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Field Determination of Single Beam Echo Sounder System Parameter Error and the Role of Sound Velocity, University of Lagos Lagoon

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Theme: Innovations for Sustainable Development and Resilient Infrastructure



OUTLINE

Presentation Outline

01 Introduction and background

02 Problem statement, aim and objectives

03 Instrument, site and methods

04 Results: parameters, admissibility and compliance

05 Conclusions and recommendations

06 References and acknowledgements

INTRODUCTION

Background to the Study

- The single beam echo sounder remains the standard instrument for inshore, harbour and inland survey, and is now carried on small uncrewed vessels (Specht et al., 2021)
- It does not measure depth: it measures two-way travel time, which an operator-supplied sound velocity converts to depth
- Two systematic errors follow — an index error constant with depth and a scale error proportional to depth (Hare, 1995)
- The bar check, the conventional field procedure, is often run at a single depth and reported as a correction without uncertainties

THE KNOWLEDGE GAP

Index and scale error are seldom determined together, with standard errors, over a stated depth span, and tested for physical admissibility.

This study determines both for a low-cost sounder under field conditions, and isolates the contribution of sound velocity.

INTRODUCTION

Problem Statement, Aim and Objectives

PROBLEM STATEMENT

Routine bar checks cannot separate index error from scale error, and calibration results are reported as corrections without uncertainties, so the dominant contribution of sound velocity to the error budget goes unquantified.

AIM

The aim of this study is to determine the system parameter error of a South SDE-series single beam echo sounder under field conditions on the University of Lagos lagoon.

OBJECTIVES

1. To estimate index and scale errors, with standard errors, under the default and a measured sound velocity
2. To test the physical admissibility of the fitted parameters
3. To test for directional hysteresis between ascending and descending sequences
4. To assess the results against the manufacturer's specification and IHO S-44

METHODOLOGY

Instrument, Site and Methods

1 Instrument

South SDE-series sounder on its 200 kHz channel, 7° beam, 0.01 m depth resolution

2 Observations

Boat station on the UNILAG lagoon, 1.15–3.00 m; 0.1 m steps, ascending and descending

3 Analysis

Least-squares fit $O = A + B \cdot M$; implied velocity from the gradient; Welch tests of hysteresis

4 Assessment

Manufacturer tolerance and the IHO S-44 Exclusive, Special and Order 1a envelopes

WHY THE DETERMINATION MOVED TO THE FIELD

Laboratory vessels 0.305 m and 0.935 m deep were tried first

A 0.30 m minimum working depth and 0.20 m blanking left no usable range

12 of 36 settings in the larger tank returned no detection

The implied velocity of about 1735 m/s is unattainable in water

KEY SPECIFICATIONS

UNILAG lagoon; depth span 1.15–3.00 m

60 paired readings in four sequences

Default 1408 m/s vs measured 1506 m/s

IHO S-44 (6th ed.); ±(1 cm + 0.1% of depth)

RESULTS

The Default Velocity Setting Makes the Sounder Under-Read

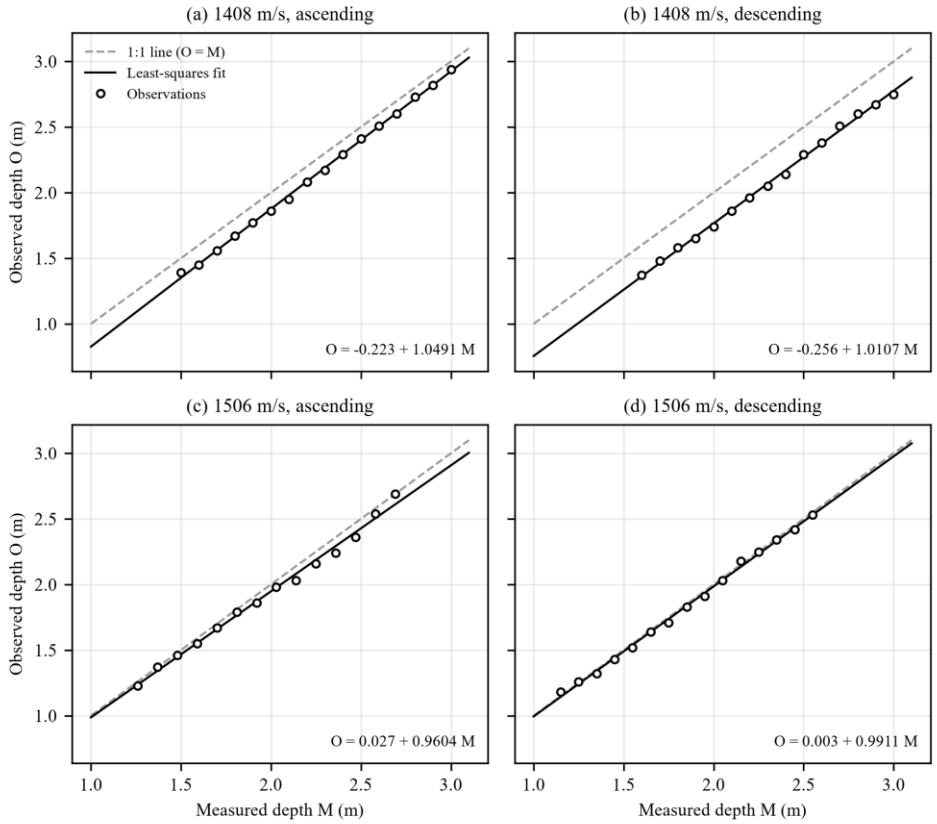


Figure 1: Observed against measured depth for each phase and direction, with the least-squares line and the 1:1 line.

KEY FINDING

−17.0 cm

pooled mean bias under the default 1408 m/s setting, against −14.8 cm expected from the velocity mismatch alone

- With the scale factor fixed at 1408/1506, the residual offset is only −2.2 cm
- Under the measured 1506 m/s the bias falls to −5.1 cm (ascending) and −1.3 cm (descending)

RESULTS

Fitted Parameters Are Admissible Only under the Measured Velocity

Phase / direction	A (cm)	B	p (B = 1)	Implied c (m/s)
1408 m/s, ascending	−22.30 ± 2.08	1.0491 ± 0.0090	< 0.001	1342
1408 m/s, descending	−25.60 ± 3.02	1.0107 ± 0.0129	0.421	1393
1506 m/s, ascending	+2.67 ± 4.63	0.9604 ± 0.0229	0.109	1568
1506 m/s, descending	+0.32 ± 2.58	0.9911 ± 0.0136	0.522	1520

Table 1: Least-squares estimates of the index error A and the scale factor B (± standard error), with the implied sound velocity.

WHAT THE TABLE SHOWS

A sounder set to 1408 m/s in water of 1506 m/s should give B ≈ 0.935; both gradients instead exceed unity, and the implied velocities are unattainable.

Over a 1.5 m span far from the origin, A and B are almost perfectly correlated (r = −0.98), so the intercept is an extrapolation.

Under 1506 m/s neither parameter differs significantly from its ideal value.

RESULTS

Under the Measured Velocity Every Reading Meets S-44 Exclusive Order

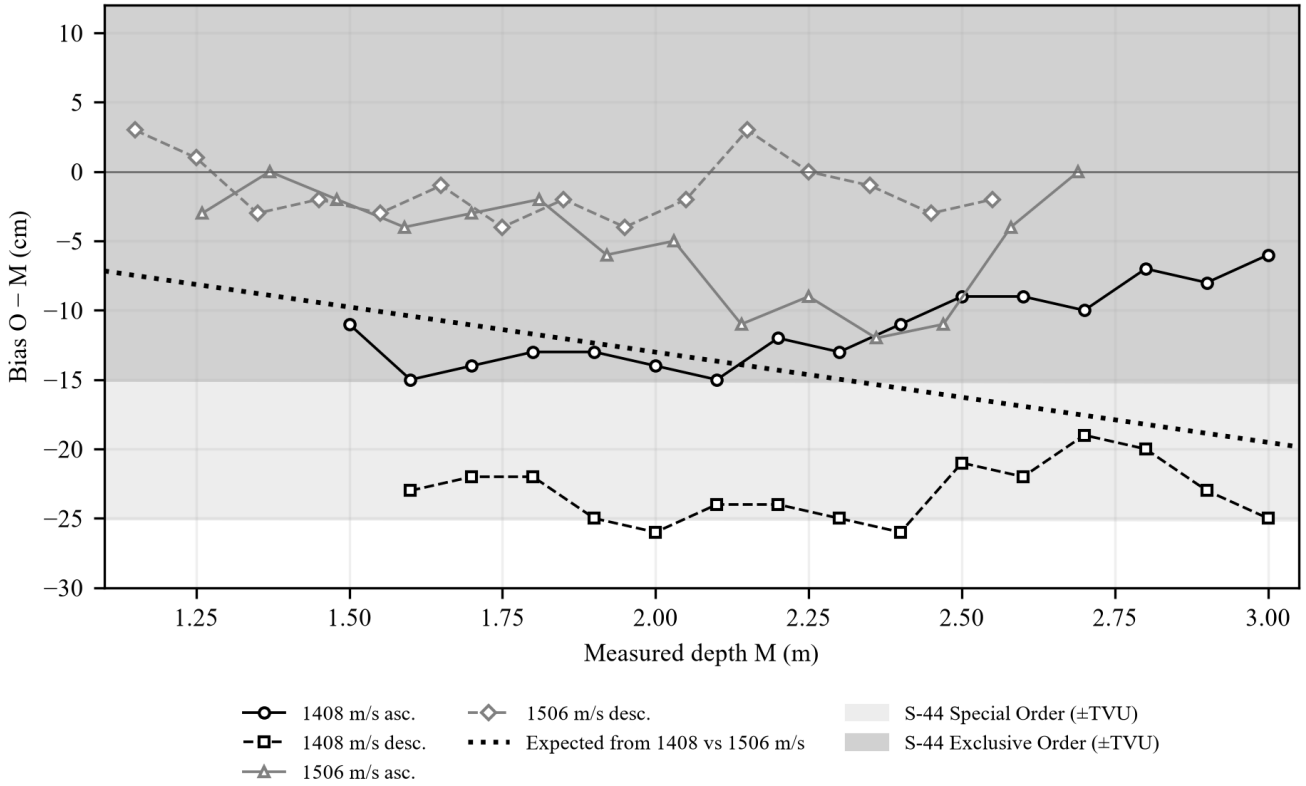


Figure 2: Bias (O − M) against measured depth, with the bias expected from the velocity mismatch and the IHO S-44 Exclusive and Special Order envelopes.

KEY FINDING

0 of 29

readings under the measured velocity fell outside the S-44 Exclusive Order envelope

- All 15 default-velocity descending readings fell outside it, and two outside Special Order
- Hysteresis of 3.8–11.9 cm between sequences points to the boat-referenced depth datum

DISCUSSION

Discussion of Findings

A This study

- The error under the default configuration is sound velocity, not a hardware index error
- A free two-parameter fit over a short span can be significant yet physically impossible
- The boat-referenced depth datum contributes errors as large as those being sought

B Previous studies

- Confirms error budgets that identify velocity as the dominant systematic term (Hare, 1995)
- Comparable with the 0.17 m mean absolute error of a low-cost sounder in a large river (Helminen et al., 2019)
- Extends bar-check practice (IHO, 2020) by reporting standard errors and testing admissibility

IMPLICATIONS

Measure and enter the sound velocity before every inshore survey; report calibration with standard errors, the depth span and the correlation between the two parameters; and check the implied velocity for physical admissibility. The same applies to the small uncrewed survey vessels now used in shallow water.

Conclusions and Recommendations

C Conclusions

1. Under 1408 m/s the sounder under-read by 11–23 cm, explained by the mismatch with the measured 1506 m/s
2. The free-fit index errors of −22 to −26 cm were extrapolation artefacts and physically inadmissible
3. Under the measured velocity A = +0.32 ± 2.58 cm and B = 0.9911 ± 0.0136, and all readings met S-44 Exclusive Order

R Recommendations

1. Measure the sound velocity of the water body and enter it before every survey
2. Report calibration with standard errors and test the implied velocity for admissibility
3. Use a platform-independent depth reference, replicated sequences and a wider depth range

References

Hare, R. (1995). Depth and position error budgets for multibeam echosounding. *International Hydrographic Review, 72*(2), 37–69.

Helminen, J., Linnansaari, T., Bruce, M., Dolson-Edge, R., & Curry, R. A. (2019). Accuracy and precision of low-cost echosounder and automated data processing software for habitat mapping in a large river. *Diversity, 11*(7), Article 116. https://doi.org/10.3390/d11070116

International Hydrographic Organization. (2020). *IHO standards for hydrographic surveys* (Special Publication No. S-44, 6th ed.).

Specht, M., Stateczny, A., Specht, C., Widźgowski, S., Lewicka, O., & Wiśniewska, M. (2021). Concept of an innovative autonomous unmanned system for bathymetric monitoring of shallow waterbodies (INNOBAT system). *Energies, 14*(17), Article 5370. https://doi.org/10.3390/en14175370

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Thank You

Questions and discussion

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