A comparison of methods for calculating Catch Per Unit Effort (CPUE) of gill net catches in lakes

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ABSTRACT

Fish constitute an important component of lake ecosystems and many different methods have been used for fish assessment. Based on gill net catches in two stratified (max depth = 14–22 m) eutrophic Danish lakes, relative fish abundance measured as Catch Per Unit Effort (CPUE) was calculated. We used three different methods of which two followed the European standard based on benthic nets (CEN (European Committee for Standardization), 2005: EN 14757. Water quality – Sampling of fish with multi-mesh gill nets. Brussels, 27 pp.), one assuming equal volumes in all depth strata and the other using calculated volumes in the depth strata. The third method followed a modified CEN standard, adopted as a new Danish (DK) standardized method based on calculated benthic and pelagic water volumes and by including both benthic nets and, compared to the CEN standard, an increased fishing effort with pelagic nets. Fish were concentrated in the littoral/benthic part of the upper two depth strata (0–6 m depth) with an up to 8 fold higher abundance than in the pelagic. Calculated CPUE is highly sensitive to the morphometry of the lakes. In lakes with extreme morphometry (unequal volumes in depth strata) it is important to use calculated water volumes for the depth strata. By including information derived from the pelagic nets, total lake CPUEs were 42–56% lower than CPUE values based on benthic nets only. We further show that the relative contribution of CPUE between habitats changes markedly with the nutrient level in 12 deep lakes. It is concluded that for deep lakes it is of key importance to include pelagic nets when comparing fish assemblages and abundances among lakes and when evaluating effects of major changes in key environmental factors, such as nutrient loading and climate.

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1. Introduction

It is generally accepted that fish strongly influence trophic dynamics in lakes, occasionally with great impact on phytoplankton and on the water quality and ecological state in both freshwater lakes (Carpenter and Kitchell, 1993; Rudstam et al., 1993; Jeppesen et al., 1997, 2000) and brackish lakes (Jakobsen et al., 2004). Fish also contribute to biodiversity and are of interest to both anglers and commercial fishermen. Moreover, fish are one of the four biological variables to be monitored according to the EU Water Framework Directive (WFD) for European water bodies (European Union, 2000). Knowledge of fish community structure and abundance is therefore of key importance. Various gears have been used for fish surveys, such as seine nets, fyke nets, trawls, gill nets, electrofishing and hydroacoustics (e.g., Mehner et al., 2005a; Prchalová et al., 2006; Juza and Kubečka, 2007), or assessments have been based on commercial catch data. In general, the methods follow traditions, laws and regulations and the specific sites and aims. However, the use of different gear renders comparisons of fish-data between lakes difficult (Lauridsen et al., 1999; Appelberg, 2000), and even if similar gear has been used, dimensions will most likely differ (Mehner et al., 2007). Results from the marine environment have indicated that an understanding of gear dynamics and environmental influences as well as of habitat and depth influence is important for analyzing CPUE (Bigelow and Maunder, 2007).

With the implementation of the EU WFD, it is claimed to use general standards in lake monitoring. Such a standard has not been adopted for fish so far; however, a European standard on gill netting (CEN, 2005) was introduced in 2005. To obtain a standardized Catch Per Unit Effort (CPUE) for fish weight and numbers,

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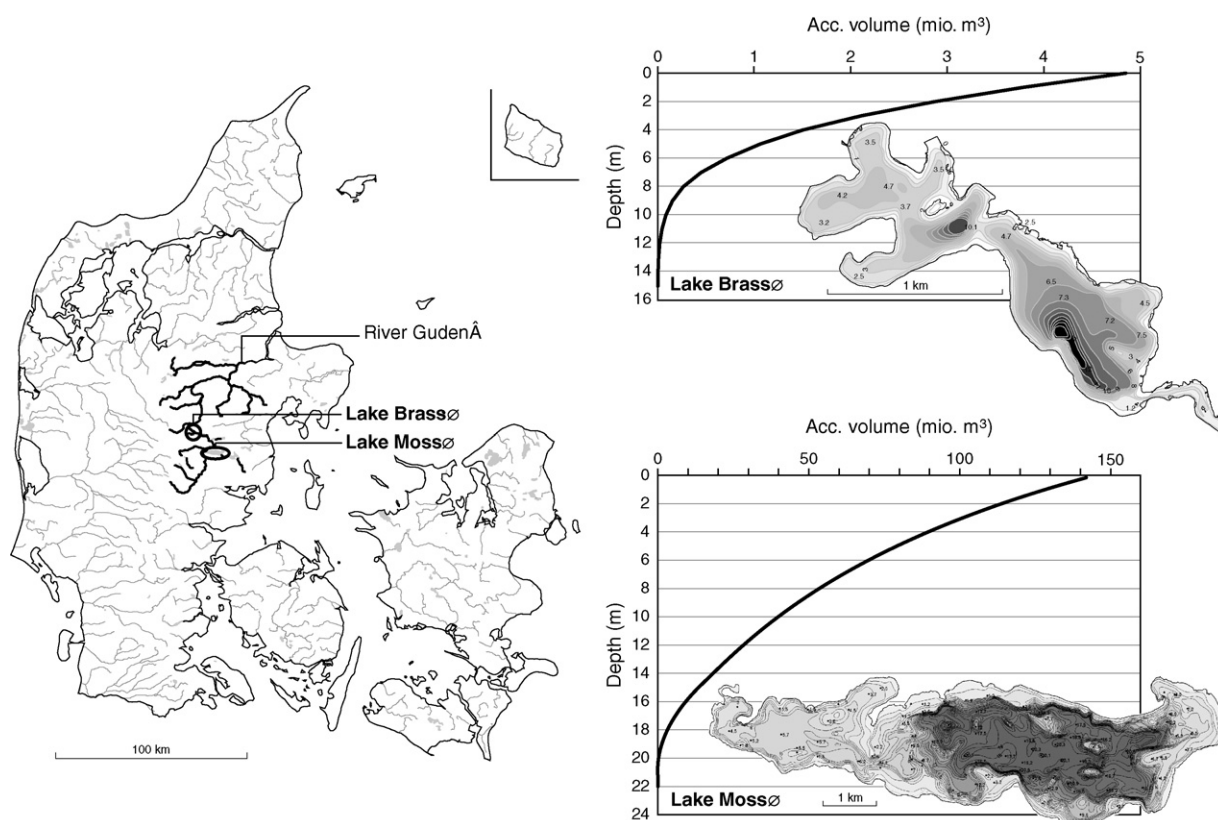
Fig. 1. Map of Denmark showing the two study lakes, Lake Brassø and Lake Mossø, in the River Gudenå system. Hypsographs illustrate the extreme morphomotry of Lake Brassø and the normal morphometry of Lake Mossø, see text for further explanation.

guidelines for field sampling using a range of depth strata and benthic gill nets combined with pelagic nets at a single site in each lake have been established.

In Denmark, a standardized gill netting method (Mortensen et al., 1990) was introduced in 1989 and used in approximately 120 lakes until 2004. The method by Mortensen et al. (1990) prescribed use of benthic, pelagic and floating Lundgreen gill nets (length 42 m, height 1.5 m, multiple mesh with fourteen 3-m panels ranging from 6.25 to 75 mm) together with electrofishing in the littoral zone. The Mortensen et al. (1990) method was not, however, directly comparable to the Swedish and Finnish standards using Nordic gill nets (Appelberg, 2000), which later became the CEN standard (CEN, 2005). To ensure comparability of data, it was decided to substitute the Mortensen et al. (1990) method with the CEN standard (CEN, 2005) for surveys in Danish lakes. However, to increase the effort on pelagic fishes, randomly distributed pelagic gill nets were introduced into the Danish (DK) version of the CEN standard, as pelagic catches may vary considerably from benthic catches and the relative contribution may change with eutrophication (Jeppesen et al., 2006). Such changes may not be registered by just using benthic nets and the change in relative abundance using the CEN standard

is actually not comparable. The DK method allows calculations of CPUE in different ways, of which one is comparable to the CEN standard and the other takes into account the pelagic gill nets.

The aim of this study is to demonstrate how the inclusion of pelagic gill nets and the diversion of depth strata into benthic and pelagic zones affect the calculated total fish CPUE in deep lakes. A second aim is to evaluate the necessity of using similar methods in the CPUE data processing.

2. Study area

Lake Brassø (122 ha, max. depth 14 m) and Lake Mossø (1690 ha, max depth 22 m) are both situated in the central part of Jutland (Denmark) (Fig. 1). They are part of the River Gudenå system and by Danish standard; they are large, eutrophic and deep lakes with low Secchi depth and sparse submerged vegetation. For more morphometric and abiotic characteristics, see Table 1. Since the lakes are large and situated geographically closely in the same river system, their fish stock compositions are very similar (Table 2).

Lake Brassø has a deeper part in its eastern end in which the deepest spot covers only a minor area (Fig. 1); a characteristic defined as 'extreme morphometry' according to the CEN standard. Lake Mossø has a large deep part in the eastern end but no small deep spot, and its morphemetry is therefore 'normal' according to the CEN standard (Fig. 1). In the period June to August and during stratification oxygen concentrations are below $6\,mg\,O_2\,l^{-1}$ in the bottom water (>18 m) of Lake Mossø (Jørgensen, 2000). Lake Brassø is not permanently stratified during summer; however, temporary oxygen depletion does occur in the bottom water (>6 m, T. Jørgensen, unpubl. results).

Table 1
Characteristics of the two study lakes

	Lake Brassø	Lake Mossø
Area (ha)	122	1690
Maximum depth (m)	14	22
Mean depth (m)	4.6	9
Retention time (yr)	0.01	2.2
Total phosphorus ($\mu g\,l^{-1}$)	101 (2005)	93 (2005)