Fisheries Research 188 (2017) 149–156

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Surface-induced errors in target strength and position estimates during horizontal acoustic surveys.

Helge Balk[a,b], Bendik S. Søvegjarto[a], Michal Tušer[b], Jaroslava Frouzová[b], Milan Muška[b], Vladislav Draštík[b], Roman Baran[b,c], Jan Kubečka[b,*]

[a] *Department of Physics, University of Oslo, PO. Box. 1048. Blindern, NO-0317 Oslo, Norway*
[b] *Biology Centre of the Czech Academy of Sciences, v.v.i., Institute of Hydrobiology, Na Sádkách 7, 370 05 České Budějovice, Czechia*
[c] *Faculty of Science, University of South Bohemia, České Budějovice, Czechia*

ARTICLE INFO

Article history:
Received 23 August 2016
Received in revised form
21 December 2016
Accepted 23 December 2016
Handled by Prof. George A. Rose
Available online 4 January 2017

Keywords:
Hydroacoustics
Surface boundary
Shallow water
Horizontal beaming
Simulations

ABSTRACT

Horizontally-aligned, fixed and mobile, transducers are routinely deployed at depths of 0.5–0.75 m to survey the surface layer of waterbodies for fish. However, simulations and measurements demonstrate that a smooth surface can cause serious errors in the target strength (TS) and split-beam angular position estimates.

Errors in TS up to 10 dB and depth position up to 0.5 m were observed. Simulations suggested that multi-path signal propagation interfered with the direct path of that signal. Furthermore, when a standard target (calibration copper sphere) was moved away from the transducer at fixed depths, the estimated TS and depth of the target started to oscillate as a function of range. The amplitude increased with increasing range. The frequency decreased from the oscillation start until a certain range where the oscillation stopped. The region of oscillation depended on both the transducer and target depth. Horizontal observations of known fish echoes behaved similarly. Experiments in a lake showed that the influence from the surface disappeared when the surface became rippled due to wind.

1. Introduction

Hydroacoustic methods are well established for monitoring fish in water bodies (Simmonds and MacLennan, 2005). The methods work for the pelagic zone, but the surface and bottom zones are challenging. The surface layer can be monitored with bottom-up (Čech and Kubečka, 2002) or horizontally mounted transducers (Kubečka and Wittingerová, 1998). Mobile bottom-up methods are technically more challenging and do not work in areas too shallow to give a sufficient sampling volume. Thus, the horizontal method often remains as the only option for hydroacoustic surveying of shallow layers.

During horizontal acoustic surveys, the transducers are often mounted at depths of 0.5–0.75 m below the surface, panned sideways, and tilted so that the upper half-power edge of the beam is parallel with the surface. According to our experience this setting allows observing ranges from 4 to something around 30 m away from the boat depending on the surface state and water depth.

The surface layer, however, poses some problems with the horizontal application (Simmonds and MacLennan, 2005). First, even slight rolling of the boat can easily cause the beam to strike the surface, which can act as a strong acoustic reflector. Second, temperature depth gradients inside the surface layer can be strong and cause refraction of the propagating sound (Medwin and Clay, 1998). Third, sound multi-pathing induced by non-ideal beam patterns and reflections from a smooth surface can cause interference.

Generally, the horizontal setup with the beam well-aligned below the surface relies on the assumption that outside the half-power beam there is too little sound energy to cause any interaction with the surface. The background for the assumption is that the acoustic intensity drops off very quickly outside the half-power beam and that the side lobes for the commonly applied transducers are well damped.

The main aim of this paper is to investigate whether this assumption is correct or not, and how failure of the assumption may influence on the echo-sounder's ability to estimate the target's vertical positions and target strengths. The influence on the echo-sounder is demonstrated with in situ experiments, and the theoretical explanation is supported with simulations.

---

* Corresponding author.

E-mail addresses: helge.balk@fys.uio.no (H. Balk), bendik@sovegjarto.com (B.S. Søvegjarto), michal.tuser@gmail.com (M. Tušer), jarkafrouzova@gmail.com (J. Frouzová), MuskaMilan@seznam.cz (M. Muška), v.drastik@gmail.com (V. Draštík), r.baran@centrum.cz (R. Baran), kubecka@hbu.cas.cz (J. Kubečka).

http://dx.doi.org/10.1016/j.fishres.2016.12.017

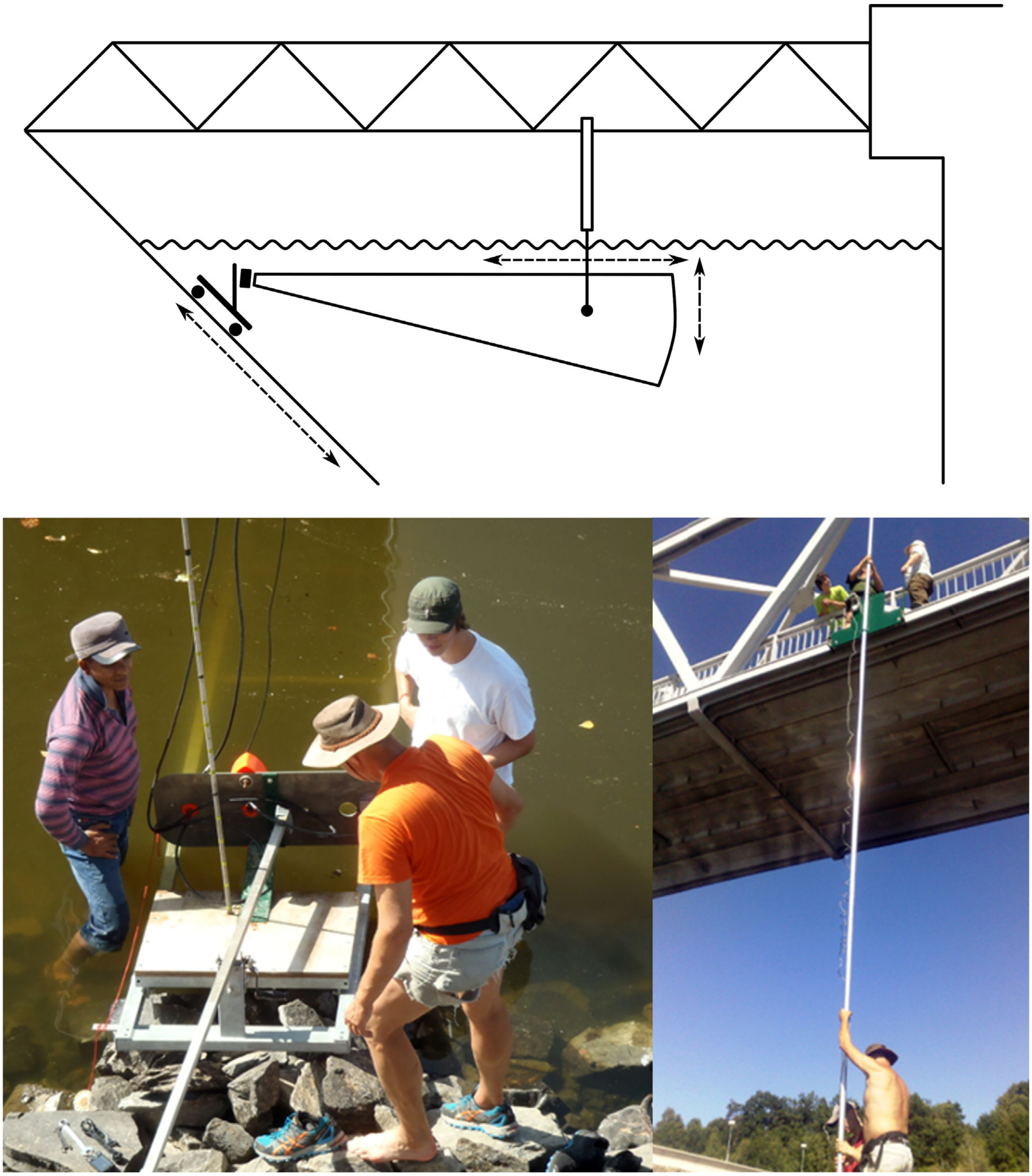

Fig. 1. Experimental setup: Upper: A scheme showing the deployment of a transducer and standard target below the bridge to the Římov reservoir control tower. Dashed arrows indicate directions of movement of the transducer's stand and the acoustic test target. Lower left: The transducer stand with the attached elliptic transducer ES120-4x10. The long bar connected to transducer's plate controlled the tilt, the vertical pole determined the depth of the transducer. An electronic Attitude and Heading Reference System (AHRS) (not seen) measured the tilt. The stand was situated on rails enabling depth adjustment. Lower right: The monorail with a long pipe sheltering and guiding a monofilament line holding the standard target to the surface of the reservoir.

2. Material and methods

2.1. In-situ experiments

We mounted standard targets at fixed depths and moved them away from the fixed positioned transducer. The main experiments were conducted in the Římov reservoir (Czech Republic) under the bridge leading to the water outlet and power control tower. The reservoir-bed is steep at this site (Fig. 1).

The acoustic recordings were done with a Simrad EK60 echosounder equipped with an ES120-4x10 transducer. The transducer was an ordinary tonpilz transducer with 108 weighted elements operating at 120 kHz, and with a $4 \times 10^{\circ}$ opening angle. The elliptical opening angle has made this transducer popular for horizontal mobile lake and fixed river counting applications. We used it in the most common way with the 4° axis marked on the transducer as the along ship axis pointing vertical in the water. The EK60 was set up with a pulse-duration of 0.128 ms, and a power of 100 W. With this setup, the pulse consists of about 15 cycles. With a sound speed of 1487 m/s, the wavelength λ is approximately 1.23 cm.

The transducer was mounted on a railcar running on a platform going down into the water along the steep reservoir bed. The platform was equipped with rails, legs and a winch. The legs facilitated deployment on the reservoir bed, and the winch enabled us