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Fish avoidance of acoustic survey boat in shallow waters

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Abstract

The avoidance reactions of fish with respect to a survey vessel were studied during horizontal acoustic applications of a Simrad EY500 split-beam echosounder (120 kHz) in two lakes (Wallersee, Balaton) and two reservoirs (Orlík, Římov). Three methods were used to assess the avoidance reaction of fish to the survey vessel: (1) comparison of acoustically detected fish biomass at different distances, (2) determination of the fish direction vector (echogram slope) with respect to the transducer and (3) direct acoustic observation of fish behaviour in front of the moving vessel. Comparing acoustic biomass in order to demonstrate avoidance reactions is limited. All fish were divided in two groups according to the slope of their movement: with a positive value of slope (fish swimming away from the transducer) and with a negative slope (fish swimming towards the transducer). Fish avoidance caused higher slope values. Most avoidance behaviour was found with small fish (target strength, TS < −40 dB, 22 cm) at distances under 10 m. Only in the clear lake Wallersee were some indications of avoidance up to a distance of 15 m from the survey boat. There were no significant indications of fish avoidance in the Czech reservoirs. Much less avoidance behaviour was found with fish larger than TS > −40 dB. At distances over 10 m, the avoidance of small boats (5–6 m long, 15–25 HP two-stroke engine) appears not to be a serious problem in shallow waters.

Keywords: Fish behaviour; Avoidance; Echogram slope; Acoustic biomass; Echosounder

1. Introduction

Fish avoidance behaviour could be a serious problem in fisheries acoustics since fish avoiding boats could bias the results of acoustic stock assessments. Fisheries management needs a precise estimate of fish stocks in order to obtain unbiased estimates of fish biomass and distribution (MacLennan and Simmonds, 1992). A number of papers have focused on fish avoidance in the marine environment (Olsen, 1990; Ona and Godø, 1990; Gerlotto and Fréon, 1992; Soria et al., 1996; Vabø et al., 2002; Handegard et al., 2003). The avoiding shoals of fish swimming away from the approaching boat, either horizontally or vertically, are exposing less reflective parts of the body to the sonar beam. The intensity of avoidance behaviour varies

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among fish species (Misund, 1990; Olsen, 1990). Only a few authors have dealt with freshwater fish avoidance behaviour (Mous and Kemper, 1996; Lucas et al., 2002) although it has been shown that routine acoustic surveys performed with marine research vessels suffer from fish avoidance (Mitson and Knudsen, 2003) and the vessel noise makes fish avoid at tens or hundreds of meters. Acoustic surveys in freshwaters are carried out by relatively small vessels beaming over short distances (usually 15–50 m) suggesting both greater (short distances, visual stimuli) and less (lower vessel size and noise intensity) avoidance. Three different approaches have been taken in this paper in an attempt to quantify the effects of potential bias, due to fish avoidance, upon surveys of shallow waters by horizontal sonar. Avoidance at different distances from the survey boat, and by different fish sizes, was considered. Routine acoustic surveys and experiments with observations of fish in front of a moving vessel were carried out in two reservoirs and two lakes with different hydrobiological characteristics, in order to evaluate fish avoidance behaviour. All four localities have some limited boat traffic, so the fish would have had some previous contacts with motorboats.

2. Materials and methods

2.1. Study area

Hydroacoustic studies of Lake Balaton, Wallersee and Orlík reservoir were chosen for analysis and direct fish avoidance experiments were carried out at Římov reservoir. Lake Balaton is a shallow eutrophic lake in Hungary with a water surface area of 600 km^2, an average depth of 3.5 m and a maximum depth of 11 m. The night survey was performed during 7–9 September 1997. The most abundant fish species were bream (*Abramis brama*), roach (*Rutilus rutilus*), bleak (*Alburnus alburnus*), rudd (*Scardinius erythrophthalmus*), and white bream (*Blicca bjoerkna*) (Bíró et al., 2003). Orlík reservoir is a deep eutrophic dam in Czech republic with a water surface area of 27 km^2, an average depth of 26 m and a maximum depth of 80 m where the fish stock mainly consisted of roach, perch (*Perca fluviatilis*), bream and bleak (Kubečka, pers. commun.). The survey was carried out during 28–30 June 1997. Wallersee is a relatively shallow meso/eutrophic lake in Austria with a water surface area of 6 km^2, an average depth of 12.5 m and a maximum depth of 22 m where the fish stock mainly consisted of bream, carp (*Cyprinus carpio*), pike (*Esox lucius*) and corregonids (Coregonidae) (Gassner and Wanzenböck, pers. commun.). The daytime survey was performed during 24–25 August 1996. Římov reservoir is a deep meso/eutrophic dam in Czech republic with a water surface area of 2 km^2, an average depth of 16 m and a maximum depth of 43 m. The fish avoidance experiments were performed during 21–23 August 2000 and 3 July 2002. The fish stock consisted of roach, bream, perch and bleak (Vašek et al., 2003). The surveys were done at night in Balaton and during the daytime in Wallersee, Orlík and Římov.

2.2. Data collection and analysis

A Dory 13 boat powered with a 15 HP combustion engine mounted outboard and with a special transducer frame mounted on the front end of the boat, enabling horizontal beaming, was used (Kubečka and Wittingerová, 1998). We have assumed only horizontal avoidance because of the shallowness (Balaton) or strong water column stratification of the lakes and reservoirs (fish seem to be very unwilling to dive to cold deoxygenated waters; Kubečka and Wittingerová, 1998). The sonar system consisted of a Simrad EY 500 split-beam echosounder operating on 120 kHz frequency. An ES-120 elliptical split-beam transducer with nominal angles of 4.3 and 9.1° was beaming perpendicularly to the direction of the boat. The transducer was about 70 cm deep and tilted 2–3° downwards. The pan of the transducer was close to perpendicular with respect to the boat movement. The whole sonar system was calibrated using a 32 mm tungsten-carbide standard target. The gain of the echosounder was calculated according to Foote et al. (1987). Statistical assessment was done in STATISTICA (data analysis software system), Version 5.5 (StatSoft, Inc., 2001). One-way or two-way ANOVA tests were used for both acoustic biomass and echogram slope analysis.

Three different approaches were used for the assessment of avoidance behaviour:

1. Acoustic biomass approach: the comparison of an acoustic measure of fish biomass, volume scattering coefficient (s_v, m^2 of backscattering cross sections