

PAMGUARD: A Semiautomated, Open Source Software Suite for Acoustic Detection and Localisation of Cetaceans at Sea

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Ocean scientists need to detect marine mammals for a wide range of reasons. Some are interested in the animals themselves, wishing to measure their abundance or study their behaviour. Others are engaged in activities that may cause harm to marine mammals, requiring them to put in place mitigation procedures that often require the real time detection of marine mammals within some mitigation zone.

Although visual observation remains the default method for observing marine mammals at sea, passive acoustic monitoring (PAM) has shown itself to be an effective tool for the detection and localisation of several species. While visual monitoring can take place only during daylight hours and calm seas, PAM can continue throughout the 24-hour day and can operate effectively in higher sea states. Most importantly, PAM systems can be automated using digital signal processing (DSP) algorithms running on relatively affordable computer systems, thus alleviating the need for large observer teams. Even though not all marine mammals are vocally active, a study in the late 1990's (Lewis et al., 1999; Gordon et al., 2000) showed that PAM can achieve detection rates up to 8 times higher than visual observers operating from a seismic survey vessel. While these initial results showed promise, further development is required to overcome some of the shortcomings now commonly associated with towed PAM systems, which include limited range and bearing estimation capabilities inherent in using a two element hydrophone array, limited automated species recognition and a need for an experienced operator to interpret detection data in real-time (Walker, C., and Hedgeland, D, 2002).

Marine mammal vocalisations range from the infrasonic moans of blue whales (<10 Hz) to the ultrasonic (>100 kHz) clicks of porpoises. Detection of such a wide variety of sounds presents a great challenge to researchers, and cannot be achieved using a single DSP technique or algorithm. PAMGUARD is a new open source software suite intended to provide a modern, flexible, integrated software infrastructure for the development and deployment of marine mammal detection and localisation algorithms.

PAMGUARD has been designed to utilise data from multiple sensors in any configuration. Structurally, PAMGUARD is highly modular, following the principle of minimal coupling. The benefits of minimal coupling are that the design is easier to maintain, understand, extend and test, and as a result of these properties, the system should be more robust. This autonomous structure also facilitates the development by different programming teams of modules designed to perform specific functions.

In its current stage of development, PAMGUARD emulates the important capabilities of the stereo monitoring systems that preceded it but it has been written in a much more structured and well documented manner with a view to long-term support and development, and it is able, crucially, to receive, display and process data from multiple (more than two) hydrophones.

The PAMGUARD software suite includes

- A flexible data model allowing efficient sharing of data and machine resources between multiple sub systems,
- A general graphical user interface (GUI) framework to accommodate an evolving set of graphical tools,
- A map view with NMEA/GPS/AIS interface to display the vessel track as well as visual and acoustic detections of marine animals (Figure 1a),

- A multi-channel real-time scrolling spectrogram and waveform display (Figure 1b),
- Click and whistle detection modules,
- An interface to standard sound cards as well as a high speed data acquisition interface for porpoise high-frequency (>100 kHz) click detection.

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References

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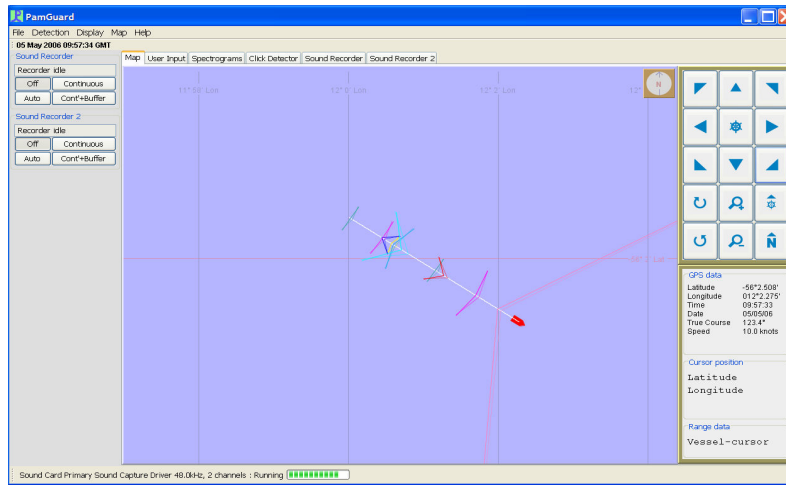


Figure 1a. Map display showing bearing and range to detected sperm whales, as well as user controls.

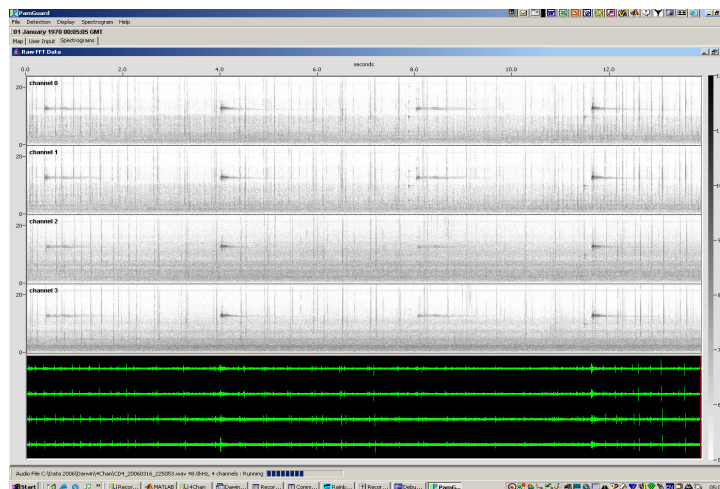


Figure 1b. Multi-channel real time scrolling spectrogram and waveform displays.