PANDA; A Rapidly Deployable, Self-Recovering Shallow Water Acquisition Platform

Teong Beng, Koay; John R., Potter; Venugopalan, Pallayil; Eng Teck, Tan
Acoustic Research Laboratory, Tropical Marine Science Institute,
National University of Singapore

INTRODUCTION

The increasing need for shallow water environmental monitoring requires extensive data collection in areas often encumbered with heavy vessel traffic and other conflicting activities. Conventional surface-expression moorings require relatively bulky buoyancy elements with correspondingly heavy deadweights to maintain placement against currents and surface wave drag. They are expensive, heavy, require considerable resources to deploy and recover and are vulnerable since their surface expression may attract undesirable human attention, unintended snagging/recovery and/or collateral damage from other marine activities, especially in coastal areas. Conventional bottom mounted subsurface systems can overcome some of the concerns with reduced component size, but still consists of multiple physical components (deadweight, securing line, release, payload and buoyancy unit) and therefore not well suited for deployment from small vessels with limited manpower.

A low cost system that is small, light, simple to operate, and deployable from small vessels by only two persons would therefore be a beneficial tool for shallow water surveys. A number of such systems could be rapidly deployed and recovered to cover a large area of interest. Acoustic Research Laboratory (ARL) of Tropical Marine Science Institute in National University of Singapore has developed and enhanced such a portable data acquisition platform; a Pop-up Ambient Noise Data Acquisition (PANDA) system for shallow water applications that acquires data for up to a couple of months depending on system setup. It has no surface expression and leaves nothing on the seabed after recovery and thus provides a system that is ecologically friendly and unobtrusive.

Physically, the system has two components; a main physical unit consists of 250m of 8 mm rope wound onto a reel-like watertight electronics housing cum buoyancy unit with a release mechanism; and an anchor. Unlike most conventional acoustic-release based systems that drift after surfacing, PANDA is held in place by its anchor, thus greatly reduces the risk of losing it. With current GPS positioning accuracy of about 5m rms, we are able to locate the recovery site to within a few tens of meters including uncertainties arising from currents, thus reduces the buoyancy size (hence the anchor size) required to provide sufficient visual exposure once released. Thus, a small vessel can release and easily locate a surfaced PANDA. Since the securing weight is recovered, it can be an anchor, chosen for its efficiency in the actual bottom conditions, rather than a heavier but less effective deadweight.

The deployment procedure is simple. A CompactFlash with acquisition parameters is loaded onto the microprocessor board; the electronics is activated and inserted into the housing; an anchor is attached onto the free end of the line, the release mechanism is armed and finally the system is dropped into the water. The system is retrieved either by the fail-safe time release or optionally triggered by acoustic command via an acoustic link. The system has been successfully deployed in up to 100 m water depth by two persons from a small boat in a number of environments.

SYSTEM DESCRIPTION AND DESIGN

PANDA's system function is determined by a re-configurable acquisition electronics package mounted inside the electronics housing. A small anchor (typically 10-24 kg) is sufficient to hold PANDA onto seabed since PANDA will lean over at an increasing angle, therefore larger horizontal drag as the current builds, which buries the anchor more securely.

Fig.1 shows a complete PANDA. When deployed, the PANDA sits with the transducers pointing upwards. A stainless steel frame at the top supports a hydrophone (and protects the acoustic release transducer) while the recovery line is held by a retaining pin gripped in release jaws at the bottom, leading to an anchor. When the release jaw opens (either by timed release or by acoustic command), the housing turns horizontal, ascends while unreeling the recovery line, but remains secured to the bottom by the anchor. The choice of anchor type and weight depends on anticipated bottom type, depth and currents expected at a site.

The self-recovering buoy

The reel and release mechanism is a variant of the commercially available 'Fiobuoy®' by Fiomarine in Australia. The PANDA housing is a factory-customized version, with the length of the buoy increased to 690 mm, twice the original length, with internal bracing rings to maintain structural strength. This modification increases the internal space and buoyancy to carry the electronics payload, as well as the length of recovery line spooled onto the casing. While original buoy comes with a single detachable end cap, the modified version has both end caps removable facilitating easy assembly and maintenance of the electronics stack.

The release package has a separate and dedicated battery pack that allows the release mechanism to operate with a delay of up to one year. The integral release is equipped with an internal leak detector that will trigger an immediate emergency-surfacing sequence in case of leak, avoiding serious damage to the payload. A standard PANDA weighs less than 30kg in air, has approximately 5 kg of positive buoyancy in seawater and operates up to 200 m depth.

Acquisition electronics, storage system and power source

The various components of the PANDA electronic package are illustrated in Fig. 2. A typical system acquires signals from a hydrophone at 5kSa/s for about 6 days of continuous acquisition. More channels could be used, with the same maximum aggregate sampling rate. A Hard Disk (HD) of 12GB storage capacity is used for data storage.

The acquisition electronics is a Persistor-based MCU system with processing power of an 80386 CPU, allowing a substantial increase over the sampling rate available in earlier versions. By utilising the Real Time Clock, time driven CPU interrupts are generated and used to trigger various preprogrammed tasks, including data acquisitions. The MCU digitises analog data through a multi-channel ADC and handles ATAPI protocol in order to stream acquired data into the HD in real time. It provides RS232 channels that accept data from sensors with digital output and facilitate external communications, for example, the electronics for acoustic link that signals the CPU of a release command, which in turn triggers the integral release via an internal wireless optical link.

A low noise analog signal conditioning circuitry, developed in house, is implemented between the hydrophone and the digitising circuitry. It consists of a preamplifier, a 10th-order linear phase low pass filter, and a variable gain stage. The system provides overall (adjustable) bandwidth from 10 Hz to 10 kHz, and sensitivity from –159 dBV re 1uPa to –116 dBV re 1μPa @ 1m with the current hydrophone.

The PANDA electronics package can withstand operational mechanical shocks up to 175 G and random vibration of 0.65 G, a limitation imposed by the storage HD while writing data. When the system is idle, these shock and vibration limitations are significantly extended. Therefore, acquisitions are programmed to avoid recording at the time of deployment and recovery processes. A multi-section cylindrical payload cage with shock mounts was designed and built to secure the electronics and battery pack to one end cap. It is designed to carry different electronics configurations, allowing us to match the electronics modules according to our needs while balancing the system bandwidth, functionality and battery life. The payload is concentrated around the axis of the electronics housing in order to increase system rotational stability when surfacing. Practical release tests in 20 m of water shows no significant precessing or nutation oscillations occur.

Eight high energy density COTS rechargeable Li-Ion batteries are combined into a battery pack capable of powering the system for about 9 days if continuously sampled at 2kSa/s. The effective acquisition period per deployment could be larger, depending on the acquisition rate and the sparseness of acquisition bursts.

APPLICATION EXAMPLES

Rapid environmental assessment in Singaporean waters

PANDA has been deployed extensively for rapid acoustic environmental assessments in local waters studying the spatial variation of ambient noise, the impact of man-made activities on the acoustic environment, marine biological noise and ambient noise characterisation. Since the majority of Singaporean waters are occupied by shipping channels, ship mooring areas or navigational hazards such as reefs, the deployment of conventional mooring systems is virtually impossible. PANDA not only overcomes this problem, it has proven its capability of rapid deployment in areas that are much more constrained in terms of maneuverability, at typically 2~3 sites (of 3 hours data each) per day, with a single system and a small 30 footer vessel or 5.2 m Rigid Hull Inflatable.

Internal wave experiment at South China Sea

A preliminary version of PANDA took part in the ASIAEX 2001 experiment in the South China Sea, jointly conducted by researchers from the US, Taiwan, China and Singapore, among others, studying the complex interaction of shelf-break ocean dynamics on acoustic propagation. Although three units were lost, probably two to trawling activity and one being deployed too deep for the recovery line length and current conditions, one PANDA was recovered within 30 m of its anticipated surfacing point using only GPS positioning. This PANDA was deployed for almost a month at 100m depth, and recorded data for 9 days continuously.

A single receiver geoacoustic inversion experiment

Conventional geoacoustic inversion methods using, for example, an array and Matched Field Processing are nearly impossible in Singaporean waters due to the heavy vessel traffic, complicated shallow water channel characteristics and lack of open areas for a large array to be deployed. The ARL is currently performing preliminary geoacoustic experiments in these waters using a single towed source and a PANDA as receiver. The PANDA is deployed and then various signal pulses are transmitted from the deploying vessel as it quietly drifts away from the deployment site. Finally the vessel returns to recover the PANDA and performs the analysis on the direct and bottom reflected signals to deduce bottom properties. Fig. 3 shows a time series and spectrogram of a couple of datasets acquired from local waters. Characteristic clicks from snapping shrimp are quite evident in these recordings

POSSIBLE SYSTEM EXPANSIONS

Additional miniature external CTD data loggers are now being integrated into PANDA, making it a potential tool for physical oceanography studies. With the multiple RS232 and ADC channels, additional sensors could easily be integrated into the acquisition system if required. Sensors such as turbidity sensor, quantum sensor and flourometer could also be integrated into PANDA, providing a configuration that is suitable for researchers in marine biology community.

CONCLUSION

The ARL has designed and built an upgraded PANDA with greatly increased sampling rate and extra electronics that allows (among other capabilities) acoustic-commanded release. This new version has been deployed in various local experiments. It is proving itself as an inexpensive, lightweight, robust, self-contained, highly integrated and yet re-configurable bottom mounted data acquisition platform that is suitable for rapid deployment at shallow waters.

Acknowledgements

The authors are thankful to Fiomarine for their continued support in customising the self-recovering buoy to ARL specifications. This work was supported under contracts from DSTA, Singapore.

References

[1] Teong Beng Koay; Potter, J.R.; Johansson, T.; Venugopalan, P. PANDA; a self-recovering shallow water acoustic logger. OCEANS, 2001. MTS/IEEE Conference and Exhibition, Volume: 3, 2001. Page(s): 1879 -1885 vol.3

[2] Lim, T.W. & Potter, J.R. Pop-Up Ambient Noise Data Acquisition (PANDA) system. Invited paper contributed to a Special Issue of a joint IEEE/MTS Journal, 33(1) 45-54.1999.

[3] Thomas A. Calupca, Kurt M. Fristrup, and Christopher W. Clark. A compact digital recording system for autonomous bioacoustic monitoring. Journal of the Acoustical Society of America, 108(5): 2582. 2000.

[4] Alec J. Duncan, Douglas H. Cato, Frank Thomas, and Robert D. McCauley. The development of a compact instrument for the measurement of biological sea noise. Journal of the Acoustical Society of America, 108(5): 2584. 2000.

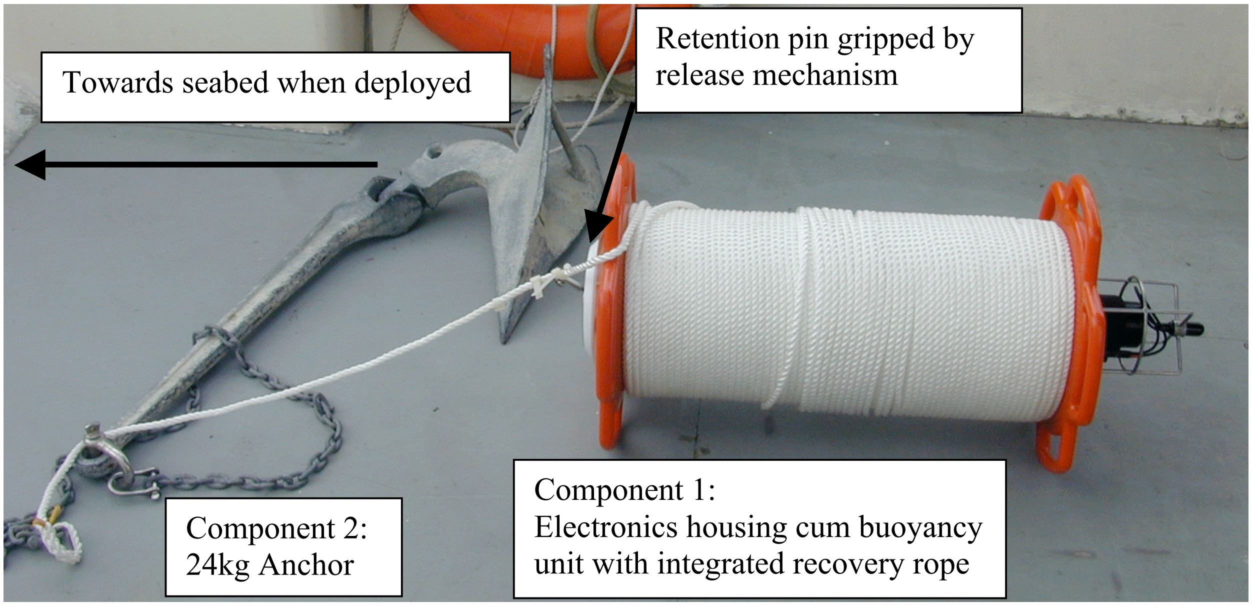

Fig. 1 Completely assembled PANDA waiting to be deployed

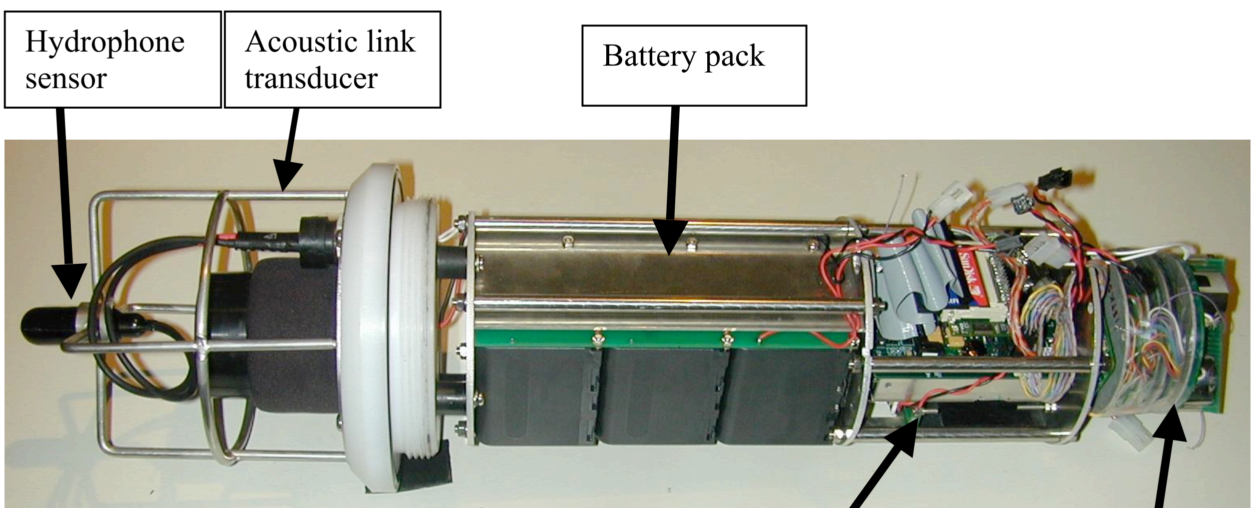

Fig 2. Electronics Payload

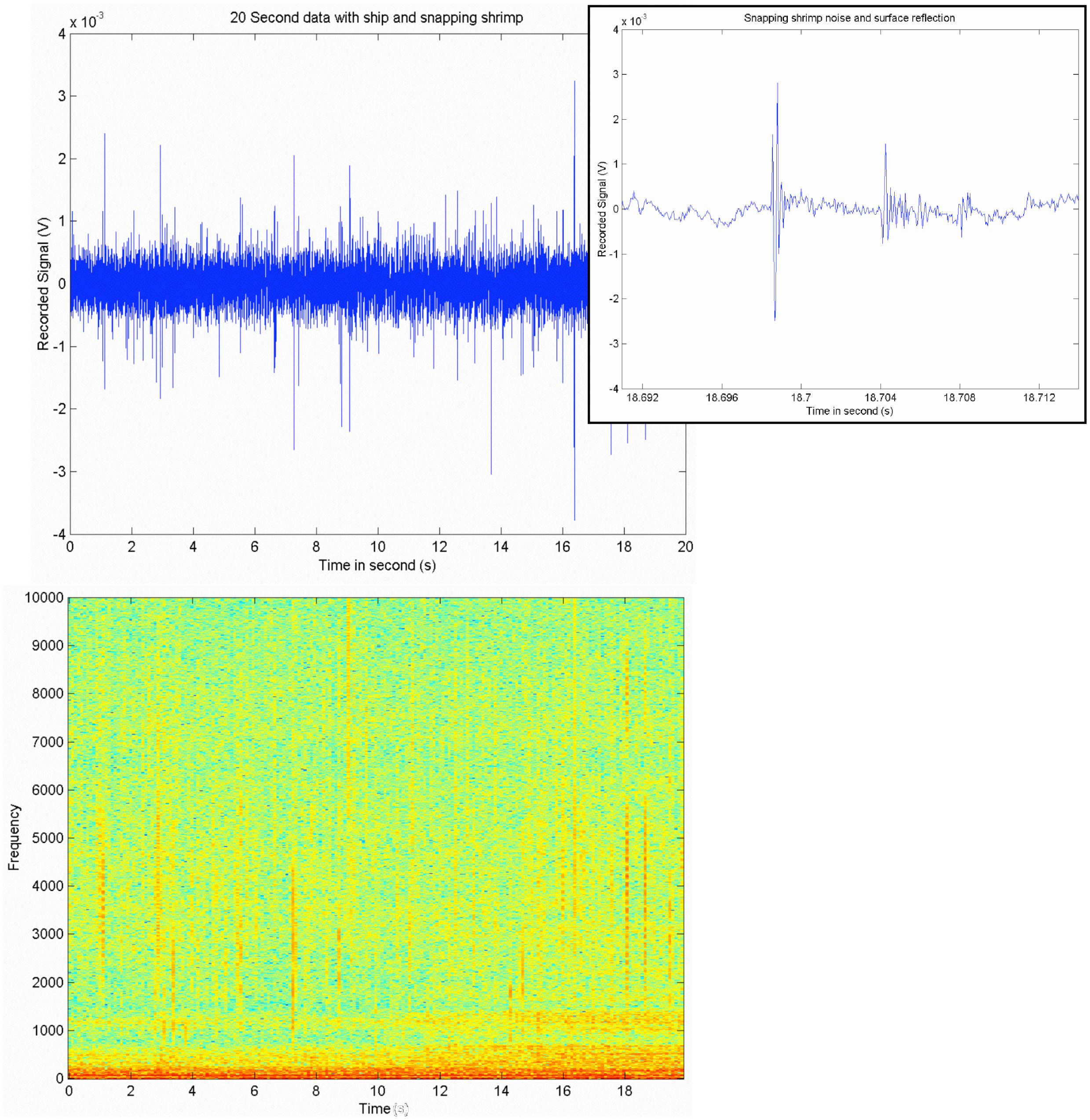

Fig. 3 Some sample data collected, time series (top), spectrogram (bottom), and a snapping shrimp click (upper right).