Acoustic Discrimination of Suspended Washload and Near-Bed Fluid Mud Dynamics in a Shallow Subtropical Lagoon

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To clarify the complex sediment transport mechanisms within a shallow subtropical lagoon and establish a high-resolution spatial distribution model, this study employed a vessel-mounted multi-frequency Acoustic Doppler Current Profiler (SonTek M9 ADCP) for transect surveys. The study simultaneously collected bathymetry, velocity profiles, and acoustic backscatter intensity (SNR) data, complemented by in-situ water sampling for Suspended Sediment Concentration (SSC) and grain size analysis. Addressing the acoustic signal processing challenges in shallow, fine-grained environments, we adopted the USGS Sediment Acoustic Index Method. Crucially, we incorporated instrument-specific parameters derived from Conevski et al. (2019), correcting the scale factor to dB/count and applying near-field corrections based on effective transducer apertures to overcome the limitations of conventional single-frequency inversion methods in heterogeneous environments.
Preliminary results indicate a statistically insignificant correlation between in-situ SSC samples and acoustic signals (SNR) in the surface layer. Grain size analysis confirmed that surface sediments are predominantly silt and clay (<63). According to Rayleigh scattering theory, this size range is largely invisible to 1.0 MHz acoustic frequencies, resulting in an "acoustic blindness" phenomenon that effectively identifies the surface layer as tidal-driven washload. In contrast, multi-frequency acoustic probing detected distinct high-intensity reflection signals and frequency-dependent boundaries in the near-bed region, revealing the presence of a high-concentration fluid mud layer or active layer. This study demonstrates that by utilizing the frequency differential technique of multi-frequency ADCP, it is possible to successfully decouple the "invisible" surface washload from the "visible" near-bed transport. This approach not only corrects concentration estimation errors in fine-grained environments but also provides a robust, non-intrusive method for quantifying near-bed sediment flux and morphological evolution in shallow lagoons.

Keywords: Acoustic Backscatter, Grain Size Effect, Lagoon

