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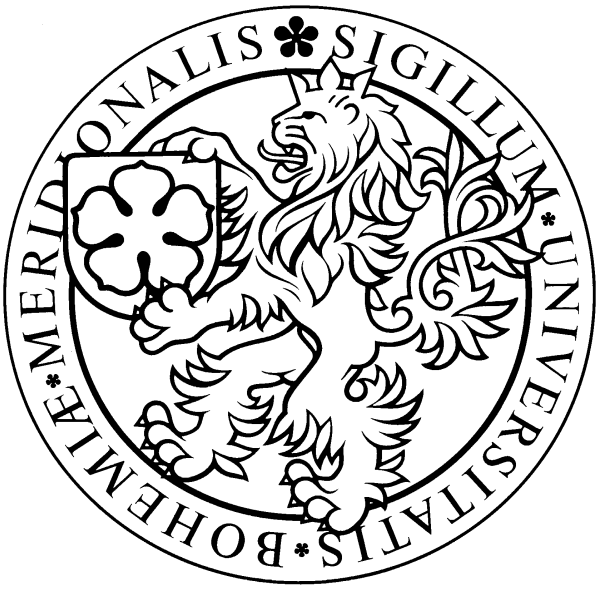

Fish avoidance of acoustic survey boat in shallow waters

RNDr. Thesis

Vladislav Draštík

Supervisor: Doc. RNDr. Jan Kubečka, CSc.
Biology Centre of the AS CR, v.v.i., Institute of Hydrobiology

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Annotation

The avoidance reactions of fish with respect to the survey vessel were studied during horizontal acoustic applications in two lakes and two reservoirs. Three methods were used to assess the avoidance reaction of fish: (1) comparison of fish biomass in different distances, (2) determination of fish direction vector and (3) direct observation of fish behaviour in front of moving vessel.

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Declaration of originality

The coauthor listed below fully acknowledges that Vladislav Draštík is the first author of the paper presented here. Also he did the major contribution in data processing and writing the manuscripts. The paper contains original results and was published in renowned international journal. The coauthors support this statement with their signatures.

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Introduction

Hydroacoustic has been proven a valuable method in fish stock assessment in both freshwater and marine environment (Horppila et al., 1996; Mehner and Schulz, 2002; Wanzenböck et al., 2003; Mueller & Horn, 2004; Simmonds & MacLennan, 2005). Hearing serves as main sense used by fishes for reception of sounds in surrounding environment (i.e. predator detection). Generally, fish are capable to hear sounds of frequencies of hundreds to thousands kHz (Baruš & Oliva, 1995; Boklach, 1989; Simmonds & MacLennan, 2005). Common scientific echosounders usually use frequencies in range of 36 kHz to 1 Mhz and are inaudible for majority of fish. Although, some species of family Alosinae and Clupeidae were reported to be capable of hearing ultrasounds of frequencies in range of 100-140 kHz (Popper & Carlson, 1998; Kumagai et al., 1999).

Main source of noise emitted by a running vessel are the vibration of the hull (vibration of diesel engine) and the propeller (Boklach, 1989). The emitted noise frequencies are in range easily sensible by fish and are audible on great distances (several kilometers) in water environment. The intensity of emitted noise depends on the construction of vessel and the engine power. It is also dependent on the speed (more noise in faster speeds). It is obvious that acoustic surveys need to be performed by vessels as silent as possible (Mitson, 1989). Acoustic noise doesn't spread uniformly from the vessel (Urick, 1975). Usually, the noise is emitted to both sides of the vessel while the area in front of the vessel is noiseless (Soria et al., 1996; Volpatti et al., 2002).

In close ranges, fish could detect survey vessels as visual stimuli and initiate avoidance behaviour. Most acoustic surveys are performed during night by various reasons, thus visual stimulation isn't usually big problem. Although similar avoidance reaction of could be evoked by deck lights, which could make fish to swim to deeper layers (Lévénez et al., 1990).

Avoidance behaviour of fish was repeatedly observed in marine environment applying mostly to schools of commercially valuable species (i. e. anchovies, herrings, mackerels, cods). Modeling of avoidance behaviour resulted in "double wave of avoidance model" or "fountain model" (Soria et al., 1996; Volpatti et al., 2002). This model suggests two waves of fish avoidance in different ranges – first horizontal avoidance to both sides of the vessel and later vertical avoidance reaction in the close range. Avoidance behaviour was also shown to change the shape of fish schools and possibly bias the biomass estimation of fish in such schools. Lower densities of fish in front of the vessel were caused by fish movements to deeper layers (Misund, 1990 and Olsen, 1990). Fish schools observed in depth up to 200 m reacted to approaching vessel by swimming further to the deeper layers. Fish schools in depths 200 – 500 m didn't show any avoidance reaction (Ona & Godø, 1990). Either horizontal or vertical avoidance reactions were connected with increasing swimming speed of fish. Avoidance behaviour with in marine environment is especially problematic when it affects significantly the effectiveness and selectivity of commercial trawling (Wardle, 1986; Ona & Godø, 1990).

Avoidance behaviour of fish in freshwaters was much less studied. Big schools aren't so common in freshwaters and individual behaviour plays important role. Also smaller vessels and weaker engines are in use caused much less intensive avoidance reaction of fish in

freshwaters. For above reasons, avoidance behaviour in freshwaters is usually neglected. Although fish reactions to survey boat were reported up to 20 m and escaping fish showed bigger target strength (TS, Mous a Kemper, 1996).

Generally, avoidance behaviour of fish could influence the estimates of hydroacoustic surveys in three ways: first, avoiding fish don't have to be even recorded if it swims far away from the insonified area; second, although recorded, density and biomass could be underestimated or overestimated by horizontal and vertical avoidance movements of fish; third, avoiding fish usually exposes the less reflective body part to the transducer (tail or head aspect) which bias the TS measurements.

Presented paper evaluates avoidance behaviour of freshwater fish in inland lakes and reservoirs. Three approaches were used assess the fish behaivour in front of surveying boat: (1) comparison of acoustic biomass in different distances from the boat, (2) evaluation of fish echogram vectors (slopes) in different distances from the boat and (3) direct observation of fish in front of approaching boat.

References

Baruš V., Oliva O., 1995. Mihulovci a ryby. Fauna ČR a SR. Academia, Praha, 623pp (in Czech)

Boklach, G. A., 1989. The effect of fishing vessel acoustic fields on the behaviour of speedy fish concentrations. Proc. I. O. A. Volume 11, part 3, 68-73

Horppila J., Malinen T., Peltonen H., 1996. Density and habitat shifts of a roach (*Rutilus rutilus*) stock assessed within one season by cohort analysis, depletion methods and echosounding. Fish. Res. 28, 151-161

Kumagai, K., Nealson, P A., Johnston, S V., 1999. Avoidance response of American shad to a 120 kHz hydroacoustic signal. Book of abstracts of the 2nd International Shallow Waters Fisheries Sonar Conference, Seattle. 14pp

Lévénez J.-J., Gerlotto F., Petit D. (1990): Reaction of tropical coastal pelagic species to artificial lightening and implication for the assessment of abundance by echointegration. Rapp. P.-v. Réun. Cons. int. Explor. Mer. 189: 128-134

Mehner T., Schulz M., 2002. Monthly variability of hydroacoustic fish stock estimates in a deep lake and its correlation to gillnet catches. J. Fish Biol. 61, 1109-1121

Misund, O. A., 1990. Sonar observation of schooling herring: school dimensions, swimming behaviour and avoidance of vessel and purse seine. Rapp. P.-v. Réun. Cons. int. Explor. Mer. 189, 135-146

Mous, P. J., Kemper, J., 1996. Application of a hydroacoustic sampling technique in large wind-exposed shallow lake. In: Cowx, I. G., (ed). Stock assessment in inland fisheries. Blackwell, Oxford, pp. 178-195

Mueller G., Horn M., 2004. Distribution and abundance of pelagic fish in Lake Powell, Utah, and Lake Mead, Arizona-Nevada. West. North Am. Naturalist 64, 306-311

Olsen, K., 1990. Fish behaviour and acoustic sampling. Rapp. P.-v. Réun. Cons. int. Explor. Mer. 189, 147-158

Ona, E., Godø, O. R., 1990. Fish reaction to trawling noise: the significance for trawl sampling. Rapp. P.-v. Réun. Cons. int. Explor. Mer. 189, 159-166

Popper, A. N., Carlson, T J., 1998. Application of sound and stimuli to control fish behavior. Transactions of the American Fisheries Society. 127: 673-707

Simmonds E.J., MacLennan, D.N., 2005. Fisheries Acoustics. Wiley-Blackwell, 2nd edition, Oxford, 437pp.

Soria, M., Fréon, P., Gerlotto, F., 1996. Analysis of vessel influence on spatial behaviour of fish schools using a multi-beam sonar and consequences for biomass estimate by echo-sounder. ICES J. Mar. Sci. 53, 453-458

Urick, R. J., 1975. Principles of Underwater Sound, 2nd edition McGraw-Hill Book Company, New York, 384 pp.

Volpatti, K., Gerlotto, F., Soria, M., Brehmer, P., 2002. A comparative evaluation of school lateral avoidance to survey vessel in different tropical areas. 6th ICES Symposium on Acousics in Fisheries and Aquatic Ecology. Papers on CD. Avoidance section.

Wanzenböck J., Mehner T., Schulz M., Gassner H., Winfield I.J., 2003. Quality assurance of hydroacoustic surveys: the repeatability of fish-abundance and biomass estimates in lakes within and between hydroacoustic systems. ICES J. Mar. Sci. 60, 486-492

Wardle, C S., 1986. Fish behaviour and fishing gear. In: Pitcher, T J., (ed). The behaviour of teleost fishes. Croome Helm, London. 463-495

Draštík V., Kubečka J., 2005. Fish avoidance of acoustic survey boat in shallow waters. Fish. Res. 72, 219-228

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Fish avoidance of acoustic survey boat in shallow waters

Vladislav Draštík[a,b,*], Jan Kubečka[a,b]

[a] *Faculty of Biological Sciences, University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic*
[b] *Hydrobiological Institute of AS CR, Na Sádkách 7, 370 05 České Budějovice, Czech Republic*

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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

Únikové reakce ryb ze zřetelem na průzkumnou loď byly studovány během horizontálního průzkumu vědeckým echolotem Simrad EY500 (120 kHz) ve dvou jezerech (Wallersee, Balaton) a ve dvou nádržích (Orlík, Římov). Tři metody byly použity pro posouzení rybích únikových reakcí na průzkumnou loď: (1) porovnání akusticky detekované rybí biomasy v různých vzdálenostech, (2) stanovení rybích vektorů (echogramový sklon) vzhledem k vysílači a (3) přímé akustické pozorování ryb před jedoucí lodí. Porovnání akustické biomasy je při studiu únikových reakcí omezeno. Všechny ryby byly rozděleny do dvou skupin podle sklonu pohybu: s pozitivním sklonem (ryba plave směrem od vysílače) a s negativním sklonem (ryba plave směrem k vysílači). Většina únikového chování byla pozorována u malých ryb (odrazová síla, TS < –40 dB, 22 cm) ve vzdálenosti do 10 m. Jen v průhledném jezeře Wallersee byly pozorovány náznaky únikového chování až do vzdálenosti 15 m od průzkumné lodi. Žádné známky rybího únikového chování nebyly pozorovány v českých nádržích. Mnohem méně intensivní únikové chování bylo pozorováno u ryb větších než TS > –40 dB. Ve vzdálenostech větších než 10 m se rybí únikové reakce před malou průzkumnou lodí (5-6 m délka, 15-25 HP dvoutaktní motor) nezdají být vážným problémem v mělkých vodách.

Author's contribution:
Vladislav Draštík is the first author of this paper. The share of her work is approximately 90%.