Fisheries Research 96 (2009) 133–138

Contents lists available at ScienceDirect

Fisheries Research

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

Hydroacoustic observations of surface shoaling behaviour of young-of-the-year perch *Perca fluviatilis* (Linnaeus, 1758) with a towed upward-facing transducer

Wolfgang Nikolaus Probst*, Gregor Thomas, Reiner Eckmann

Limnological Institute, University of Konstanz, Mainaustrasse 252, 78457 Konstanz, Germany

ARTICLE INFO

Article history:
Received 23 May 2008
Received in revised form 2 October 2008
Accepted 20 October 2008

Keywords:
Echosounding
School
Depth distribution
Pelagic zone
Lake Constance

ABSTRACT

The near-surface distribution of young-of-the-year perch was observed with a towed upward beaming echosounder system (SIMRAD EK60 with a circular 7° transducer). Perch aggregated densely in the epilimnion during daytime and dispersed evenly below the surface at night. Shoaling commenced in late June when perch metamorphosed from the larval to juvenile stage. Average shoal width was 6.6 m and average shoal height was 2.35 m in July, when perch were observed for the last time in the pelagic zone of Lake Constance.

Upward echosounding revealed the presence and near-surface distribution of pelagic juvenile perch and therefore this method can be used as a complementary survey tool to get more precise information about the distribution, behaviour and abundance of near-surface fish.

1. Introduction

Echosounding is one of the most feasible methods for *in situ* observation and documentation of fish distribution (Simmonds and MacLennan, 2005). Unfortunately, each echosounding application has its drawbacks: in vertical downward echosounding a blind zone of several meters below the surface has to be tolerated, as the transducer is mounted in a certain depth and cannot reliably measure objects within its near-field. Therefore objects within the first 2–3 m below the surface cannot be detected (Cech et al., 2005). Horizontal echosounding cannot determine the precise depth of an object, as the sound beam emitted by the transducer is bent by the vertical gradient in water temperature and reflected or scattered in an unpredictable manner at the thermocline and the surface. The only method for the detection of near-surface objects with precise depth information is thus vertical upward beaming, where the near-field of the transducer is not at the same depth as the investigated objects.

In larval and juvenile fish, behavioural adaptations have evolved to reduce the risk of mortality and optimize growth. Among these, shoaling is a common phenomenon among fish species experiencing high predation likelihood (Krause and Ruxton, 2002; Pavlov and Kasumyan, 2000). Shoaling decreases the risk for an individual to become a victim of a predator. The formation and synchronous swimming behaviour of schools distract the predator and reduce their capture efficiency. Shoaling is often species-, size- and even kin-assortive (Behrmann-Godel et al., 2006; Hoare et al., 2000; Krause, 1994). Besides reducing predation risk for the individual, shoaling can increase the foraging efficiency of planktivorous fish, when food resources are distributed in horizontal patches (Krause and Ruxton, 2002).

Perch larvae *Perca fluviatilis* (Linnaeus, 1758) hatch in the littoral zone in May and are transported into the open water within a few days after hatch (Urho, 1996). Wang and Appenzeller (1998) found perch in the open water of Lake Constance until the end of July, where they inhabited the epilimnion during day and night. During their pelagic stage they first feed on rotifers and small copepods and switch to large copepods and *Daphnia* with increasing gape size (Wang, 1994). While the abundance and distribution of pelagic perch has been investigated by Wang and Appenzeller (1998), the observation of their fine-scale depth distribution during day and night has not been attempted.

In the pelagic zone of Lake Constance, perch shoals are found directly below the surface during daytime and thus within the blind zone (mounting depth of transducer plus near-field) of a downward-beaming echosounder. In this study the shoaling behaviour of juvenile perch was observed by a towed upward beaming transducer as a method for the observation of near-surface objects.

* Corresponding author. Tel.: +49 7531 883216; fax: +49 7531 883533.
E-mail address: wolfgang.probst@uni-konstanz.de (W.N. Probst).

0165-7836/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.fishres.2008.10.009

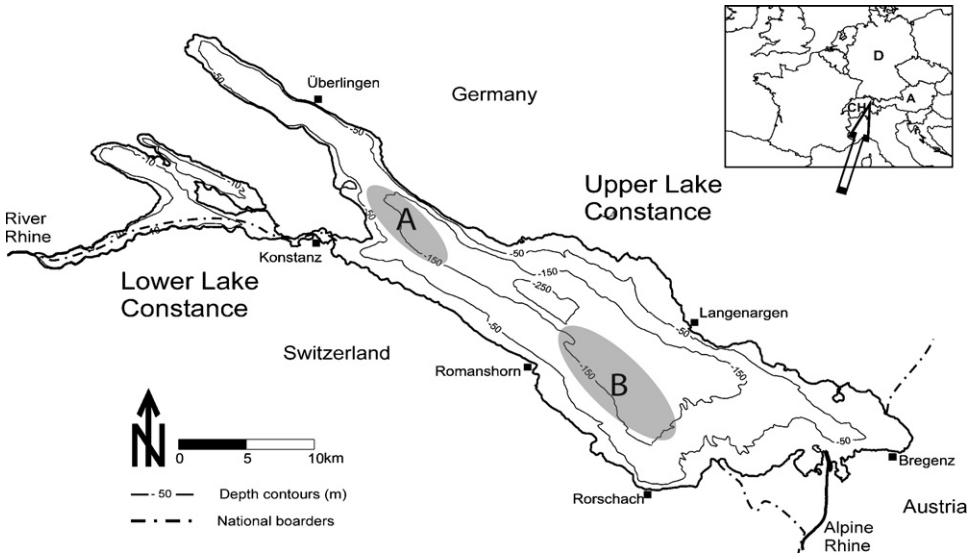

Fig. 1. Location of Lake Constance at the borders of Switzerland, Austria and Germany (small map, open arrow). The shaded areas indicate the areas of net catches and upward-beaming hydroacoustic surveys. Area A: net catches on the 30 May 2007, 29 June 2007 and hydroacoustic surveys on the 2 June 2007 and 24 June 2007. Area B: hydroacoustic survey on the 7 July 2007.

2. Materials and methods

2.1. Research area

All data were sampled from the main basin of Upper Lake Constance, a warm monomictic pre-alpine lake with an average water depth of 101 m and a surface area of 456 km^2 (Mürle et al., 2004). During the summer, the lake stratifies and a thermocline is established between 10 and 15 m depth. The echosounding surveys were conducted in the western part of Upper Lake Constance (2 June 2007 and 24 June 2007, Fig. 1, Area A) and in the south-eastern part of the main basin (7 July 2007, Area B). During the surveys the boat cruised on transects parallel to the main axis of the lake (NW–SE) within the research area (Fig. 1).

2.2. Net catches

From the middle of May until the beginning of August 2007 net catches were conducted in Area A (Fig. 1). Pelagic fish larvae/juveniles were caught with two conical ichthyoplankton nets at 0, 5 and 10 m depth to confirm the presence of YOY perch. Unfortunately, catches were not performed quantitatively and thus abundance data from net catches were lacking. Instead, the minimum number of caught perch is indicated in Table 1.

The ichthyoplankton nets had a length of three meters, a circular opening of 1.4 m diameter and mesh sizes of 1200/800 μm and 1600/1200 μm in the front and rear, respectively. The net with 1200/800 μm mesh size was used on the 30 May 2007, while the net with 1600/1200 μm mesh size was used on the 29 June 2008

Table 1
No. of young-of-the-year (YOY) perch and burbot caught in the pelagic zone of Lake Constance. TL refers to the mean total length of all perch and burbot caught on the according day. Day refers to 6:00–21:00, dusk to 21:00–23:00, night to 23:00–4:30 and dawn to 4:30–6:00. Note that on the 30 May 2007 and 29 June 2007 the no. caught are not quantitative and hence do not indicate relative abundances of YOY perch and burbot! On the 29 June 2007 neither perch nor burbot were caught during daytime, because perch displayed strong gear avoidance and burbot migrated to the hypolimnion.

Species	Date	Time	Catch depth (m)	No. caught	Mean TL (±S.D.) (cm)
Perch	30 May 2007	Day	0	52	1.26 (±0.21)
		Dusk	0	42	
		Night	0	40	
		Dawn	0	30	
	29 June 2007	Day	0, 3	No catch	2.14 (±0.63)
		Dusk	0	24	
		Night	0	27	
		Dawn	0	24	
	22 July 2007	Dusk	5	3	4.63 (±0.21)
Burbot	30 May 2007	Day	28	12	0.87 (±0.17)
		Dusk	20	29	
		Night	5	8	
		Dawn	0, 28	17	
	29 June 2007	Day	25	No catch	1.36 (±0.21)
		Dusk	20, 0	14	
		Night	0	12	
		Dawn	0, 28	9	
	22 July 2007	Dusk	5	4	1.98 (±0.38)