Monitoring of Marine Mammals: PAM and PamGuard Software

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(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**

<table>
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<tr>
<th>Module</th>
<th>Description</th>
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<tr>
<td>Map</td>
<td>NMEA / GPS Acquisition</td>
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<tr>
<td>Acquisition</td>
<td>Acquisition (sound cards, NI cards, files)</td>
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<tr>
<td>FFT (Spectrogram) Factories</td>
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<tr>
<td>Decimator</td>
<td>Sound Recording (can also do clip generation)</td>
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<td>Spectrogram Smoothing</td>
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<td>Spectrogram and 'Radar' Displays</td>
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<td>Whistle Detector</td>
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<td>AIS Acquisition</td>
<td>Ishmael Interface</td>
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<td>Ishmael Detectors</td>
<td>Database Storage</td>
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<td>User Documentation</td>
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**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
GUI view of the data model – build your own PAM system
PamGuard Plug-ins

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

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<th>Pam Process</th>
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<td>Detection menu</td>
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<td>Produces output data</td>
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<tr>
<td>Graphic overlays</td>
<td>Provides graphic overlays for output data</td>
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<td>Plug in panels</td>
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## PamGuard Plug-ins

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PamGuard Spectrogram
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**
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.soundandmarinelifelife.org)
That’s all folks, thanks.