Shallow Water Survey with a Miniature Synthetic Aperture Sonar

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Abstract
Many military operations such as beach reconnaissance and explosive ordnance detection require high-resolution surveys in shallow water and surf zones. Surveying in such shallow water presents a variety of operational challenges. The two fundamental constraints to operating in very shallow water are vehicle size and performance degradation related to environmental constraints. To effectively access very shallow water, lightweight man-portable Autonomous Underwater Vehicles (AUVs) are often desired. To be suitable for very shallow water the vehicle requires miniaturized components, low power consumption, high-grade navigational sensors, and an imaging sonar capable of high area coverage rates and high resolution. The sonar system design and processing must also be equipped to handle the challenges of the very shallow water environment, which include sloping seabed surfaces, strong multi-path environments, and highly nonlinear vehicle motion, all of which can impair sonar target detection and analysis.

Synthetic Aperture Sonar (SAS) is well suited to seabed survey operations because it can achieve a high area coverage rate at constant, centimeter-scale resolutions. Kraken's high frequency AquaPix® SAS is particularly adept in shallow water conditions where narrow beamwidths and coherent integration help reject multipath and enhance target detection. SAS performance can be optimized for shallow water using performance prediction models. These models have yet to be validated for very shallow water conditions. In this paper we will compare the modeled and observed results of SAS performance from two different shallow water surveys.

We demonstrate results from two shallow water sea trials using different AquaPix® SAS systems: the InSAS (Interferometric Synthetic Aperture Sonar) and MINSAS (Miniature Interferometric Synthetic Aperture Sonar). Both systems produce high resolution imagery and bathymetry. The InSAS operates at center frequencies of 240 and 337 kHz, while the MinSAS operates at a 337 kHz centre frequency. The InSAS has been designed for multipath suppression in very shallow water and is most suitable for medium and large AUVs [1]. The MINSAS unique modular embodiment and compact size make it ideally suited for the small man portable AUVs often used for shallow water surveys.

Both the InSAS and MINSAS have been demonstrated to have excellent multipath performance in shallow water. During a sea trial on an AUV in Sydney harbour, Australia, the InSAS was able to successfully image the seabed up to the shoreline while operating in 5 to 10 m water depths (Figure 1). In addition to AUV applications, the MINSAS is also highly effective as a towed shallow water survey system. During a recent (2018) shallow water sea-trial in Conception Bay, Newfoundland, the MINSAS effectively mapped the very near shore while deployed from Kraken's KATFISH actively controlled towfish. While being towed from a small 43-foot vessel (MV Ocean Predator I) in water depths of 0 to 60 m, the MINSAS was able to produce both imagery and bathymetry of the seabed all the way to the shoreline (Figure 2).

To optimize both MINSAS and InSAS performance in future shallow water surveys, sonar performance must be well understood. In this paper, sonar performance models will be presented to highlight the key factors limiting shallow water operations, including sloping seabeds and severe multipath. Initial results from these models show that multipath is well mitigated by both the MINSAS and InSAS sonar designs, and SAS processing provides a signal-to-clutter gain that allows targets to be detected in very shallow water. MINSAS and InSAS data will be presented to validate and refine these sonar performance prediction models.

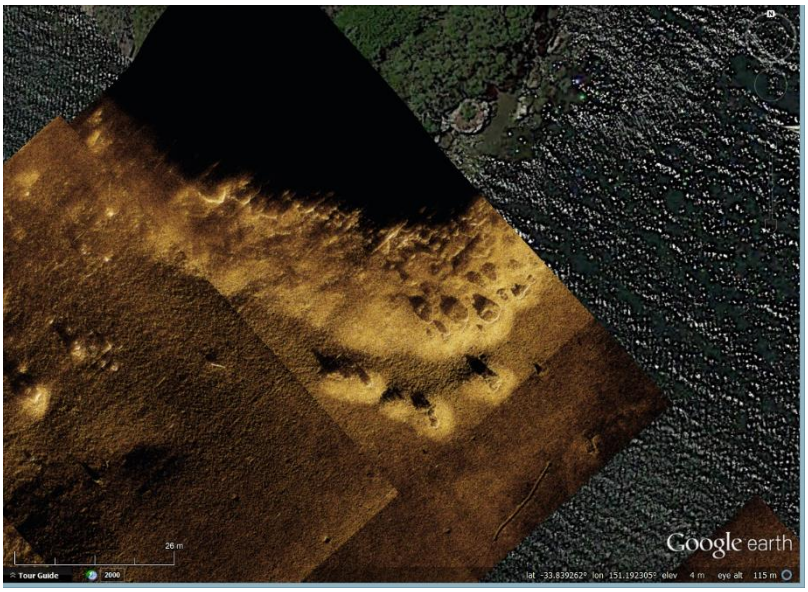

Figure 1: InSAS seabed imagery while operating in very shallow water.

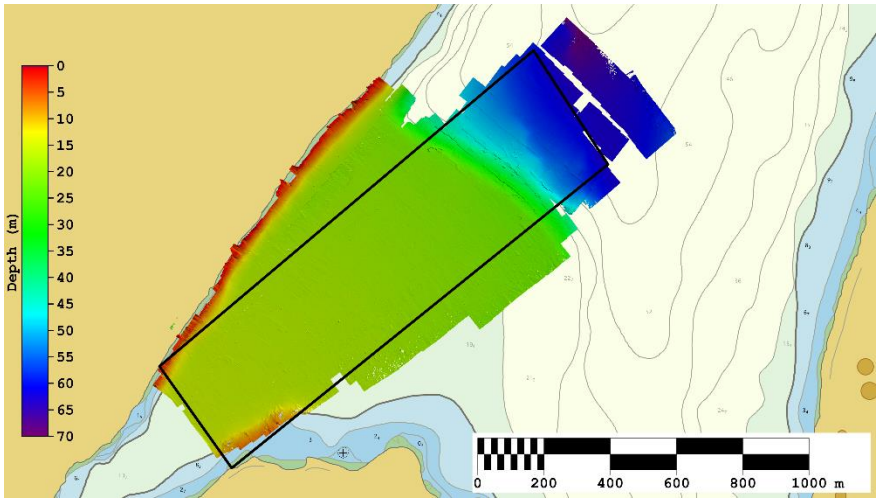

Figure 2: MINSAS bathymetry collected in shallow water near Holyrood, Newfoundland.

References

[1] M. Pinto, "Interferometric synthetic aperture sonar design optimized for high area coverage shallow water bathymetric survey", in *Proc. Underwater Acoustic Measurements*, Kos, Greece, 2011.