

## A comparison between the benthic Nordic gillnet and whole water column gillnet for characterizing fish assemblages in the shallow Lake Balaton

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**Abstract** – Performance of the prescribed gear of the European Standard (*i.e.* 1.5 m deep Nordic gillnet) was compared with gillnets deep enough to cover the whole water column (WWCG) for characterizing fish assemblages in a large and shallow lake (Lake Balaton, Hungary). Differences in species number, relative abundance and biomass, and length distribution of fish were examined in both inshore and offshore habitats of the lake. Nordic gillnet samples provided comparable information to that of WWCG for both species richness and abundance and biomass of benthic species. However, substantial differences were found between the two net types in the representation of pelagic fish species (*i.e.* bleak, razor fish and asp). Overall, the WWCG provided different information with more precise (less variable) data on fish assemblage structure than the Nordic gillnet. Results suggest that identification of neither horizontal nor vertical gradients in within lake fish assemblage structure can be guaranteed with the Nordic gillnet alone even in such shallow lakes, like Lake Balaton. It was concluded that benthic Nordic gillnet samples should be complemented with information on fish occurring in the upper water layers (*i.e.* pelagic species) even in very shallow lakes either by using pelagic or floating gillnets or by whole water column gillnetting.

**Key words:** Nordic gillnet / EN 14757:2005 / representative sampling / pelagic fish species / shallow lake

### Introduction

Representative fish assemblage data are required for environmental quality assessment and management, studying specific trophic processes, and for large scale environmental gradient analyses. Presently, gillnetting is probably the most commonly used fishing method for accessing fish assemblages in standing freshwaters. In order to ensure the comparability of gillnet data in both space and time, standardized sampling protocols were developed (Hammar and Filipsson, 1985; Mortensen *et al.*, 1990; Fjälling and Fürst, 1991; Appelberg *et al.*, 1995; Appelberg, 2000). In Europe, this process has resulted in an operative standard (CEN, 2005), which is largely based on the original Swedish Standard for sampling fish with multimesh gillnets (Appelberg *et al.*, 1995). The suggested protocol has already been adopted in many European countries, particularly to fill the requirements of the Water Framework Directive of the European Union (*e.g.* Mehner *et al.*, 2005; Gassner *et al.*, 2006; Kubečka and Prchalová, 2006).

Although important results have been achieved during the last few decades on how to improve the representativity and comparability of gillnet data, there are still many unresolved questions. For example, it has been emphasized that further research is needed to develop more accurate corrections for size selectivity (Prchalová *et al.*, 2009) and more reliable methods for incorporating benthic and pelagic gillnet data to whole lake CPUE estimations (Lauridsen *et al.*, 2008). One possible problem of the European Standard of gillnet sampling (CEN, 2005) can be that it is based largely upon the sampling of benthic fish assemblages, and some complementary sampling of pelagic fish assemblages is required only in lakes with a maximum depth of >10 m. However, it is well documented that pelagic (or non-benthic) fish species may also play a very important role in large, shallow lakes, and their diversity and density may change considerably both within and among lake habitats (Holmgren and Appelberg, 2000; Olin *et al.*, 2002; Mehner *et al.*, 2005; Jeppesen *et al.*, 2006; Tátrai *et al.*, 2008; Olin *et al.*, 2009). For example, in Denmark sampling by the European Standard (CEN, 2005) was complemented with more intense random

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sampling of pelagic habitats for lakes deeper than 4.5 m (Lauridsen *et al.*, 2005). As a result, Lauridsen *et al.* (2008) argued that the so called Danish method can give more reliable whole lake level fish community estimations compared to those suggested in the European Standard (CEN, 2005). Clearly, more studies are necessary for large and shallow lakes to reveal how much information is lost by the single application of the European Standard as compared with sampling methods which sample the whole water column.

The purpose of this study was to compare the performance of the prescribed gear of the European Standard (*i.e.* 1.5 m deep Nordic gillnet; CEN, 2005), with gillnets deep enough to cover the whole water column, in a large and shallow lake (Lake Balaton, Hungary). Specifically, we assess the surplus information the use of the whole water column gillnets (WWCG) provide compared to the suggested European protocol of gillnet sampling. Differences in species number, relative abundance and biomass, and length distribution of fish are considered in both inshore and offshore habitats of the lake.

## Material and methods

### Study area

With its 593 km<sup>2</sup> surface area, Lake Balaton is the largest shallow lake in Central Europe, situated at 46° 42' – 47° 04' N, 17° 15' – 18° 10' E and 104.8 m above sea level. The lake is 78 km long, on average 7.6 km wide and 3.2 m deep. In > 99.9% of the lake area the water depth is ≤ 5 m and there is only a *ca.* 10 ha area at the end of the Tihany peninsula where the water depth ranges between 5 and 11 m. Presently Lake Balaton is meso-eutrophic with mean annual chlorophyll-*a* concentrations of 3.6–18.7 mg.m<sup>-3</sup> (Istvánovics *et al.*, 2007). Forty-seven % of the lake shore is covered by reed grass that corresponds to an 1107–1129 ha total covered area, but there are only sporadic patches of submerged macrophytes in the littoral zone. This slightly alkaline lake contains about 400 mg.L<sup>-1</sup> of Ca<sup>2+</sup> and Mg<sup>2+</sup>(HCO<sub>3</sub><sup>-</sup>)<sub>2</sub>, the pH varies within the range of 8.2–9.1 and the conductivity is 550–671 ms.cm<sup>-1</sup>. A wind over 4 m.s<sup>-1</sup> velocity disturbs the loose sediment and disperses the solid particles in the whole water body. Although in exceptional cases (*i.e.* under ice cover) water transparency may reach 1.5–1.8 m, in general the lake is turbid with Secchi depth varying between 0.2 and 0.8 m. During this study the Secchi depth was 0.52 ± 0.14 m (mean ± SD). Oxygen deficiency has never been registered in the lake and also concentrations of pollutants are low or insignificant.

The fish fauna of the lake consists of 30 permanent species of which common bream *Abramis brama* (L.), razor fish *Pelecus cultratus* (L.), bleak *Alburnus alburnus* (L.) and the introduced silver carp *Hypophthalmichthys molitrix* (Valenciennes) are the most abundant in biomass (Bíró, 1997; Specziár *et al.*, 2000). Lake Balaton is one of

the most intensively studied lakes in Europe, thus there are several reviews on its limnology (*e.g.* Herodek *et al.*, 1988; Istvánovics *et al.*, 2007) and fish fauna (*e.g.* Bíró, 1997; Specziár *et al.*, 2000) which can serve as a source of further information on its biological and physical-chemical characteristics.

### Gears and sampling protocol

The Nordic multimesh benthic gillnet (made by Nippon Verkko oy, Finland) is composed of 12 different mesh-sizes ranging from 5 to 55 mm (knot to knot) and it is 1.5 m deep. Order of the panels of different mesh-sizes is fixed as 43, 19.5, 6.25, 10, 55, 8, 12.5, 24, 15.5, 5, 35 and 29 mm. Each mesh panel is 2.5 m long and mounted on a 30 m long buoyancy line (linear density in water 7 g.m<sup>-1</sup>) and a 33 mm long lead line (linear density in air 22 g.m<sup>-1</sup>). The hanging ratio is 0.5 for all mesh-sizes (for more detailed description of this net see CEN, 2005). The whole water column gillnet (WWCG) was the deeper version of the Nordic gillnet, except the missing 5 mm mesh-size panel (also made by Nippon Verkko oy, Finland). Three and 4.5 m deep WWCGs were used in order to secure the sampling of the whole water column in both inshore and offshore habitats. In the inshore area (1.6 to 2.8 m water depth) the 3 m deep WWCG, while in the offshore area (3.2 to 4.5 m water depth) the 4.5 m deep WWCG were used.

Between April 2006 and May 2007, altogether 26 trials (156 gillnet sets) were performed. Twelve trials were carried out in the inshore area at 50 to 200 m distance from the shore and 14 trials in the offshore area at least 1500 m from the nearest shoreline. In each trial three Nordic gillnets and three WWCGs were set linearly at the same water depth in randomized sequence and with one net length gap between them. All sampling sites had smooth bottom with constant water depth and were free of macrophytes and any other objects on the lake-bed.

Gillnets were set in the morning (after sunrise) for one to four hours sampling intervals based on our previous experience on expected CPUE values by sampling sites. Relatively short fishing times were set according to the high expected CPUE in productive and turbid Lake Balaton (Specziár *et al.*, 2000; Specziár, 2001; Tátrai *et al.*, 2008) and the recommended catch limit for the Nordic gillnet so as to avoid saturation of nets with fish (Olin *et al.*, 2004; CEN, 2005). Fishing times were the same for all gillnet sets within a given trial.

### Data evaluation

Catches of each net were handled separately. Since the WWCG did not include the 5 mm mesh-size panel, catches of this panel were also excluded from the Nordic gillnet samples. All fish were identified to species level, and standard length (SL) and mass measured in the laboratory. Gillnet catches were first standardized for one hour fishing time, and then converted to catch per unit effort (CPUE)

Table 1. Numbers (N) and mean sizes (SL) of fishes captured during the study. WWCG – whole water column gillnet.

|   | Inshore area                        |               |                           |               | Offshore area                       |               |                           |               | Altogether |
|---|-------------------------------------|---------------|---------------------------|---------------|-------------------------------------|---------------|---------------------------|---------------|------------|
|   | Nordic gillnet<br>(12 × 3 gillnets) |               | WWCG<br>(12 × 3 gillnets) |               | Nordic gillnet<br>(14 × 3 gillnets) |               | WWCG<br>(14 × 3 gillnets) |               |            |
|   | N                                   | SL (j SD, mm) | N                         | SL (j SD, mm) | N                                   | SL (j SD, mm) | N                         | SL (j SD, mm) |            |
| Roach <i>Rutilus rutilus</i> (L.)                         | 243                                 | 140 j 39      | 211                       | 143 j 38      | 21                                  | 148 j 49      | 22                        | 183 j 51      | 497        |
| Rudd <i>Scardinius erythrophthalmus</i> (L.)              | 0                                   | –             | 1                         | 173           | 0                                   | –             | 0                         | –             | 1          |
| Asp <i>Aspius aspius</i> (L.)                             | 1                                   | 215           | 19                        | 310 j 46      | 1                                   | 420           | 5                         | 329 j 50      | 26         |
| Bleak <i>Alburnus alburnus</i> (L.)                       | 977                                 | 77 j 13       | 6198                      | 79 j 15       | 214                                 | 90 j 11       | 3488                      | 83 j 16       | 10 877     |
| White bream <i>Blicca bjoerkna</i> (L.)                   | 410                                 | 132 j 42      | 382                       | 129 j 38      | 77                                  | 121 j 40      | 80                        | 112 j 33      | 949        |
| Common bream <i>Abramis brama</i> (L.)                    | 528                                 | 162 j 56      | 451                       | 161 j 51      | 442                                 | 115 j 59      | 483                       | 115 j 58      | 1904       |
| <i>R. rutilus</i> × <i>A. brama</i>                       | 3                                   | 152 j 22      | 1                         | 140           | 0                                   | –             | 0                         | –             | 4          |
| Razor fish <i>Pelecus cultratus</i> (L.)                  | 28                                  | 262 j 7       | 40                        | 267 j 13      | 40                                  | 252 j 23      | 360                       | 245 j 26      | 468        |
| White-finned gudgeon <i>Romanogobio alpinus</i> (Lukasch) | 2                                   | 48 j 3        | 5                         | 46 j 2        | 13                                  | 49 j 7        | 18                        | 49 j 5        | 38         |
| Bitterling <i>Rhodeus sericeus</i> (Pallas)               | 82                                  | 42 j 4        | 29                        | 43 j 5        | 0                                   | –             | 0                         | –             | 111        |
| Gibel <i>Carassius gibelio</i> (Bloch)                    | 14                                  | 238 j 10      | 7                         | 226 j 13      | 2                                   | 238 j 13      | 0                         | –             | 23         |
| Common carp <i>Cyprinus carpio</i> L.                     | 3                                   | 268 j 8       | 0                         | –             | 0                                   | –             | 1                         | 194           | 4          |
| Black bullhead <i>Ameiurus melas</i> (Rafinesque)         | 0                                   | –             | 0                         | –             | 0                                   | –             | 1                         | 115           | 1          |
| Ruffe <i>Gymnocephalus cernuus</i> (L.)                   | 123                                 | 62 j 14       | 112                       | 57 j 13       | 46                                  | 67 j 12       | 35                        | 64 j 11       | 316        |
| Pikeperch <i>Sander lucioperca</i> (L.)                   | 26                                  | 239 j 133     | 34                        | 158 j 117     | 34                                  | 169 j 114     | 46                        | 169 j 114     | 140        |
| Volga pikeperch <i>Sander volgensis</i> (Gmelin)          | 44                                  | 216 j 73      | 48                        | 205 j 94      | 26                                  | 106 j 62      | 32                        | 106 j 62      | 150        |
| Monkey goby <i>Neogobius fluviatilis</i> (Pallas)         | 8                                   | 58 j 3        | 6                         | 60 j 1        | 14                                  | 56 j 6        | 16                        | 56 j 7        | 44         |
| Total   | 2492                                | 116 j 60      | 7544                      | 91 j 37       | 930                                 | 115 j 63      | 4587                      | 101 j 53      | 15 553     |
| Number of species (hybrids)                               | 14 (1)                              |               | 14 (1)                    |               | 12                                  |               | 13                        |               | 16 (1)     |

and expressed both in number (NPUE) and biomass (BPUE) of fish per one hour per standard net size. The standard net area was set to 41.25 m<sup>2</sup> according to the area of the Nordic gillnet (without the 5 mm mesh-sized panel; 27.5 m long and 1.5 m deep). Standardization for the net area of the Nordic gillnet is common in fish assemblage studies (*e.g.* Olin and Malinen, 2003; Rask *et al.*, 2003) and it is also suggested by the European Standard (CEN, 2005). In the WWCG the CPUE standardization was done according to the active net area which equalled the product of the net length and the water depth. It should be noted, however, that in case of species richness the fishing effort could not be standardized for gillnet area. Since the material and the mesh-size distribution of the studied nets were identical, size dependent gillnet selectivity was not considered in this study.

### Statistical analysis

Rarefaction analyses were used to examine changes in the estimated number of species as a function of number of samples and number of individuals collected (Gotelli and Colwell, 2001). Analyses were performed with the EcoSim 7.72 software (Gotelli and Entsminger, 2008).

Principal component analysis (PCA) was run on square-root arcsin transformed relative abundance and biomass data to explore the distribution pattern of Nordic gillnet and WWCG samples. To obtain robust and readily interpretable results, PCA analyses were based on means of three parallel samples per gillnet type for each trial. Consequently, positions of 52 data points (two gillnet type, and 12 inshore and 14 offshore trials) were compared in the analyses. Since both water depth and duration of fishing varied among trials, effects of these factors on fish assemblage composition estimates were tested by correlating these factors with the principal component (PC) scores of fish assemblage composition data. These relationships were analysed with the Spearman rank correlation.

Differences between the number of species, and NPUE and BPUE values between the two net types (Nordic gillnet, WWCG) were compared with two-way repeated measures ANOVA. CPUE data were  $\ln(x+1)$  transformed to approximate normality. Since CPUE data analyses included multiple statistical tests (45 ANOVAs were performed on both inshore and offshore CPUE data), the level of significance (P) was adjusted using the Bonferroni correction to decrease the probability of type I error.

Precision of species number and CPUE estimates was quantified for the two gillnet types by determining the number of samples required for detecting 20% change of the mean value at  $P < 0.05$  (Krebs, 1989). Required sample sizes were determined with the iteration method based on the *t*-distribution.

Differences in fish length distribution data between gillnet types were analysed by using the chi-squared test for independent samples with the Bonferroni method for correction of significance level.















