A quick guide to PAMGuard

Passive acoustic monitoring: a promising tool with some drawbacks

The default method for finding marine mammals at sea is visual detection. But this has obvious limitations at night and in poor weather. Moreover, some mammals make long dives, which means they're hard to detect at the surface of the water.

Passive acoustic monitoring (PAM) helps detection by picking up the distinctive vocalisations that some species produce. It can greatly enhance the effectiveness of visual monitoring. But there are drawbacks.

Marine mammals vocalise in a wide variety of ways. Blue whales produce low-frequency moans (as low as 10Hz), which can be detected over tens of kilometres or more. But other mammals use higher frequencies that are detectable only over much shorter distances. Harbour porpoises, for example, echolocate with ultrasonic clicks (105–150 kHz) . Some mammals vocalise close to the surface, others only at depth. Some remain silent for long periods. PAM, therefore, works better with some species than others, and detection hardware and software that might be perfect for one species might not work at all for another.

Two types of PAM

There are two ways of using PAM: towed and fixed. Towed systems use a hydrophone array pulled behind a boat, whereas fixed ones use hydrophones left on the seabed or attached to buoys on the sea surface. Fixed systems are used to collect data over a given area for extended periods of time, which is then analysed later. Towed systems, on the other hand, are used to collect data, which can be analysed as it is collected. Both types need further development and each has particular software requirements. Software that works for towed PAM may or may not be suitable for a fixed system. Although PAMGuard was originally developed for towed PAM, it is now used increasingly for looking at data from fixed systems as well.

The ability of a PAM system to pinpoint the exact whereabouts of an animal varies, depending on the type of sound. Measur-

ing bearings to an animal is generally quite straightforward using two or more towed hydrophones. However larger and more sophisticated arrays can be used to improve range estimation for most species.

An interactive display which enables users to visualise sound at any frequency is essential to PAM.

Enter PAMGuard software

PAM applications have previously been developed to detect a signal from a certain species under certain conditions. But PAM is also useful for detecting more than one species at once or in different geographical locations. What's more, in the past, running one application has precluded running another one that's better suited to a different species, or it hasn't been possible to display data from both applications on the same map, due to lack of compatibility.

So standard software that could handle many types of data would be hugely helpful. And that is exactly what PAMGuard sets out to provide.

PAMGuard is free and open source

PAMGuard is software that's free and open source. Both these factors are crucial.

Other PAM software is available of course. But access to source code is often limited – for commercial reasons, for example. Detection, classification and localisation technologies are protected in the case of the military and some commercial organisations. This means that only a few in-house developers can take the software forward. It excludes the help others might give in expanding the technology and moving it on, if they had access to the source code.

Because PAMGuard is open source, it's open to the intellectual resources of the research community. There is a wealth of knowledge out there. To reach it, there must be straightforward access to the software's source codes. PAMGuard is easy to access because it's on SourceForge.net, an open-source software development website which provides free services to help people build software and share it.

You can find PAMGuard on SourceForge. net via our website: www.pamguard.org.

Benefits the industry and the marine environment

The oil and gas industry has put four years' work and approximately $3 million into developing PAMGuard. The vision from the start has been to benefit not just the industry, but the marine environment. Improving passive acoustic monitoring, so it can live up to its potential as a monitoring tool, will help all users. As well as benefiting the industry, PAMGuard will enable researchers to learn more about marine animals – their abundance and distribution, where they go and when they go there.

It's been crucial to us to make sure PAMGuard works well for researchers, as well as industry. As you'll see below, we've done our best to make sure that PAMGuard is accessible to everyone.

Support for developers

As well as making access to source codes easy, we want to help developers take PAMGuard forward. That's why the PAMGuard website supports developers with a developer tutorial and full developer training notes: www. pamguard.org/developerTutorial.shtml. We explain how to make PAMGuard plug-ins, too. And developers can sign up for the PAMGuard developer mailing list.

Being open to many developers will speed up innovations and improve the performance of PAMGuard's code. PAMGuard can grow and change as our knowledge and skill expand. It's ready for the future.

A design that looks to the future

PAMGuard also looks to the future in its design, which is highly modular. This means different programming teams can develop modules to perform specific functions in an autonomous way. PAMGuard's flexible architecture will help it adapt to future developments. Users can easily integrate a growing range of plug-in applications.

We've designed PAMGuard with plenty of room to grow. Once users have become familiar with PAMGuard, they will be able to keep on working with it for years to come. That's important, because consistency for users will benefit us all.

Creating a pool of experienced software operators

At present, user experience is spread across a range of different software. PAMGuard sets out to provide a single solution, so that users can work with the same software in different situations, now and in the future. That way, users can build up their experience efficiently. They won't have to keep learning their way around new interfaces.

A familiar look and feel

Of course, PAMGuard isn't the first free PAM software. PAMGuard replicates and builds on the important strengths of the free acoustic monitoring and detection software that preceded it. We've kept the familiar look and feel of software such as the International Fund for Animal Welfare (IFAW) software suite and Ishmael .

This will help developers and users who have already worked with Ishmael or IFAW software to quickly feel comfortable with PAMGuard. Consistency has been one of PAMGuard's watchwords.

Compatible with existing hardware

PAMGuard is being developed to work on Windows, Linux and Macintosh operating systems (further information is available on the PAMGuard website). To ensure this, it uses Java as its programming language. Therefore, software operators can use it consistently in different situations, which builds familiarity.

PAMGuard works with different types of hardware used for picking up sounds in the water. It doesn't require expensive investment in new equipment. The PAMGuard project has done everything possible to ensure the software is fully accessible to the research community, including research students using basic equipment.

A simple, intuitive user interface

PAMGuard's graphical user interface (GUI) is simple and intuitive, to help users gain confidence as quickly as possible.
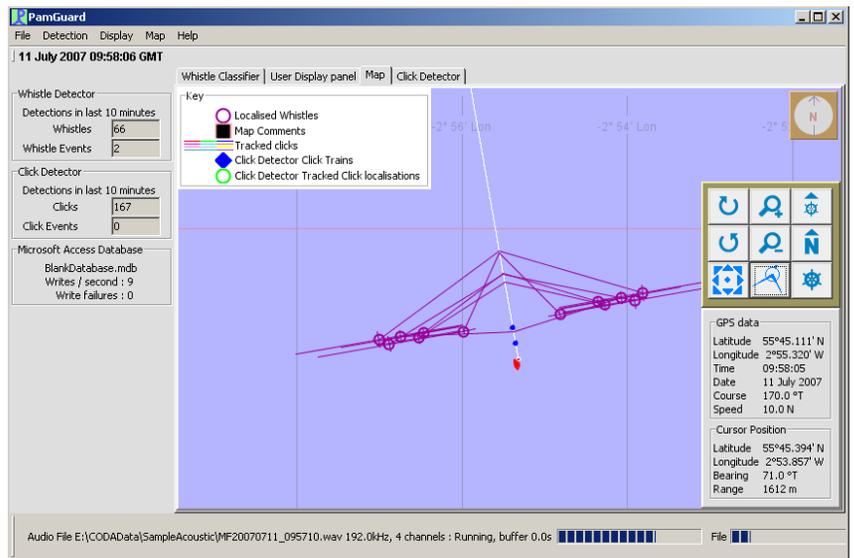
A PAMGuard map: overlays detector information on ship position

This lets them easily confirm detections; select sounds for localisation; and interpret results, which appear on the map, spectrogram and other displays.

It also allows them to add and remove modules, or to configure modules for a particular cetacean monitoring task.

The PAMGuard map

The primary way the software displays information is through the PAMGuard map, which shows the ship's position and overlays detector information. In the example below, the ship is red, the track is white and hydrophone locations are blue. The overlay shows dolphin whistles.

A PAMGuard map: overlays detector information on ship position

Smaller side panels summarise recent detection information. Other tabs in the main display lead to more detailed information from other detectors.

You can see screenshots of other displays on our website: www. pamguard.org/screenshots.shtml.

Critical fixes have improved PAMGuard

Like most other new software, PAMGuard has had some initial glitches. But we have now made critical fixes and PAMGuard today works better than ever.

Ready for the fu ture

The industry currently funds basic support for PAMGuard. But we know there is a whole community of users and developers who can take PAMGuard forward in ways we haven't imagined.

We've designed PAMGuard to feel familiar, by keeping the look and feel of existing software. We've made sure it's accessible to the whole community, by ensuring it works with a wide range of hardware and operating systems. But we've also made it as flexible as possible, so that developers can add new modules and adapt the technology to new possibilities.

Next steps

PAMGuard won't fit every detection situation. But it's a big leap forward, dramatically increasing the chances of marine mammal detection. And it's ready for the future.

To help improve success rates in this area, we ask you to:

- become familiar with PAMGuard: visit www.pamguard.org, where you can also register for updates
- encourage the use of PAMGuard
- provide feedback on glitches and suggest improvements.

Thank you for reading about PAMGuard.

For further details, please contact john.campbell@ogp.org.uk.