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Gillnet catch in estimating the density and structure of fish community—Comparison of gillnet and trawl samples in a eutrophic lake

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ABSTRACT

To improve the accuracy of fish population estimates, understanding the deficiencies of fish sampling methods is important. Gillnets are a passive and selective gear and give biased estimates of abundance and distribution of species and their size structure. By comparing gillnet results with those of active gear (e.g. trawl), it is possible to account for the bias in the gillnet data. The aim of this study is to compare fish-community data collected with two different methods: gillnet and trawl, and to consider possible reasons for differences in the results. The fish community in the two basins of a shallow, eutrophic lake in southern Finland was sampled diurnally with gillnets and trawl in different years. The differences in abundance estimates, species and length distributions were considered. The gillnet NPUE (number per unit effort) of ≥6.0 cm fish was correlated with the trawl-abundance estimate. The most abundant species in the trawl catch, smelt, was almost totally missing from the gillnet catch. The proportion of bream was lower, while perch, roach and white bream were higher in the gillnet catch. Gillnets regularly underestimated the proportion of small (<10 cm) individuals in size distributions. Due to many confounding factors, caution is recommended when making deductions of fish density from gillnet NPUE.

1. Introduction

To reveal the real abundance and structure of a fish community is a challenging task. All fish sampling methods give estimates of species abundance, distribution and size structure that are biased to some degree. Simultaneous sampling with different gears produces information on the flaws that the fish-community data can contain. In particular, the reliability of data from passive gears (e.g. gillnet) can be improved by comparison with data collected with active gears (e.g. trawl).

The probability that a fish will encounter and be retained in a gillnet depends on its activity, speed and morphology, e.g. spiny or streamlined species (Hamley, 1975; Backiel and Welcomme, 1980; Kurkilahti, 1999). The size-distribution estimates from gillnets are skewed because small fish move less and when encountering the net are caught less effectively due to their slower speed and the lower flexibility of small mesh sizes. In addition, the accumulation of fish reduces the catchability of gillnets (Minns and Hurley, 1988; Olin et al., 2004). Despite these problems, gillnets are widely used in fish monitoring (e.g. Jeppesen et al., 2000; Olin et al., 2002; Mehner et al., 2005) due to simplicity and applicability. A trawl net, being an active gear, is less selective and thus provides more reliable estimates of species abundance and length distribution. However, the trawl is less applicable in shallow or rough-bottom waters (Backiel and Welcomme, 1980). Furthermore, large, fast-swimming individuals may avoid the trawl (Bethke et al., 1999; Hjellvik et al., 2001) and may be more vulnerable to gillnets (Richardson, 1956).

This study continues the pilot study we conducted in 2001 (see Olin and Malinen, 2003) in order to compare fish-community data collected with two different methods: the Nordic gillnet and a small pair-trawl. The main results of the pilot study were (1) gillnets underestimate the abundances of the smallest individuals and species (like smelt *Osmerus eperlanus*) and also the largest cyprinids, and (2) the abundance estimates of gillnet and trawl correlated if small fish were excluded. In the present work, our aim was to study the between-gear differences in species composition and in the size structure of the entire fish community. In addition, we determined an approximate relationship between the trawl-abundance estimate and the gillnet NPUE of different species and size classes. We also examined the effect of gillnet set time on the above-mentioned relationship.

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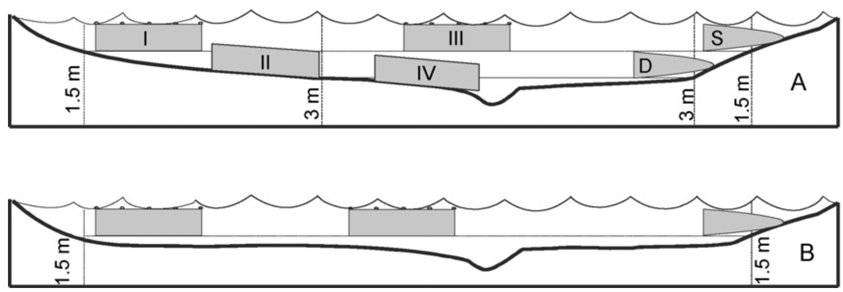

Fig. 1. Sampling procedure in Mustionselkä basin (A) and Kirkkojärvi basin (B). Depth contours at 1.5 and 3 m are shown. In Mustionselkä basin, I = surface nets in 1.5–3 m depth zone, II = bottom nets in 1.5–3 m depth zone, III = surface nets in 3–4.5 m depth zone and IV = bottom nets in 3–4.5 m depth zone. S = shallow hauls from 1.5 m depth contour to another and D = deep hauls from 3 m depth contour to another. In Kirkkojärvi, all gillnets and trawl hauls were at the surface above the >1.5 m depth area.

2. Material and methods

2.1. Study area

The study was conducted in two basins of the eutrophic Lake Hiidenvesi in southern Finland (Repka, 2005). The basin Mustionselkä (area 2.6 km^2 and mean depth 1.7 m) was sampled in August 2001 and 2002 and the basin Kirkkojärvi (area 1.6 km^2 and mean depth 0.9 m) in August 2003 and 2004. The surface water temperatures in years 2001–2004 were 20, 22, 23 and 21 °C, respectively. The corresponding Secchi depths were 0.4, 0.7, 0.3 and 0.2 m. Sunrise was at 5 a.m. and sunset at 10 p.m.

2.2. Sampling of fish

The gillnet data were collected with Nordic multimesh gillnets (Olin et al., 2004) having 12 mesh sizes (5–55 mm, from knot to knot) and an overall size of 1.5 m × 30 m. The trawl was a small pelagic pair-trawl with a total length of 19 m, a theoretical opening of 1.5 m × 5 m, mesh sizes of 20, 10, 6 and 3 mm, and a 3-m long cod-end.

In Mustionselkä 2001–2002, gillnetting was conducted in four different depth zones: at the surface or on the bottom at 1.5–3 or 3–4.5 m depth (Fig. 1A). The fishing effort (number of gillnets) in a given depth zone was adjusted to the volume of the zone. The trawl was towed in two depth layers: at a depth of 0–1.5 m from one 1.5 m depth contour to another (layer area 175 ha), and at a depth of 1.5–3.0 m from one 3 m depth contour to another (layer area 44 ha). The length of transects ranged from 500 to 800 m, and the total trawled area was 11.8 ha. The average towing speed was 1.2 m s^{-1} in both years. Sampling was carried out on a 24 h timescale comprising six 4 h periods: 20–24, 00–04, 04–08, 08–12, 12–16 and 16–20 h. Gillnet sites and trawl transects were randomly selected. The gillnet sites were changed after each period, but the trawl transects were maintained. Total fishing effort per year was 72 gillnets and 19 trawl hauls (12 gillnets and 3–4 hauls per period).

In Kirkkojärvi 2003–2004, trawling and gillnetting was carried out only in surface water of the >1.5 m depth zone, due to shallowness of the basin and to target surface-oriented bleak *Alburnus alburnus* that was assumed to be abundant in the area (Fig. 1B). Gillnet sites were randomised but trawl transects were systemically placed in the deepest area due to the small number of possible towing lines. The length of the trawl transects ranged between 560 and 620 m in 2003, and between 500 and 860 m in 2004. The average towing speed was 1.1 and 0.9 m s^{-1}, and the total trawled area 2.3 and 2.8 ha in years 2003 and 2004, respectively. Fishing was done during 1 day and night in four periods in relation to sunset and sunrise: day (12:40–14:30), dusk (20:50–22:40), night (0:40–2:30) and dawn (4:20–6:10). In each period, two trawl hauls were done and six gillnets were set for 1 h. The shorter setting time in Kirkkojärvi basin compared to Mustionselkä basin was due to assumed higher fish densities which can lead to a decrease in catchability as gillnets become saturated with fish (Olin et al., 2004). Total fishing effort per year was 24 gillnets and 8 trawl hauls.

The catch of every gillnet and trawl haul (10–30 kg sub-sample of the trawl catch if the fish were very small) was sorted to species, and then counted and weighed. All or at least 50 individuals of each species in one gillnet or haul were measured (total length, 1 mm accuracy). Bream (*Abramis brama*), white bream (*A. bjoerkna*) and blue bream (*A. ballerus*) smaller than 7.6 cm were treated as a one group, ≤7.5 cm *Abramis* sp., due to damage to the trawl catch and the consequent difficulty in assigning to species.

2.3. Statistical analyses

The trawl data were transformed to number ha^{-1} and kg ha^{-1} estimates. From every haul, fish catch ha^{-1} was assessed by dividing the catch by the hauled area (trawl width (5 m) × hauled length (500–800 m)). Average catch ha^{-1} in a given depth layer was calculated as the weighted mean with the transect lengths as weights. In Mustionselkä, the catch ha^{-1} for the total study area (C_{tot}) was summed as

$$C_{tot} = C_{shallow} + \frac{A_{deep}}{A_{tot}} \times C_{deep} \quad (1)$$

where $C_{shallow}$ = catch ha^{-1} from shallow layer, A_{deep} = area of deep layer, A_{tot} = area of total study area and C_{deep} = catch ha^{-1} from deep layer.

Percentage values for each species were calculated from the trawl data (ha^{-1} estimates) and from the total gillnet catch. To produce more reasonable comparisons, species shares were calculated from the gillnet and trawl catches including species that could be caught effectively by both gears. The latter data included eight species: perch (*Perca fluviatilis*), pikeperch (*Sander lucioperca*), ruffe (*Gymnocephalus cernuus*), roach (*Rutilus rutilus*), bleak, and >7.5 cm white bream, bream and blue bream. The homogeneity of whole-species distribution in the gears was tested using contingency tables (species × gear, H_0 = the relative abundances of species are equal regardless of the gear) for the number catches of all species and the eight species individually. The species-specific differences between the gears were tested with the non-parametric sign test including observations of the percentages in trawl and gillnet catches during each sampling period. The sign tests had 6 (Mustionselkä, 2001, 2002), 8 (Kirkkojärvi, 2003, 2004 pooled) or 20 observations (all years pooled).

From the gillnet data, mean NPUEs (number net^{-1} 4 h^{-1} or 1 h^{-1}) were calculated from ln(x + 1) transformed data. As only few <6.0 cm fish were caught by gillnets, these length classes were excluded from the comparison of gillnet and trawl total abundance estimates. The relationship of gillnet NPUE to trawl density