Available online at www.sciencedirect.com
ScienceDirect
Fisheries Research 88 (2007) 139–145
FISHERIES RESEARCH
www.elsevier.com/locate/fishres

Short communication

Assessing the biomass of small fish with a split-beam sonar in the Murray River, Australia

Vladimir F. Matveev *

CSIRO Land and Water, 120 Meiers Road, Indooroopilly, Qld 4068, Australia

Received 4 April 2007; received in revised form 2 July 2007; accepted 10 July 2007

Abstract

Split-beam hydroacoustics revealed large numbers of small fish in the lower reaches of the Murray River in autumn. At slow-flow sites, acoustically estimated fish biomass could reach 102 kg/ha in mid channel, which compares with the biomass level of planktivorous fish in eutrophic lakes. These results were confirmed by direct catches with a push net of Australian smelt (*Retropinna semoni*) and juvenile bony herring (*Nematalosa erebi*) ranging in length from 18 to 150 mm. Fish densities in the river channel doubled at night compared to the day. The density and total biomass estimates from net catches were strongly correlated with the acoustic data. However, the catch estimates were only 50–60% of the acoustic measurements, which is explained by the limited netting efficiency. The two methods produced similar estimates of fish mean weights. These results suggest that the density and biomass of small fish in open water habitats of the river can be reliably determined with acoustics. The high biomass of planktivorous fish and the diverse zooplankton community found in the same habitat suggest that the fish probably exploit an advantageous ecological niche in the main channel of the Lower Murray. The high biomass of small fish in this reach of the river, which has previously been underestimated, provides a large potential food source for native predators.

Keywords: Fish biomass; Acoustics; River; Sonar; Push net

1. Introduction

In large regulated rivers, the flow may be slow enough to allow small fish to resist downstream displacement by the current and stay in the open water of the river channel. Fish can potentially exploit planktonic food resources there, which Thorp and Delong (1994) suggest come from in-channel primary production. In large Australian rivers, small native fish are reported to occur in the main channel, at least, near banks (Lloyd and Walker, 1986; Gehrke et al., 1995; Gehrke and Harris, 2000, 2001). However, none of the studies has specifically focused on the estimation of the abundance and biomass of small fish, in spite of their conservation value and potentially important role they may play in ecosystem processes. Small fish are part of the diet of big native Australian fishes, Murray cod and golden perch as well as of birds, such as cormorants and pelicans (McDowall, 1996; Pusey et al., 2004). So far, collecting quantitative data on small fish in channel habitats has been hampered by the limitations of the catch methods. For instance, electro-fishing, applied on the Murray River, produced either qualitative data or the variance was too high for reliable estimates of the biomass, which limited the scope of studies to comparisons of species richness (Gehrke and Harris, 2000). Relative abundance of a species could vary from 1 to 64% of the catch depending on catch method (Pusey et al., 2004, p. 94). The hydroacoustic method, which has been widely used for stock assessment at sea, can provide a solution to this problem.

Side-looking sonars have been successfully deployed in shallow-water fisheries for detecting and counting fish in rivers (Hughes, 1998; Kubecka and Duncan, 1998; Ransom et al., 1998; Trevorrow, 1998). However, big fish rather than small ones were often the priority in river surveys, so detection thresholds were usually set close to −50 dB, roughly equivalent to a 4 cm-long fish, on the implicit assumption that smaller fish were probably difficult to detect due to low signal-to-noise ratio (Guillard, 1998; Lyons, 1998; Lilja et al., 2003). Nevertheless, it has been demonstrated that, at least in lakes, reliable estimates of abundance of fish as small as 15 mm is possible (Rudstam et al., 2002). In large regulated rivers the slow flow and low turbulence should not pose a major problem for hydroacoustic surveys as

* Tel.: +61 7 3214 2755; fax: +61 7 3214 2881.
E-mail address: vlad.matveev@csiro.au.

0165-7836/$ – see front matter. Crown Copyright © 2007 Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.fishres.2007.07.008

conditions would resemble, to some extent, those in lakes and reservoirs.

The aims of the present study were to test whether split-beam sonar could be a useful tool for assessing the stock of small fish in the main channel of the Murray River, to determine whether hydroacoustic measurements could be used to estimate fish biomass, and to test whether this biomass was formed in the environment trophically suitable for fish.

2. Methods

2.1. Study sites

The Murray River is the second longest Australian river and is 2520 km long. It is large, regulated and economically important because of its use for urban and industrial water supplies, as well as for irrigated agriculture (Eastburn, 1990). The river is also important for fisheries and supports a diversity of native fish (Cadwallader and Lawrence, 1990). Hydroacoustic scans and simultaneous fish catches were performed in this study at four different sites in the austral autumn (April) and spring (September) 2006. Two sites represented dammed sections of the river, with water velocities $<0.25\ \mathrm{m\,s^{-1}}$: a reach upstream of Lock 4 (34.32613°S, 140.59006°E) and Mildura Weir Pool (34.18390°S, 142.17545°E); two other sites were located at free-flow sections of the river with velocities $>0.25\ \mathrm{m\,s^{-1}}$: one downstream of Lock 5 (34.19736°S, 140.76637°E) and another in Hattah National Park (34.56233°S, 142.42258°E) (see map in Mackay, 1990). Channel depths at the sites varied from 2 to 6 m.

2.2. Hydroacoustics

The Murray River was surveyed using a 120 kHz split-beam echo sounder (SIMRAD EY500) with a circular composite transducer (6.9° at 3 dB) mounted on an adjustable bracket and submersed to a depth of 30–35 cm. The transducer had a near-field zone of 83 cm, which was determined in an indoor calibration test. Scanning at a given site was performed from a motor boat moving parallel to the banks at a speed of $3.6\ \mathrm{km\,h^{-1}}$ with beam directed horizontally and reaching the middle of the river channel. Surveys lasted for 40 min, were conducted at least 1 h after sunset, with 0.1 ms pulse length and 0.2 s ping interval. Acoustic data, which included sample power, sample range and sample angle telegrams, were recorded to a laptop PC in the field and analysed with the Sonar5-Pro software, version 5.9 (Balk and Lindem, 2004). For biomass estimations, $20\log R$ time-varied-gain (TVG) was applied in the file conversions to compensate the echo amplitudes for beam spreading. Echo detections were performed with a threshold value of −70 dB, maximum gain compensation of 3 dB and maximum phase deviation of 3 phase steps. Minimum echo duration of 0.7 and maximum echo duration of 1.3 of the transmitted pulse duration were used. The acoustic system was calibrated with a standard 23 mm copper sphere prior to and after field surveys. Calibrated gains varied within ±0.5 dB during the period of study.

2.3. Day versus night surveys

Night surveys may provide more accurate estimates of fish abundance because fish may be more dispersed in the dark, which is the assumption of the echo integration method (MacLennan and Simmonds, 1992). Also, fish densities in river channels can be higher at night compared to the day because of diel migrations (Kubecka and Duncan, 1998). Higher night counts of single-echo detections, indicating increased activity of fish after sunset, can be considered an additional way of validation of acoustic data as it is unlikely that the density of non-fish echoes, such as those resulting from turbulence or drifting debris, would rise at night on a regular basis. An acoustic test for the presence of increased numbers of fish at night was performed at the Lock 4 site in April 2006. Stationary scanning was made from a boat, anchored in the middle of the river channel. Analysed acoustic range was 10 m and scans were made 1 h before (light conditions) and 3 h after the sunset (complete darkness).

The acoustic method was directly validated through comparison of acoustic estimates of fish density, size and biomass with catch results. The design of this procedure was primarily driven by the limitations of the catching method. While the recorded echogram range could extend to 25 m, the range for analysis was restricted to 5 m from the transducer face. This was dictated by the small catching range of a push net used for fish harvesting and ensured comparability with the net data. Greater acoustic ranges incorporated too many echoes of big fish. These fish were never found in the catch of the push net, but were caught by an electro-fisher applied from a different boat in the same area. Single-echo detection echograms and target strength (TS) distributions in the analysed 5-m zone were also inspected for the echoes of the big fish, which, if found, were deleted during post-processing. Their presence had an effect on the mean TS, introducing a noticeable bias. The overwhelming majority of fish caught by the push net were small fish <10 cm. This size roughly corresponds to a target strength of −38 dB for the side aspect of the fish (Frouzova et al., 2005), and was used as the boundary value for separating big fish echoes.

2.4. Netting

A push net mounted on the bow of a fast moving boat was found in this study to be the most effective method for catching small fish in the main channel of the river. Similar nets have been successfully used in lentic habitats of the Murray River system (Lieschke and Closs, 1999; Matveev et al., 2002). Other sampling methods, for instance, electro-fishing, either did not catch small fish effectively or produced unacceptably high variance in catch sizes.

A push net of dimensions 0.6 m × 0.4 m and a length of 1.5 m was attached to a sliding rack that allowed adjustment of its vertical position. Nets of different mesh sizes and mesh-hole shapes were tested for their catching success. A mesh of 3.6 mm with round holes provided the highest catches of fish and was standardly used. To determine the expected smallest size of fish caught by the mesh, 30 smelt from early juveniles to adults of various sizes were measured for total length (TL)