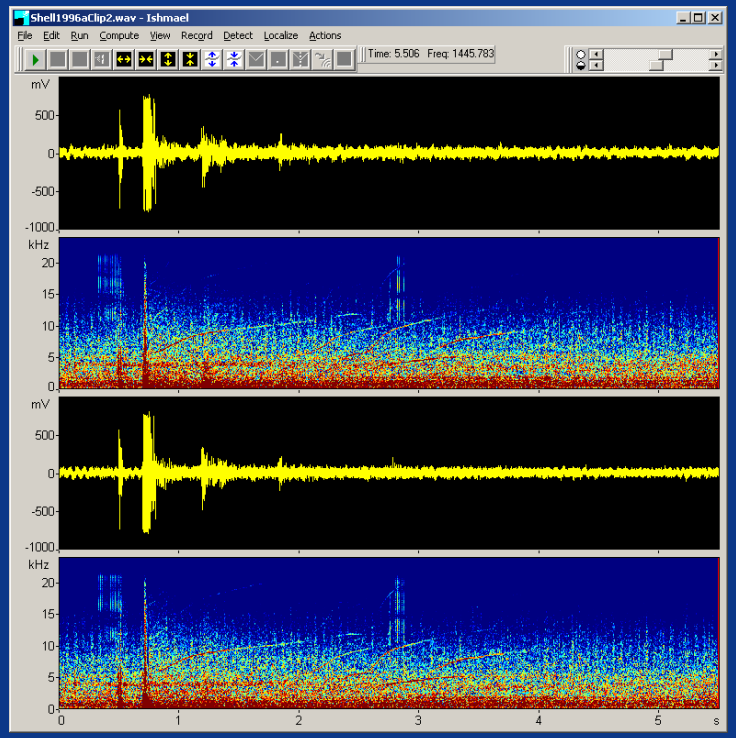


Whistle user interface

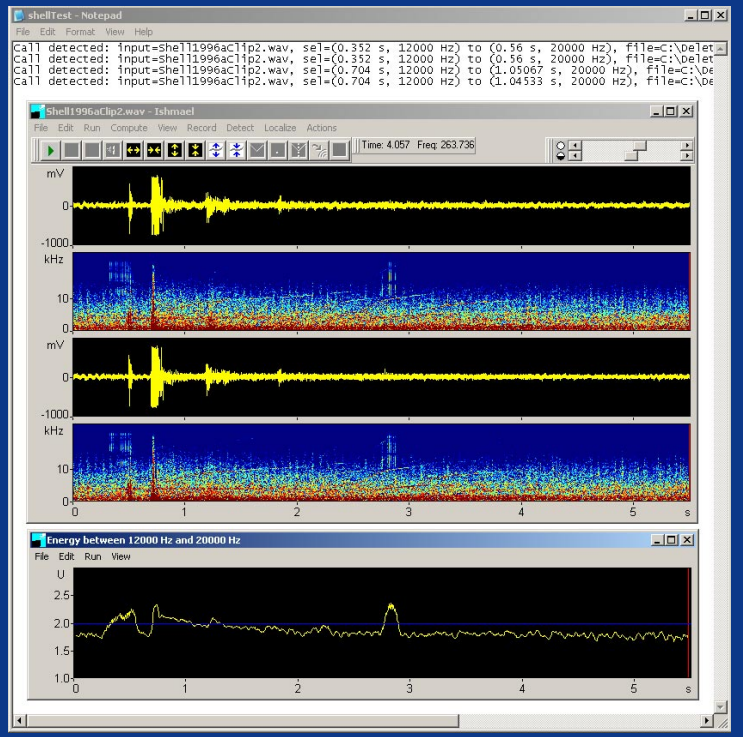
Rolling spectrogram display which overlays each detected whistle in distinct colours to aid viewing.

Real-time detection and analysis for tonal sounds

(b) PamGuard software: Like Ishmael



Time series & spectrogram



Energy detection option & automatic call logging

(b) PamGuard software: it is also free!

From the onset it was agreed that PAMGUARD would be a freely available, platform independent, open source project

This would:

- Ensure its long-term viability
- Encourage its acceptance as the new "standard" within the research and commercial communities
- Foster a community of programmers to contribute to the code
- Cross platform compatibility is achieved through the choice of Java as the programming language
- Open source through project's presence on SourceForge

(b) PamGuard software: The technical bit!

Built in modules

Array Configuration

Model manager and profiler

GUI Container for plug ins (handles graphic displays, menus, help, etc).

Help manager

Configuration and settings manager

Standard graphics layout classes for plots, axes, colour themes, etc.

(b) PamGuard software: The technical bit!

Plug in modules

Map

NMEA / GPS Acquisition

Acquisition (sound cards, NI cards, files)

FFT (Spectrogram) Factories

Decimator

Sound Recording (can also do clip generation)

Spectrogram Smoothing

Spectrogram and 'Radar' Displays

Click Detector

Whistle Detector

AIS Acquisition

Ishmael Interface

Ishmael Detectors

Database Storage

User Documentation

Built in modules

Array Configuration

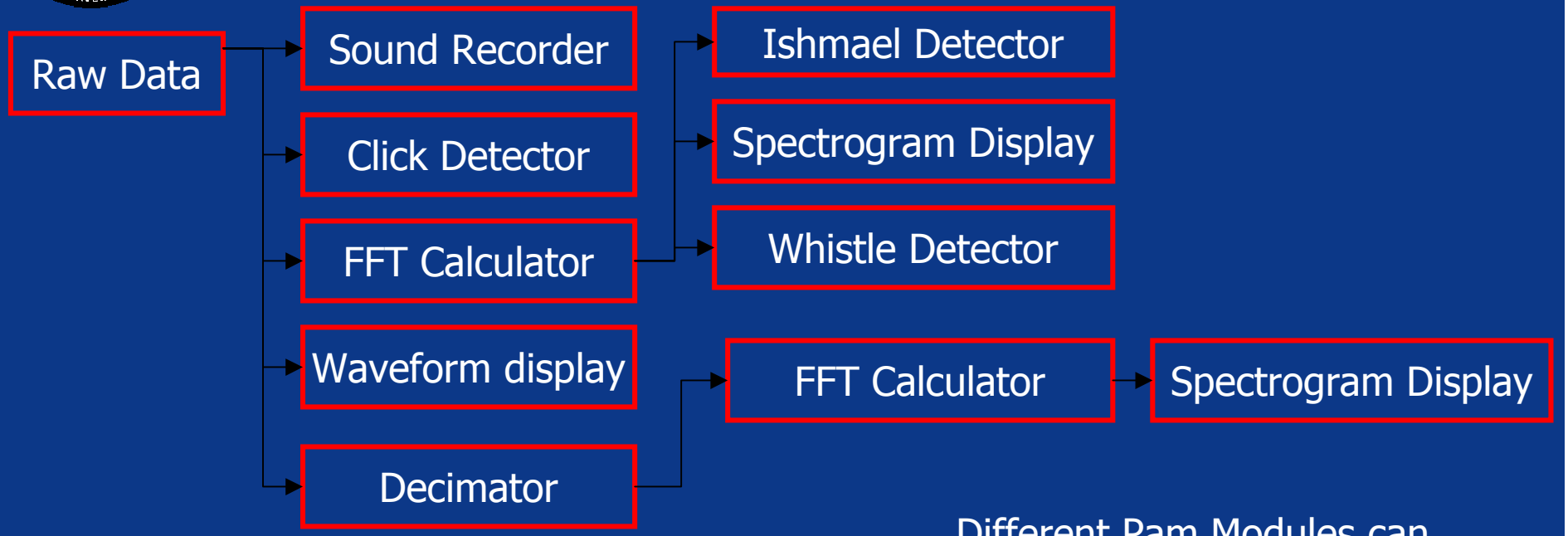
Model manager and profiler

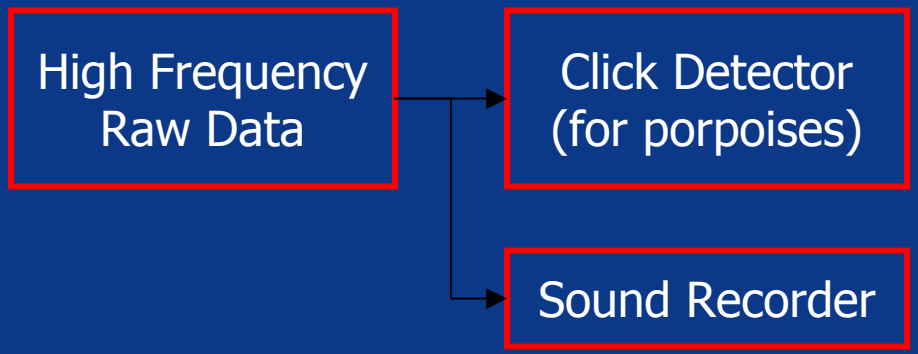
GUI Container for plug ins (handles graphic displays, menus, help, etc).

Help manager

Configuration and settings manager

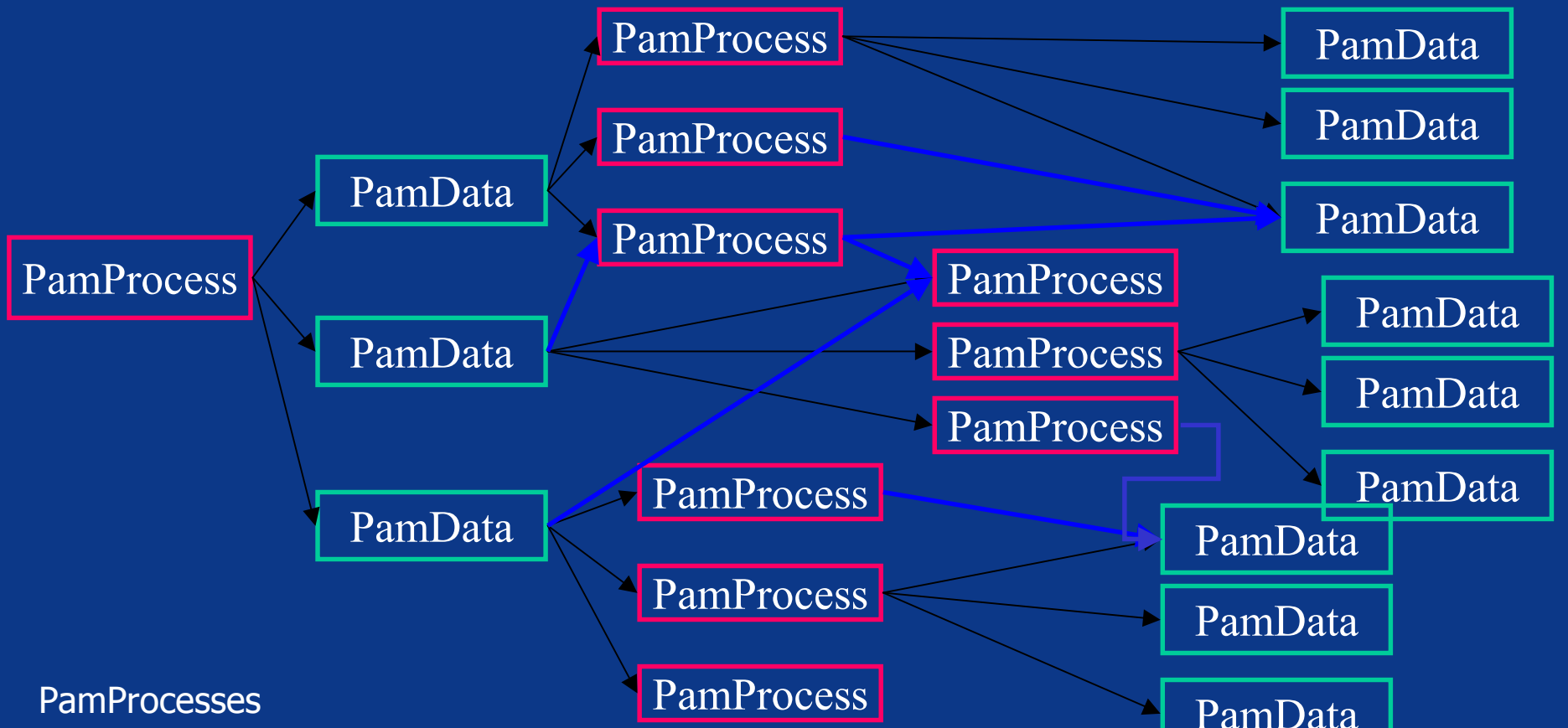
Standard graphics layout classes for plots, axes, colour themes, etc.





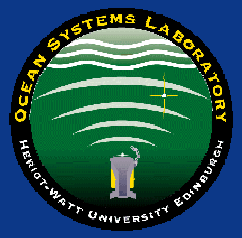
Different Pam Modules can share common data.

e.g. Multiple spectrogram displays, the whistle detector and Ishmael detector can all share the same FFT data.



PamProcesses

- Create PamDataBlocks
- Subscribe to PamDataBlocks
- Say for how long they need the data to be in memory



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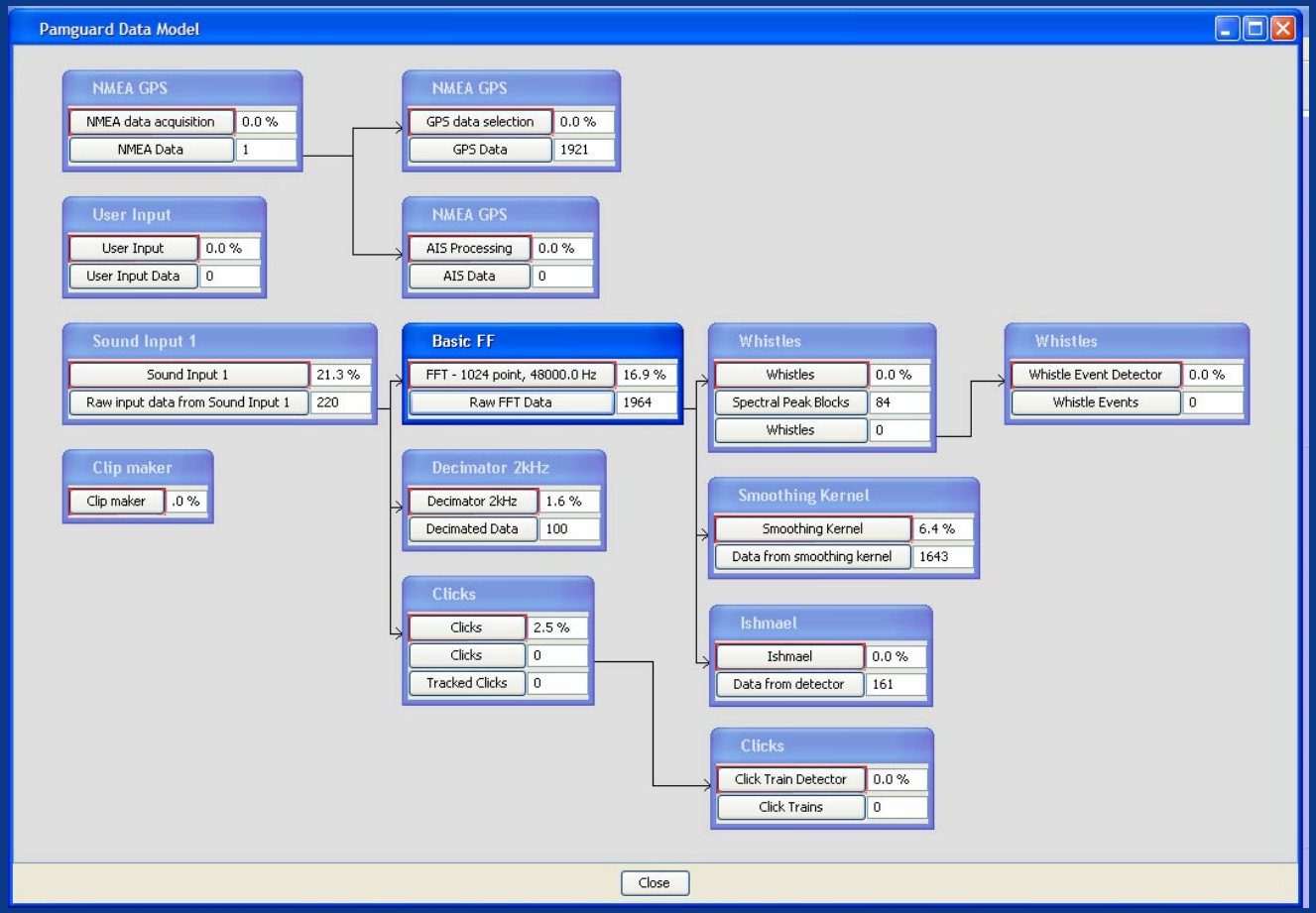


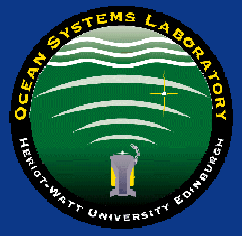
GUI view of the data model – build your own PAM system

PAMGUARD

PamGuard Plug-ins

Each plug-in (PamControlledUnit) provides a number of optional functionalities for processing, providing, and displaying data

Pam Process	Calculates / detects
Tab Panel	Provides a main display panel
Detection menu	Provides items for the detection menu
Display menu	Provides items for the display menu
Side Panel	Provides display side panels
Output data blocks	Produces output data
Graphic overlays	Provides graphic overlays for output data
Plug in panels	Provides plug-in graphics for output data



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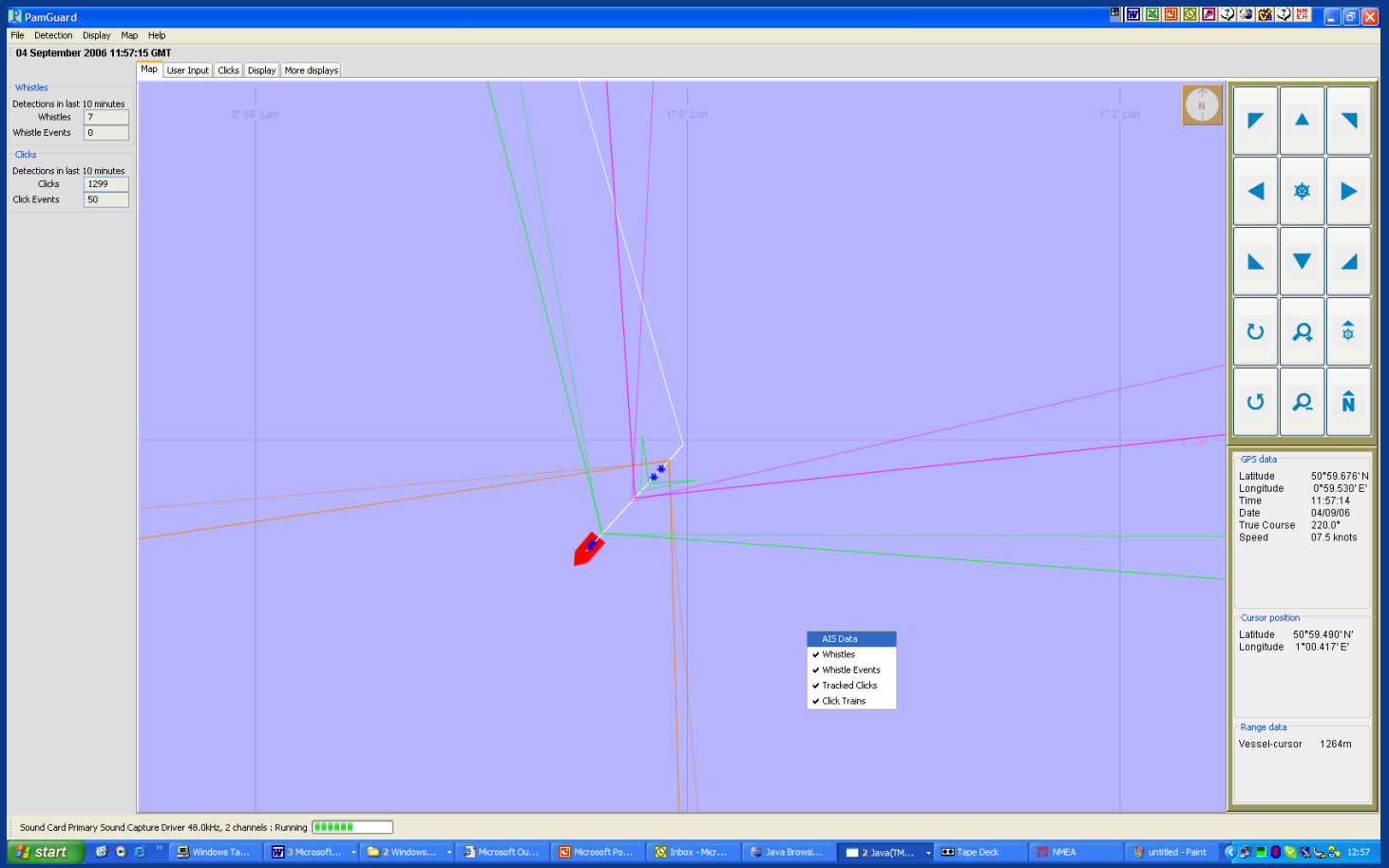
PamGuard Plug-ins

		Map	NMEA / GPS	Sound Input	FFT Processing	Decimator	Smoothing Sound Recorder	Disp' Spectrogram	Spectrogram / Radar	Click Detector	Whistle Detector	AIS Acquisition	Ishmael Interface	Ishmael Detector(s)
Pam Process	Calculates / detects		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Tab Panel	Provides a main display panel	✓					✓		✓	✓				
Detection menu	Provides items for the detection menu		✓	✓	✓	✓	✓	✓		✓	✓			✓
Display menu	Provides items for the display menu	✓							✓	✓				
Side Panel	Provides display side panels						✓			✓	✓			
Output data blocks	Produces output data		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Graphic overlays	Provides graphic overlays for output data									✓	✓	✓	✓	✓
Plug in panels	Provides plug-in graphics for output data			✓		✓				✓				✓

PAMGUARD



PamGuard Map

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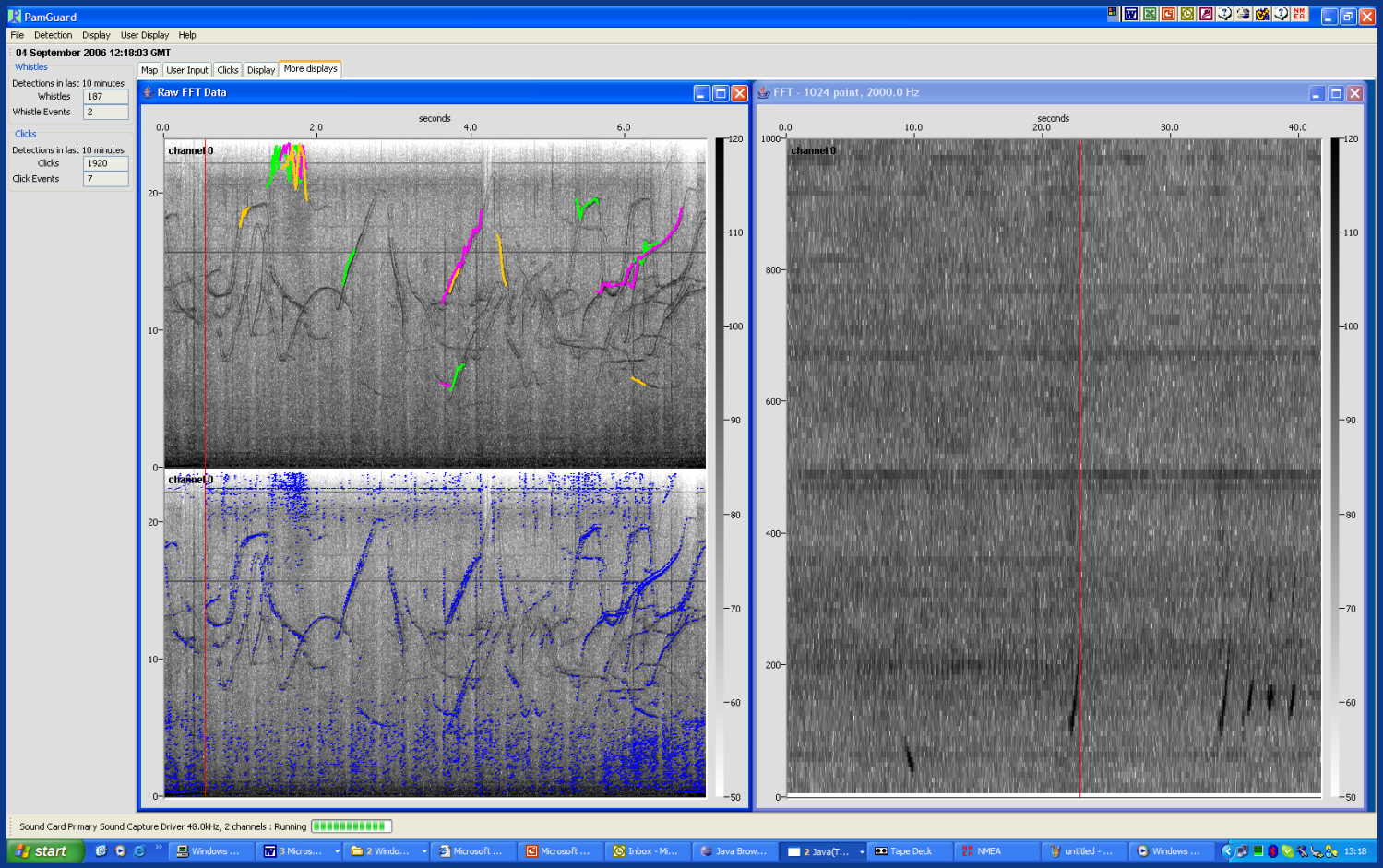

PamGuard Spectrogram

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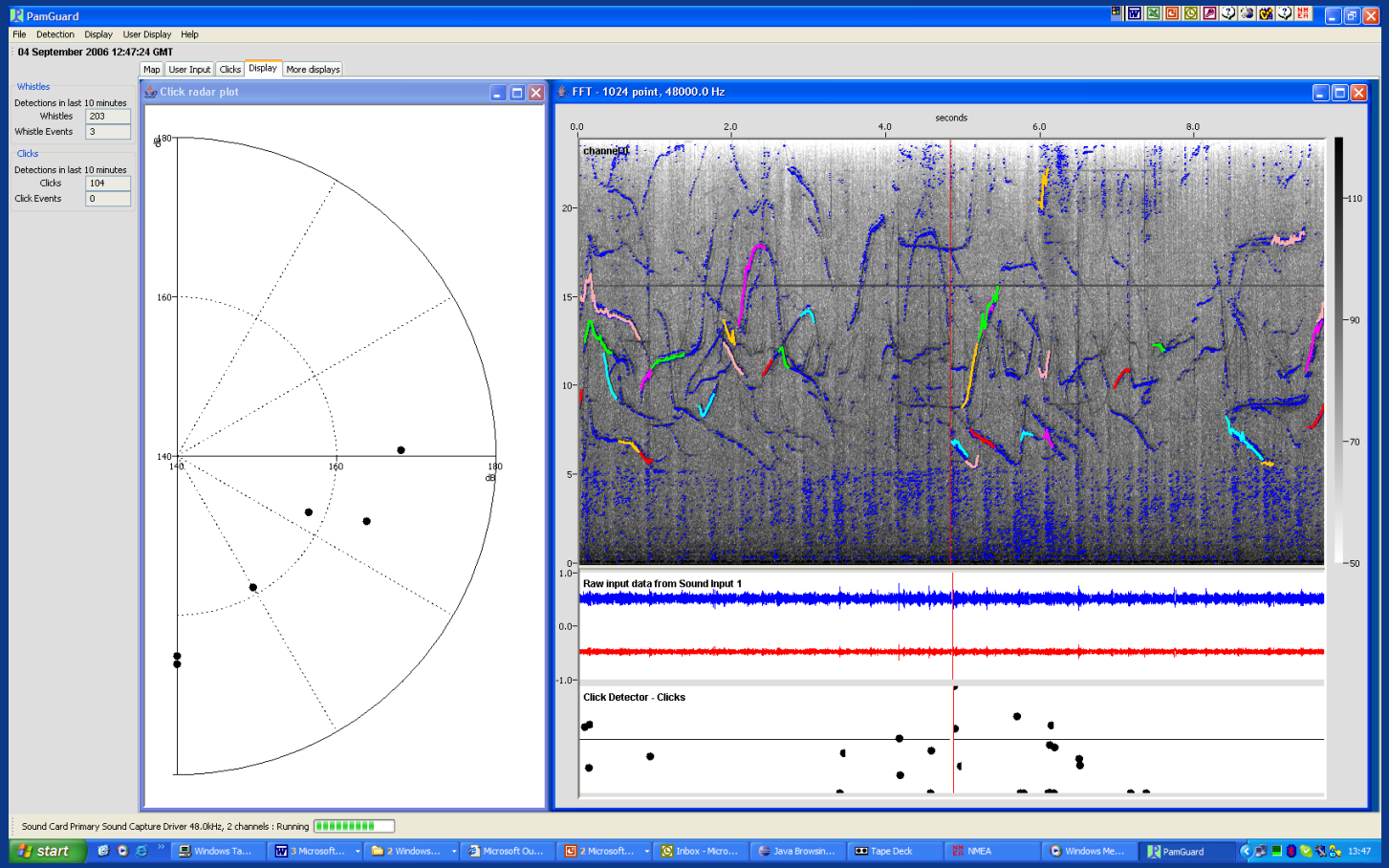
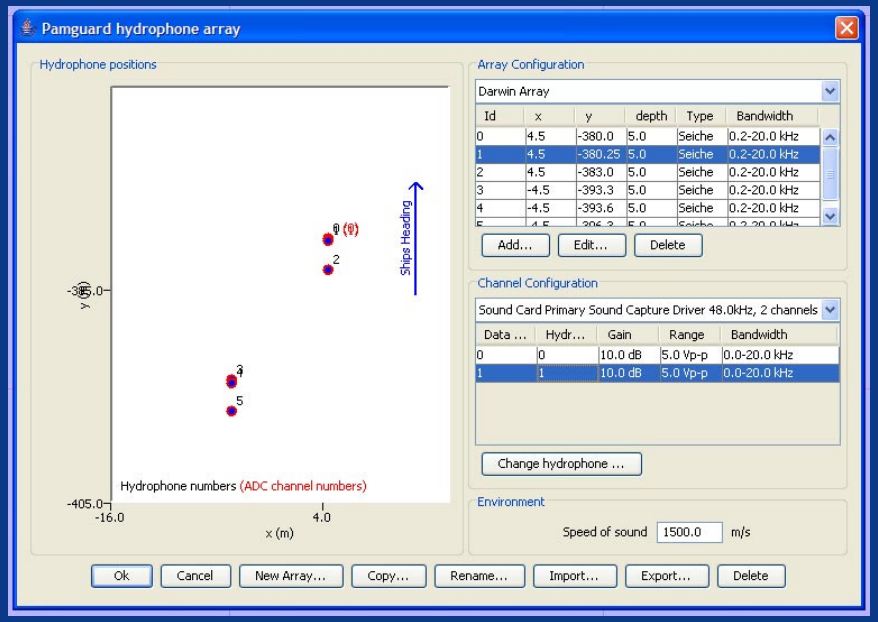
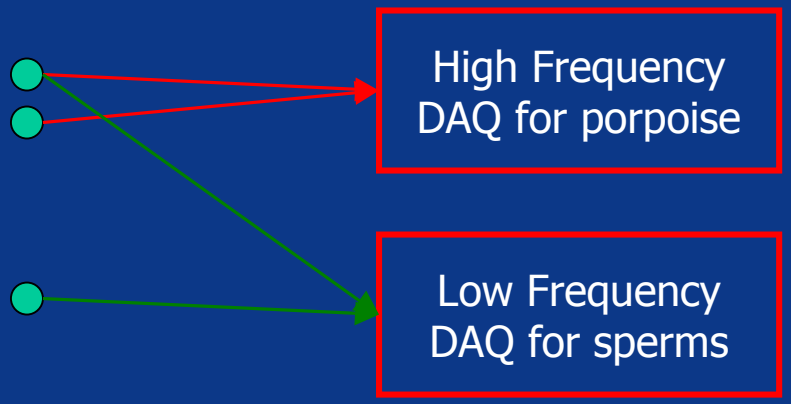


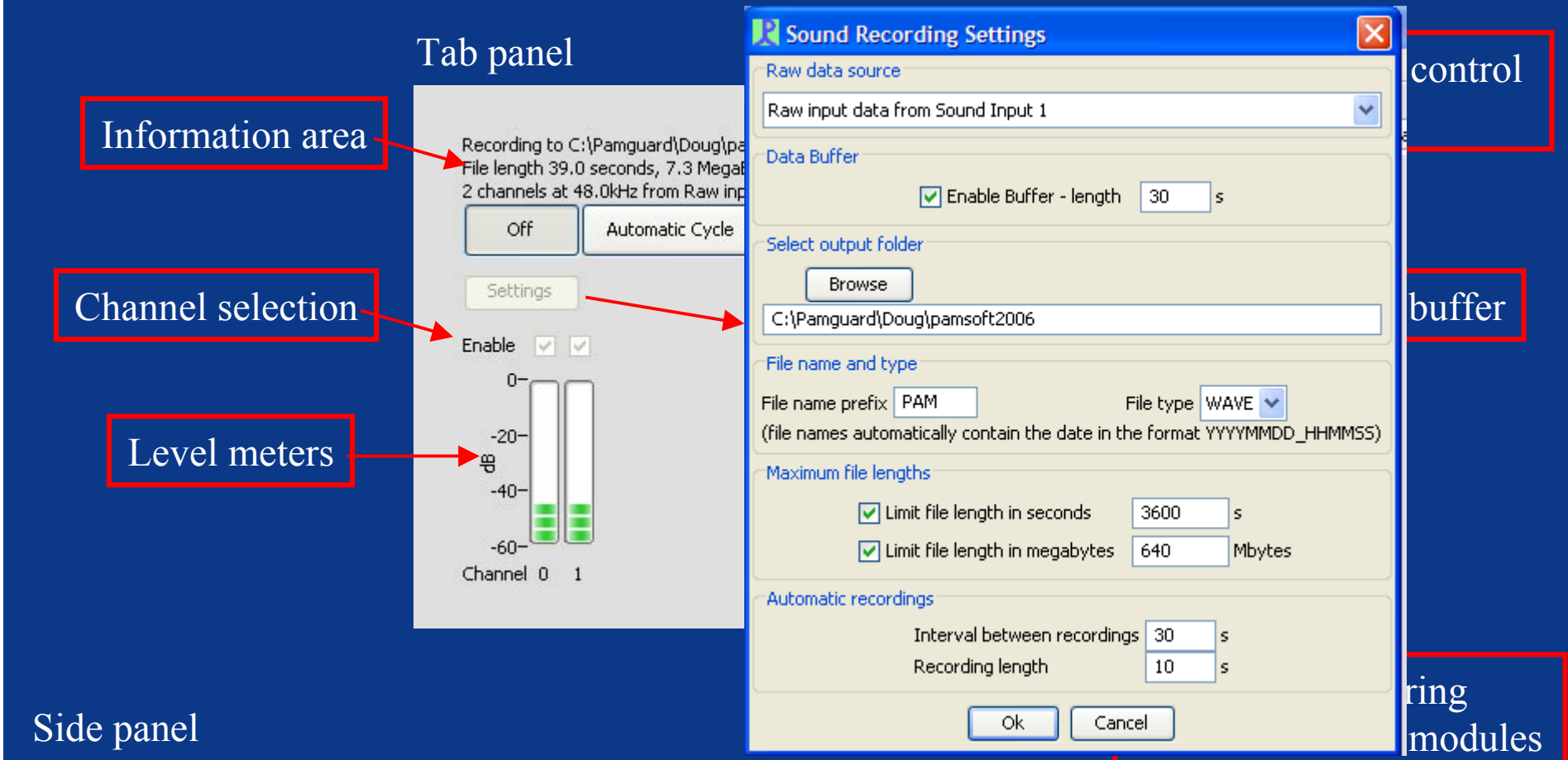
PamGuard Radar & Spectrogram plug ins



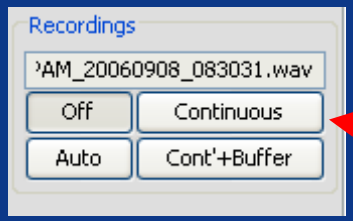
- Support arrays of up to 32 hydrophones
- 3-D position information can be entered manually or from sensors
- Supports one to many relationship between hydrophones and ADC channels.
- Handles calibration information
- Provides information for localisations modules
- Handles data from static hydrophone arrays.



PamGuard array configuration set-up

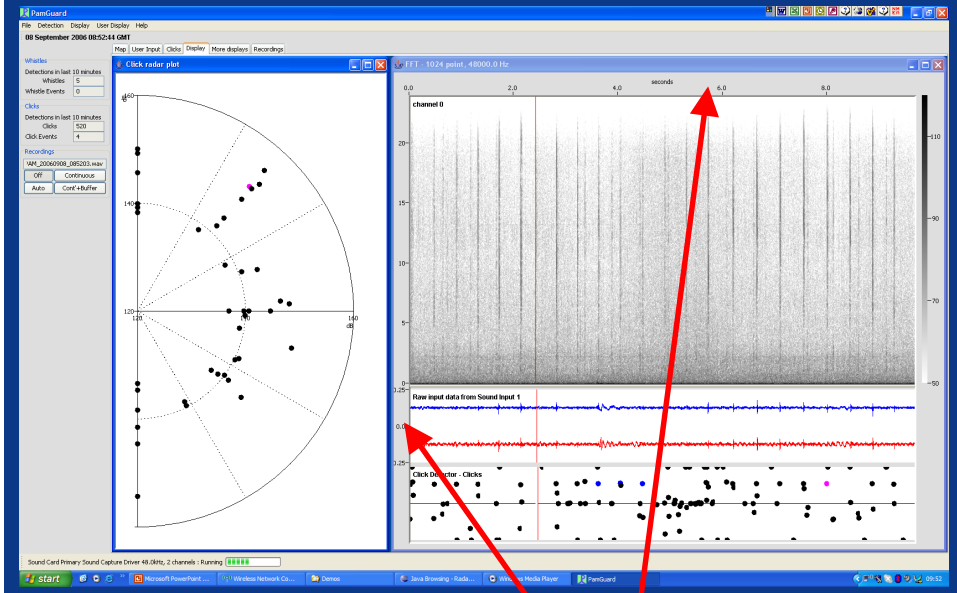


Side panel

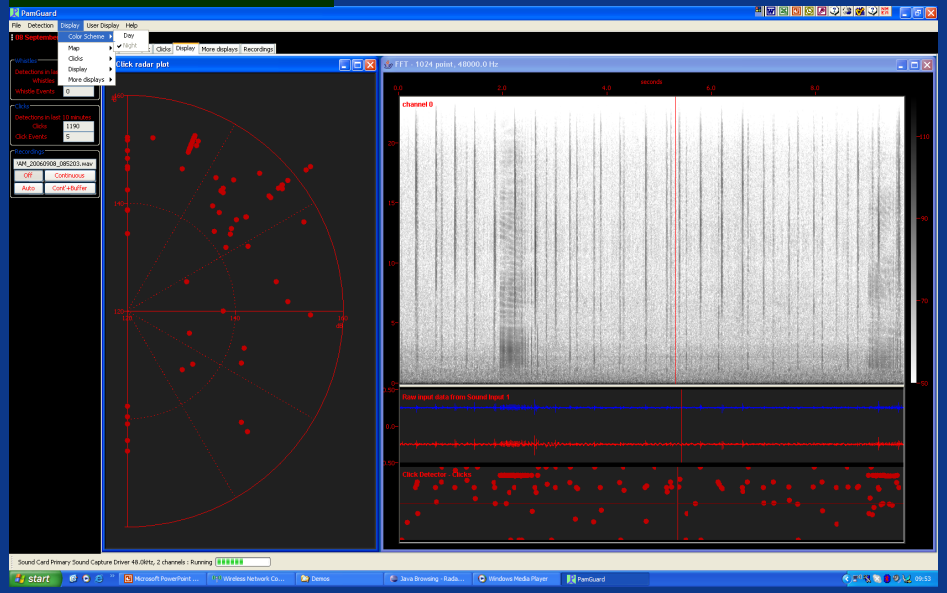


Replicates manual buttons for quick access

Day view



Night view



General classes for graphics layout, axis, etc.

PamGuard display options

(b) PamGuard software: Tested at Sea under research conditions

- *RRS Charles Darwin March / April 06*
- *NOAA Delaware II: July 06*
- *Coda Survey: July 07*

(b) PamGuard software: Open Source – How do I get a copy?

(a) Go to PamGuard website: www.pamguard.org

(b) Click on the link to SourceForge

(c) and……

(b) PamGuard software: 2008 and beyond

(Funded by OGP JIP till the end of 2007)

Under discussion:

Guardianship: levy to be requested from industrial users based on the amount of time that PamGuard is used at sea

Guardian role / interface through which developers will file their software / there to ensure quality of product

Support: For users who may wish custom adaptations of the software

Consultancy role?

(b) PamGuard software: The Team and Acknowledgements

PamGuard has been very much a team effort, many thanks to:

- St Andrews University SMRU/Ecologic: Douglas Gillespie and Jonathan Gordon
- Oregon State University, USA : David Mellinger
- Scripps Institution of Oceanography, USA: Aaron Thode
- Heriot-Watt University: Phil Trinder, David McLaren & Paul Redmond

Funders:

E & P Industry since the projects conception in 2004.

2004/5: Industry Research Funders Coalition

2006: OGP Sound and Marine Life JIP (www.soundandmarinelife.org)

That's all folks, thanks.

K. Mullin