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Vertical and Spatial Variability of Sound Velocity in a Shallow Tropical Lagoon: Implications for Echo Sounding at the UNILAG Waterfront

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12:40 – 1:00 pm (WAT) | In person

Theme: Innovations for Sustainable Development and Resilient Infrastructure



OUTLINE

Presentation Outline

01 Introduction and background

02 Problem statement, aim and objectives

03 Study area, data and methods

04 Results: profiles, stratification and depth error

05 Conclusions and recommendations

06 References and acknowledgements

Background and Study Area

- An echo sounder converts travel time to depth with an assumed velocity, so any error in that velocity scales with depth (Lurton, 2010)
- Lagoon salinity responds to river inflow, rainfall and tidal exchange, giving marked spatial and seasonal gradients
- Sand dredging is widespread and depths of up to 9.9 m have been recorded, so depressions can retain denser saline water
- Hydrographic work around UNILAG nevertheless assumes a nominal 1500 m/s, and no profile structure has been published

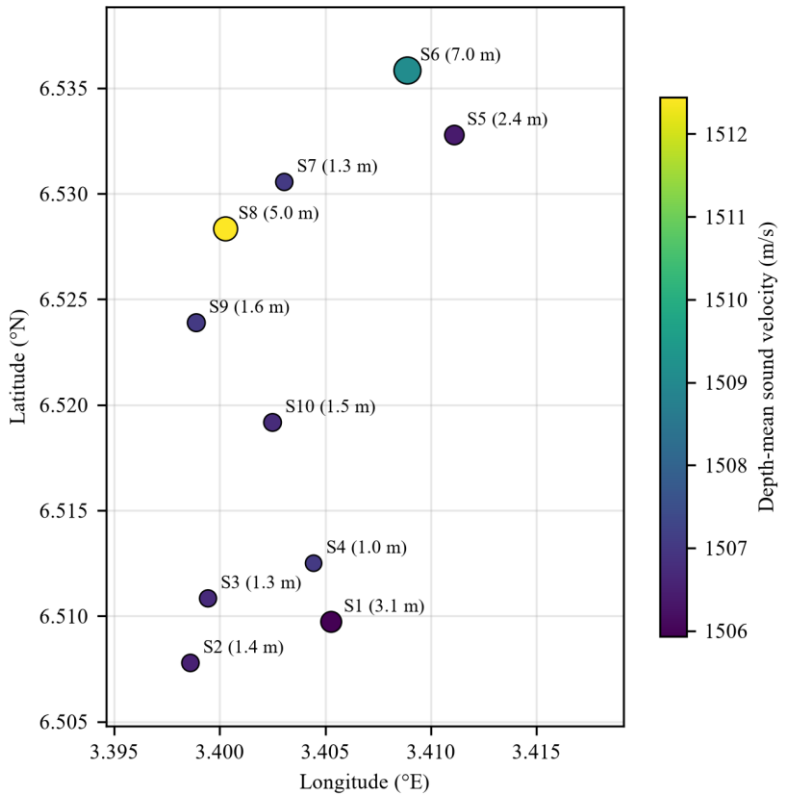


Figure 1: Sampling stations along the UNILAG waterfront, with water depth (labels) and depth-mean sound velocity (colour).

INTRODUCTION

Problem Statement, Aim and Objectives

PROBLEM STATEMENT

Surveys along the UNILAG waterfront assume a nominal sound velocity of 1500 m/s, although neither the vertical structure of the water column nor its variation between stations has been measured.

AIM

The aim of this study is to characterise the vertical and spatial variation of sound velocity along the UNILAG waterfront and quantify its consequences for depth determination.

OBJECTIVES

1. To derive quality-controlled sound velocity and temperature profiles at ten stations
2. To compare depth-mean velocities between stations and identify stratification
3. To infer the salinity structure implied by the profiles
4. To evaluate the depth error arising from an assumed velocity of 1500 m/s

METHODOLOGY

Data Acquisition, Quality Control and Analysis

1 Data acquisition

Ten stations, 19 casts with a Hydro-Tech SVP1500 at 8 Hz, 4 September 2026, high tide

2 Processing

Binary decode; pressure converted to depth with the in-air reference removed

3 Quality control

In-air, bottom-contact and outlier records removed: 2,447 of 4,537 retained

4 Analysis

Harmonic depth-mean velocity, inferred salinity and depth error against IHO S-44

QUALITY CONTROL IN FOUR STEPS

Remove in-air records and anything shallower than 0.15 m

Keep the down-cast only; use the up-cast as a repeatability check

Truncate at the first bottom-contact drop of more than 3 m/s

Remove isolated low values in the lowest 0.3 m of each cast

KEY SPECIFICATIONS

UNILAG waterfront; depths 1.0–7.0 m

10 stations, 19 casts, 4 September 2026

SVP1500: ±0.05 m/s; temperature ±0.05 °C

IHO S-44 Special and Exclusive Orders

RESULTS

The Shallow Margins Are Well Mixed; the Deep Stations Are Stratified

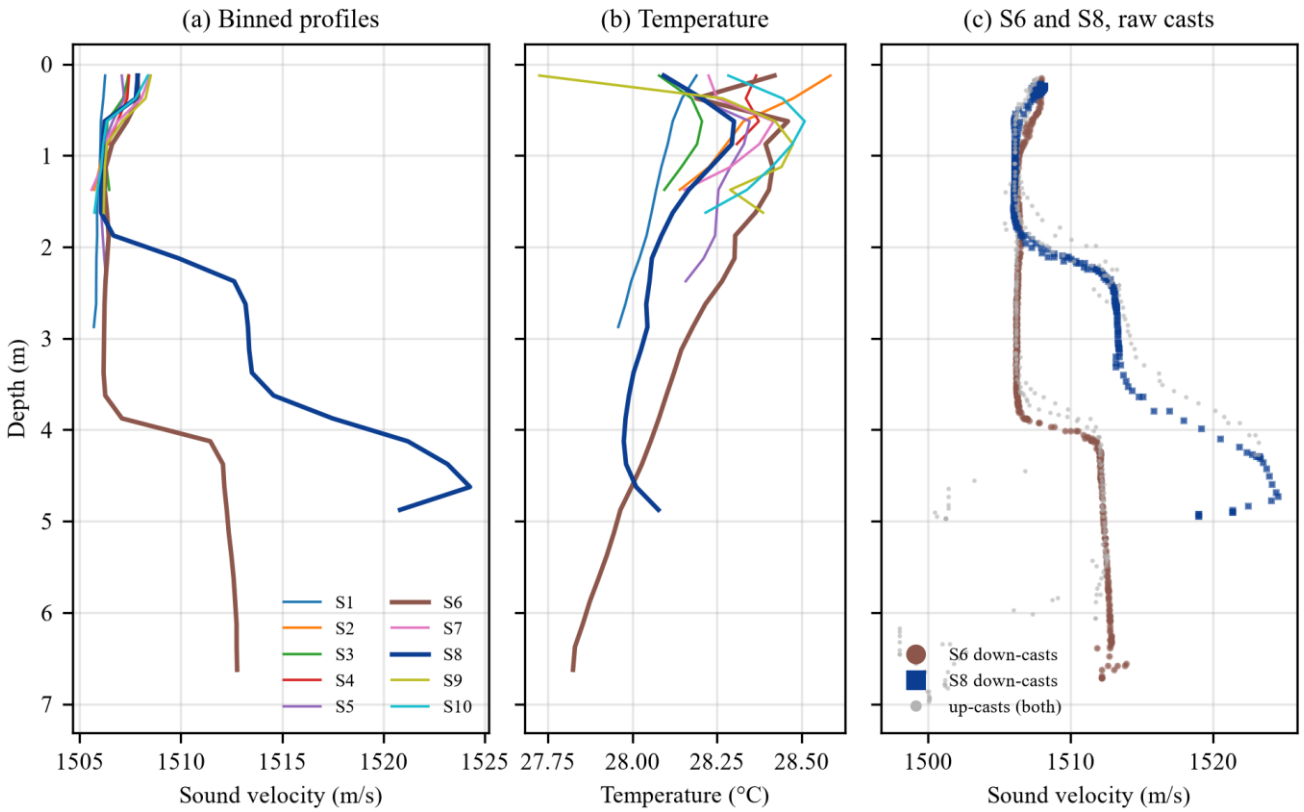


Figure 2: (a) Quality-controlled sound velocity profiles in 0.25 m bins; (b) temperature profiles; (c) raw down- and up-casts at Stations 6 and 8.

KEY FINDING

18 m/s

rise in sound velocity below 1.9 m at Station 8, with a 6.5 m/s halocline below 3.6 m at Station 6

- The eight shallow stations (≤ 3.1 m) are homogeneous at 1505.9–1507.1 m/s
- Temperature varies only between 27.6 °C and 28.6 °C, so the structure is salinity-driven

RESULTS

Depth-Mean Velocity Is Governed by Depth, Not by Position

Station group	Depth (m)	Mean c (m/s)	ΔD at 1500 m/s (cm)	% of Special TVU
Shallow margins (8 stations)	1.0–3.1	1505.9–1507.1	−1.2 to −0.5	1.8–4.9
Station 6 (stratified)	7.0	1509.1	−4.2	16.4
Station 8 (stratified)	5.0	1512.4	−4.1	16.2

Table 1: Depth error from an assumed velocity of 1500 m/s and its share of the IHO S-44 Special Order total vertical uncertainty.

WHAT THE TABLE SHOWS

Every measured velocity exceeded 1500 m/s, so a sounder set to that value under-reads throughout.

At the deep stations the error consumes about 16% of the Special Order budget, and 26% of the Exclusive Order budget, before any other source.

A single survey-wide mean of 1507.5 m/s corrects the shallow margins but leaves −0.7 and −1.6 cm at the stratified stations.

RESULTS

Bottom-Contact Artefacts Affected Almost Half the Casts

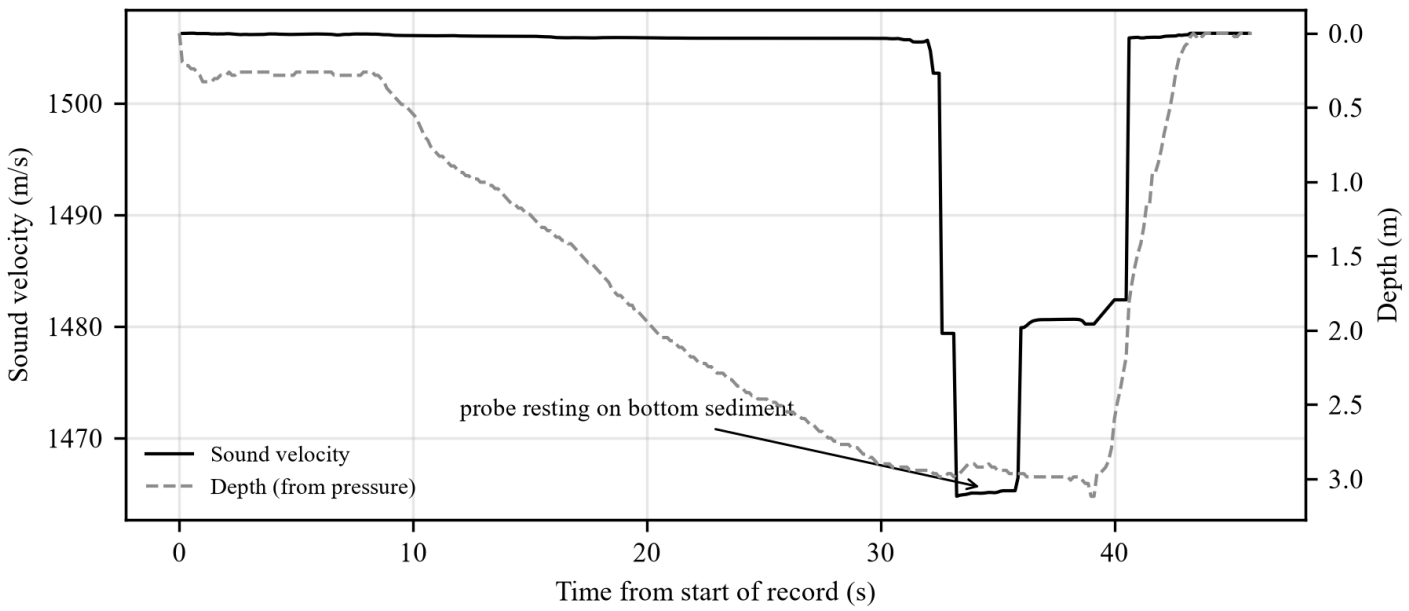


Figure 3: Raw record of the Station 1 cast — sound velocity collapses by about 41 m/s while the probe rests on the bed, then recovers on lifting.

KEY FINDING

8 of 19

casts contained bottom-contact episodes, depressing sound velocity by 10–46 m/s

- Retaining them lowers the cast mean by up to 5 m/s and suggests apparent depth errors above 2%
- The pressure channel records absolute pressure and must be referenced to the in-air value

DISCUSSION

Discussion of Findings

A This study

- The shallow margins behave as a single, well-mixed acoustic medium
- Saline bottom water persists in two depressions 5–7 m deep, consistent with dredged or sand-mined pockets
- Acoustic structure is governed by bathymetry as much as by distance from the sea

B Previous studies

- Analogous to the salt wedges of microtidal estuaries (Krvavica et al., 2021)
- Confirms that stratification biases swath bathymetry where profiles are poorly resolved (Nistad & Westfeld, 2022)
- Shows the limit of inferring salinity from temperature alone, as shallow-water practice often does

IMPLICATIONS

Take velocity profiles in, and not merely near, the deeper depressions of the lagoon; screen raw profiler data for bottom-contact artefacts before use; and sample haloclines explicitly for swath systems, where gradients of 10–12 m/s per metre refract oblique beams.

Conclusions and Recommendations

C Conclusions

1. Shallow margins are near-fresh and well mixed at 1505.9–1507.1 m/s; the deepest stations reach 1509.1 and 1512.4 m/s
2. An assumed 1500 m/s under-reads by 0.39–0.82% (0.5–4.2 cm), up to 16% of the S-44 Special Order budget
3. Bottom-contact artefacts in 8 of 19 casts must be removed before any profile is applied to soundings

R Recommendations

1. Profile sound velocity inside the deeper depressions, not only over the shallow margins
2. Screen raw profiler data and convert pressure to depth with the atmospheric reference removed
3. Add a conductivity sensor, a winch-controlled deployment and repeat surveys over tidal and seasonal cycles

References

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Thank You

Questions and discussion

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