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Evaluating gillnetting protocols to characterize lacustrine fish communities

Timothy J. Alexander[a,b,*], Pascal Vonlanthen[a,b], Guy Periat[a], François Degiorgi[c], Jean-Claude Raymond[d], Ole Seehausen[a,b]

[a] Department of Fish Ecology and Evolution, Centre of Ecology, Evolution and Biogeochemistry, EAWAG Swiss Federal Institute of Aquatic Science and Technology, Seestrasse 79, CH-6047 Kastanienbaum, Switzerland
[b] Division of Aquatic Ecology and Evolution, Institute of Ecology and Evolution, University of Bern, Baltzerstrasse 6, CH-3012 Bern, Switzerland
[c] CNRS-University of Franche-Comte/UMR 6249 Chrono-environment, La Bouloie, F-25030 Besançon Cedex, France
[d] ONEMA French National Agency for Water and Aquatic Environment, Unité Spécialisée Milieux Lacustres, Pisciculture de Rives 13, Quai de Rives 74200, Thonon-les-Bains, France

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ABSTRACT

Ecological research and monitoring of lacustrine ecosystems often requires a whole-lake assessment of fish communities. Gillnet sampling offers an efficient means of estimating abundance, biomass and fish community composition. However the choice of gillnet sampling protocol may influence lake characterization via physical properties of the nets and allocation of sampling effort between littoral, benthic and pelagic habitats. This paper compares two commonly used, whole-lake sampling protocols applied across 17 prealpine, subalpine and alpine European lakes ranging widely in size, depth and altitude to determine their relative strength for research and management applications. Effort-corrected estimates of abundance, biomass and species richness were correlated between the protocols and both distinguished the trout-dominated alpine communities from subalpine and prealpine lakes dominated by whitefish and perch. A considerable amount of variance remained unexplained between the two protocols however, which seemed to correspond with differences in the proportion of effort among benthic and pelagic habitats. We suggest that both the European standard (CEN) and vertical (VERT) netting protocols are suitable for assessing ecological status and monitoring changes in lake fish communities through time. However the details of each protocol should be kept in mind when comparing fish communities between lakes. Mesh sizes used in CEN nets produce a more even size frequency distribution, suggesting that this protocol is most appropriate for assessing size structure of fish assemblages. The high proportion of netting effort in benthic habitats shallower than 70 m depth under the CEN protocol means that, particularly in larger lakes, outcomes will be disproportionately influenced by the ecological condition of this habitat. The VERT protocol presumably provides a more accurate estimate of whole-lake CPUE and community composition because effort, in terms of net area, is more evenly distributed across the entire volume of the lake. This is particularly important in large and deep lakes where pelagic habitats occupy a high proportion of the lake volume.

1. Introduction

The European Union Water Framework Directive (WFD) requires that all member countries characterize, assess and if necessary, improve the ecological status of their freshwater ecosystems by 2015. Fish, benthic invertebrates, phytoplankton and other aquatic flora form the basis of the biological component of the assessment. In particular, the longevity of many fish species makes them robust and temporally integrated indicators of ecosystem status (Vander Zanden and Vadeboncoeur, 2002). The WFD requires assessment of three aspects of the fish community: whole-lake estimate of catch per unit effort (CPUE), species composition and the age structure of fish assemblages. A multimesh gillnetting protocol has been adopted across Europe to conduct assessments under the WFD and facilitate intercalibration of quality thresholds between countries (hereafter refered to as CEN protocol;

* Corresponding author at: Department of Fish Ecology and Evolution, Centre of Ecology, Evolution and Biogeochemistry, EAWAG Swiss Federal Institute of Aquatic Science and Technology, Seestrasse 79, CH-6047 Kastanienbaum, Switzerland; Division of Aquatic Ecology and Evolution, Institute of Ecology and Evolution, University of Bern, Baltzerstrasse 6, CH-3012 Bern, Switzerland. Tel.: +41 58 765 2202.
E-mail address: tjalexander001@gmail.com (T.J. Alexander).

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Appelberg, 2000; Comité Européen de Normalisation, 2005). The CEN protocol divides each lake into benthic and pelagic zones and samples these zones using gillnets deployed horizontally in the water column or on the lakebed. Netting effort is allocated in the benthic zone by randomly sampling within defined depth strata with replication determined according to the maximum depth and area of a lake. Pelagic netting effort is also conducted within depth strata but only within one column at the deepest point of the lake.

A second gillnetting protocol has been used widely to survey whole-lake fish communities for management and research in eastern France. This protocol describes the use of vertically oriented gillnets that simultaneously survey from the water surface to the lake floor. The vertical nets were originally developed in the USA for studying depth distribution of fishes in lakes and reservoirs (Horak and Tanner, 1964; Lackey, 1968; Lynch et al., 1989). The vertical netting protocol (hereafter referred to as VERT protocol), introduced by Degiorgi et al. (1993) and amended in Degiorgi et al. (2001), describes the application of vertical nets to sample whole-lake fish communities. Under the VERT protocol, replicate gillnet series are deployed within each type of littoral and offshore habitat present in the lake. Littoral habitats (<5 m deep) are classified based on substrate composition and particle size, macrophyte morphology and density, and proximity to an inwardly or outwardly flowing watercourse. Two sublittoral and three deep pelagic habitats are also defined relative to the maximum depth of the lake.

The widespread use of the CEN sampling protocol provides an unprecedented opportunity for community- and macro-ecological research into natural and anthropogenic conditions influencing lacustrine fish communities (e.g. Brucet et al., 2013; Mehner et al., 2005, 2007). However, meaningful interpretation of the results of such research requires an understanding of the strengths, weaknesses and idiosyncrasies of the data on which it is based. Multiple authors have commented that the CEN protocol under-represents pelagic species in assessments of whole-lake fish communities (Achleitner et al., 2012; Deceliere-Vergès et al., 2009; Deceliere-Vergès and Guillard, 2008; Diekmann et al., 2005). Other authors have noted that sampling only at the deepest point of the lake probably overlooks horizontal variation in fish communities living in pelagic habitats (Lauridsen et al., 2008; Specziar et al., 2009). These issues are particularly important in large and deep lakes where pelagic habitats constitute the vast majority of the lake volume. This paper therefore aims to assess and compare the utility of CEN and VERT protocols for management and research into whole-lake fish communities. The investigation will focus on the level of correspondence and discrepancy between the protocols and their relative strengths in providing reliable estimates of whole-lake fish CPUE, size structure, species richness and community composition.

2. Methods

2.1. Fish sampling

Comparison of CEN and VERT protocols was conducted by sampling fish communities using both protocols in 17 lakes across eastern France, Switzerland and northern Italy (Fig. 1). Physical characteristics of the sampled lakes are provided in Table 1. Surveys were conducted between August and October 2010–2013. All nets were set before dusk and retrieved approximately 14 h later. Due to the logistics of the large-scale field schedule, soak times occasionally varied from this target. To reduce the influence of variation in soak time, catches were standardized to 14 h by dividing by the soak time (in decimal hours) and multiplying by 14. Biomass and number of fish (abundance) were also standardized by the area of net. The resulting biomass per unit effort (BPUE) and number of fish per unit effort (NPUE) therefore reflected fish catches per square meter per 14 h. Catch per unit effort (CPUE) is used in this paper as the collective term for both BPUE and NPUE. Catch rate and CPUE are also used interchangeably. Use of the terms biomass and abundance always refers to effort corrected values.

Sampling under the CEN protocol was conducted according to the European Committee for Standardization standard EN14757:2005 (Comité Européen de Normalisation, 2005). Briefly, benthic netting effort was located randomly within defined depth strata with replication determined by the maximum depth and area of a lake. Pelagic nets were set suspended in the water column within the same depth strata at the deepest point of the lake over consecutive nights. Benthic habitats were sampled with Nordic type gillnets consisting of a series of contiguous panels of twelve mesh sizes following a geometric series: 5, 6.25, 8, 10, 12.5, 15.5, 19.5, 24, 35, 43, and 55 mm (measured knot to knot). Each mesh panel was 1.5 m high and 2.5 m wide. The combined multimesh net was 1.5 m high and 30 m long. Pelagic nets consisted of the same mesh sizes, minus the 5 mm mesh. Panels in pelagic nets were 6 m high making the combined net 6 m high and 27.5 m long.

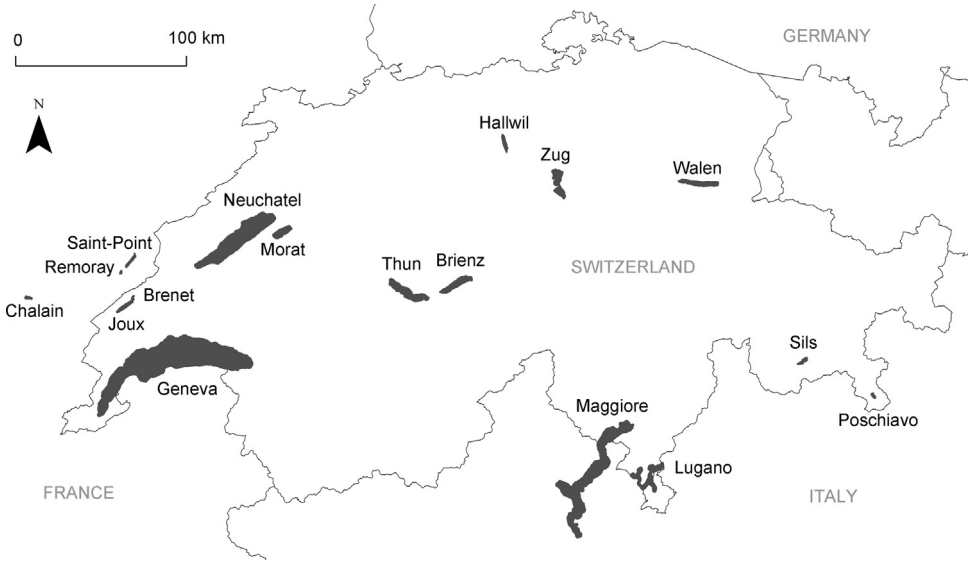

Fig. 1. Map of sampled lakes across Switzerland, eastern France and northern Italy.