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Comparison of Schindler-Patalas Traps and Wisconsin Nets for Monitoring Zooplankton in a Large, Shallow Reservoir

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ABSTRACT

Zooplankton collection methods can differ substantially in the information produced; therefore, determining the best method or methods for a particular ecosystem is essential in understanding limnological processes. We compared results of two sampling methods, Wisconsin net vertical tows and Schindler-Patalas traps, that have been used in a long-term monitoring program in a large, shallow reservoir, Kentucky Lake, USA. Although there were differences in net mesh size and volume of water sampled, statistically similar cladoceran and copepod communities were captured by both methods. Population densities and the number of taxa collected did differ between methods, with many smaller rotifer taxa being found only in the vertical tows, but there were higher densities of larger taxa in the traps. Annual patterns were similar for most larger taxa, except that Wisconsin net tows revealed an autumn density peak for *Bosmina longirostris* not well-detected in the trap samples. Given the biases of each method, the Schindler-Patalas trap appears to be more efficient overall in long-term monitoring studies, particularly in shallow systems where multiple samples are taken frequently at a number of sites.

KEY WORDS: Zooplankton, shallow reservoir, Kentucky Lake, Schindler-Patalas trap, Wisconsin net, method comparisons

INTRODUCTION

A wide variety of sampling gear is used to assess zooplankton populations (Wetzel and Likens 2000), and comparisons among the methods have been conducted in marine, lake, reservoir, and river ecosystems (e.g., Kankaala 1984; Cook and Hays 2001; Sluss et al. 2011). Typically, zooplankton are captured in traps that sample a known volume of water or in nets designed to be towed over some distance, e.g., from the bottom to the top of the water column. Traps might be preferred when one is interested in data for zooplankton population spatial and temporal distributions, either horizontal or vertical. Nets may be preferred when more qualitative data are desired or when zooplankton populations are sparse requiring larger volumes of water to be filtered (Kankaala 1984). More comprehensive studies may use several methods to capture representative samples of zooplankton communities (Wetzel and Likens 2000). Not surprisingly, different methods often give different results in species composition, densities, and the sizes of organisms captured. Differences may be further magnified by filter mesh sizes. Such differences may be significant in quantitative studies of life histories, secondary production, food webs, or community structure (Kankaala 1984).

In 1988, a long-term limnological monitoring program began on Kentucky Lake, USA, the terminal and largest reservoir on the Tennessee River system (White et al. 2007). Kentucky Lake averages 6 m deep and is considered mesotrophic. The 16–17 monitoring sites cover approximately 30 km of the lower portion of the lake and are located in the main channel and several shallower embayments (White et al. 2007). Monitoring cruises occur every 16 days in spring through autumn and 32 days in winter. Objectives of the monitoring program have been to follow spatial and temporal patterns over time as they relate to seasonal, longitudinal, lateral and reservoir operational variations. Particular emphasis is placed on understanding processes in sidearm bays of a variety of sizes and watershed uses. For zooplankton the goal has been to understand population density, phenology, and species composition, primarily for the cladocerans and copepods, in relation to other parameters, e.g., temperature, dissolved oxygen, hydrology, invasive species, etc. (Yurista et al. 2001; White et al. 2007). Two types of zooplankton samples have been taken at each site, with slightly different objectives. The primary sampling uses triplicate 15-L

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Schindler-Patalas trap collections to examine aerial and seasonal distributions at a single depth. These samples are supplemented with a single finer meshed Wisconsin net bottom to top of the water column tow to examine size fractions or collect species that might have been missed.

To date, only the Schindler-Patalas samples have been analyzed consistently, while most of the net tows have been archived. Thus, the objectives of this study were 1) to compare overall results between traps and nets, 2) to determine if traps and nets gave consistent and similar results across monitoring sites, and 3) to determine if greater effort should be placed on analyzing net tow samples.

METHODS

Kentucky Lake monitoring cruises are conducted during the first half of the day, between approximately 0700 and 1300 hr. At each site, three replicate 15-L Schindler-Patalas trap samples (243 µm mesh sieve) are taken at 5 m deep or half the water column depth for shallower sites to approximate the 1% light depth (Yurista et al. 2004). One unmetered Wisconsin net tow (13 cm diameter mouth, 153 µm mesh net) is taken from just off the bottom to the top of the water column. The net is towed at approximately 1 m/sec. All zooplankton samples are rinsed into 70-ml tissue culture flasks (TFCs), kept on ice until returned to the lab, relaxed with tonic water, and preserved with 4% formalin solution. Because the numbers of organisms captured in net tows usually are considerably higher than in the traps, most have not been enumerated while all Schindler-Patalas trap samples have been processed. We analyzed a subset of both sample types that were taken in 2008 from 6 sites, 3 in the main channel and 3 in shallower embayments. This included 22 sampling dates and a total of 108 matched net and trap samples. The year was selected because there were fewer hydrologic anomalies, such as floods or drought conditions that could affect sampling efforts and species composition.

All organisms from both trap and net samples were counted and identified to the lowest convenient taxon by placing TFCs on a gridded plate and using a stereo dissecting microscope. Data were entered into the Kentucky Lake Monitoring Program database (White et al. 2007). First, we made qualitative observations on differences between sampling results that included smaller taxa such as rotifers. To account for the differences in mesh sizes in quantitative comparisons, we limited the analysis to those taxa with larger individuals that would have been caught in the mesh of both traps; i.e., cladocerans, copepods, and some larger rotifers. Densities in trap samples were calculated by compositing data from the three replicate 15-L samples and dividing by 45. Densities per liter in net tows were calculated by multiplying the area of the mouth of the net ($\pi \times 0.13\ m^2$) times the water depth times 1000. All summary statistics and graphics were generated using the R project (R Core Development Team 2010). Site-by-date pairs for a taxon were excluded from analyses when a taxon was not captured by either method, however when one sample caught a given taxon and the other did not, we assigned a zero to the latter.

RESULTS

The sum of all the Schindler-Patalas traps at the six sites for the year 2008 captured a total of 23,478 organisms in 4185 L of water, an average of 5.6 L^{-1}. Net tows captured an estimated 236,604 total organisms (including small rotifers) in 65,302 L, an average of 3.6 L^{-1}. Excluding the small rotifer taxa, net tows captured an average of 3.0 L^{-1}. Taxonomic richness differed significantly between sampling methods ($t_{107} = 17.049$, p-value <0.001) because of the larger variety of small rotifers in the net tows. For the larger taxa alone, the community represented by both methods was similar (Figure 1). Proportionately more *Bosmina longirostris* (Müller) and *Daphnia* spp. (primarily *D. retrocurva* (Forbes)) were collected in the trap samples, while higher numbers of the larger rotifers *Synchaeta, Keratella,* and *Asplanchna* were present in the tows. This also was evident for cyclopoid and calanoid copepod nauplii that were proportionately much less abundant in the trap samples.

Bosmina longirostris was the most common cladoceran collected by both methods, followed by calanoid and cyclopoid copepods, *D. retrocurva* (Forbes), *Leptodora kindtii* (Focke), *Ceriodaphnia* (two species), and *D.*

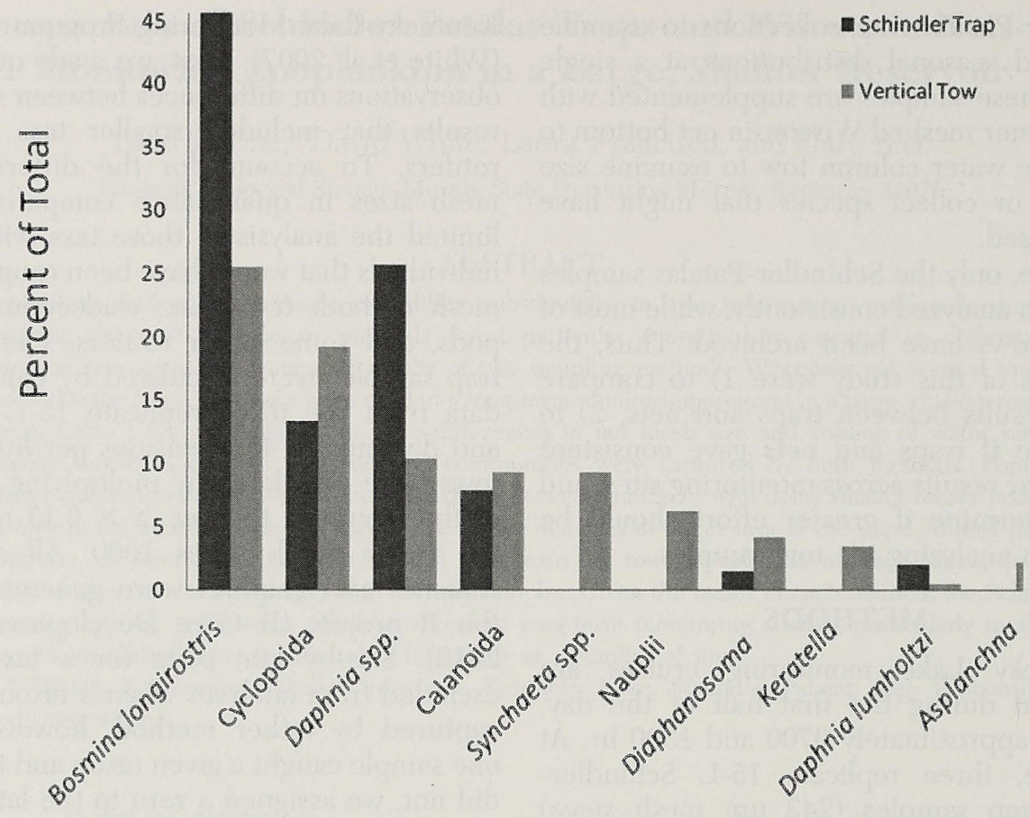

Figure 1. Histograms of dominant larger zooplankton taxa showing the proportions of the total number of larger organisms captured in each sampling method. Data represent >90% the total larger organisms for each method. *Daphnia* spp. is primarly *D. retrocurva*.

lumholtzi (Sars) (Figure 1). Other zooplankton taxa occurred in one or both sample types, but were relatively uncommon. These uncommon taxa included *Taphromysis louisianae* (Banner), *Chaoborus punctipenis* (Say), *Holopedium amazonicum* (Stingelin), and species of *Alona*, *Leydigia*, *Chydorus*, harpacticoid copepods, and ostracods. These taxa did not occur in sufficient densities to make statistical comparisons.

Part of our objective was to determine if any differences occurred between nets and traps among specific monitoring sites. Traps captured up to 7 of the larger taxa in a sample, and net tows collected up to 13. Analysis of variance (ANOVA) showed no significant differences in species richness among sites based on trap samples ($F_5 = 1.185$, $P = 0.32$). Net tow data, however, did show significant differences among sites ($F_5 = 5.13$, $P < 0.001$) with the northernmost channel site being more species rich, on average 9.68, than either of the other two channel sites that averaged 7.1 and 7.4 taxa. Aside from slightly greater depth we are unaware of any features that distinguished this site from others that could cause higher species richness.

Paired *t*-tests revealed significantly different zooplankton density estimates between the sampling methods. *Daphnia* spp. (primarily *D. retrocurva*) occurred in high densities, and estimates were significantly different between methods (Schindler trap mean = 3.02/L; Vertical tow mean = 1.48, $t_{58} = 4.78$, $P < 0.001$), likewise *D. lumholtzi* density estimates were significantly different between the methods ($t_{37} = 3.6$, $P = 0.001$). The most common taxon, *B. longirostris* (Schindler trap mean = 4.59; Vertical tow = 3.17) exhibited higher densities in Schindler traps but differences were not significant between collection methods ($t_{83} = 0.726$, $P = 0.47$). Density estimates for several other taxa were significantly higher in vertical tows, including *Ceriodaphnia* spp. ($t_{10} = 2.44$, p-value = 0.034), *Diaphanosoma* spp. ($t_{37} = 4.94$, $P < 0.001$), calanoid ($t_{94} = 5.86$, $P < 0.001$) and cyclopoid ($t_{65} = 9.18$, $P < 0.001$) copepods and *L. kindtii* ($t_{23} = 3.24$, $P = 0.003$). Our density estimates for these taxa were generally

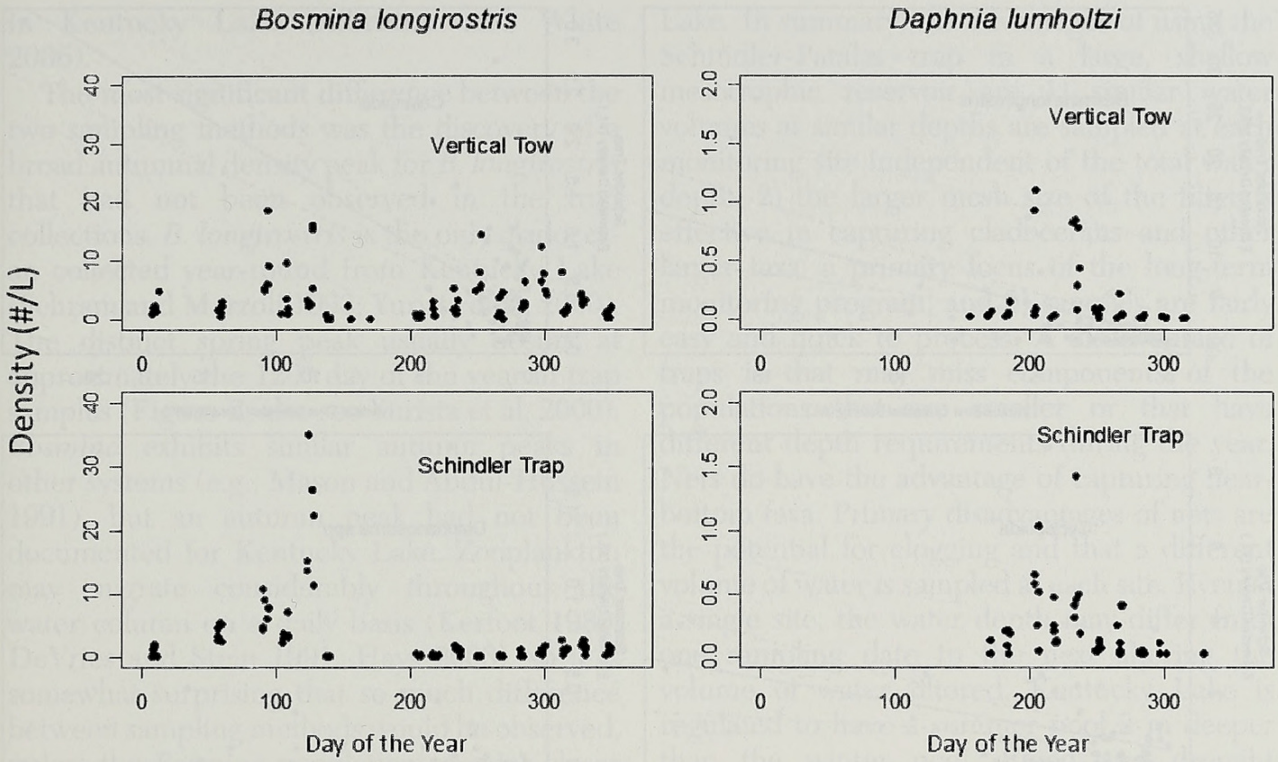

Figure 2. Comparison of *Bosmina longirostris* and *Daphnia lumholtzi* densities in paired vertical tow and trap samples in 2008. Each dot represents the mean number of individuals per sampling site. Dots are "jittered" horizontally to add random variation on the x-axis and to allow overplotted points to show up separately.

lower, ranging from cyclopoid copepods (Schindler trap = 1.03; Vertical tow = 2.19) to the predaceous *L. kindtii* (Schindler trap = 0.03; Vertical tow = 0.07). Other taxa occurred too infrequently to compare statistically.

Timing of spring and summer peak densities was qualitatively similar in both methods for most species (e.g., *D. lumholtzi*, Figure 2). *Bosmina longirostris* had similar intra-annual patterns in the two methods but differed in that there was a broad autumnal density peak from about day 220 to 340 not seen in the traps. Net tows also indicated a much longer spring peak for *B. longirostris* (lasting over 3, 16-day sampling events). Overall similarities suggested that, while absolute densities may be different between the two methods, densities in one sampling method should predict densities in the other method. We tested this using regressions of density estimates from the two sampling methods for each of several dominant species (Figure 3). *Bosmina longirostris* exhibited statistically related densities between the two methods ($r^2 = 0.89$, $P < 0.001$) when the autumn samples were excluded. Similarities between estimates produced from these methods were observed in other taxa, including calanoid copepods ($r^2 = 0.44$, $P < 0.001$), *D. retrocurva* ($r^2 = 0.11$, $P = 0.01$), *D. lumholtzi* ($r^2 = 0.30$, $P < 0.001$). No similar relationships could be detected in the remaining taxa, most likely because of low densities in both collection methods.

DISCUSSION

With the exception of *T. louisianae* and the invasive, *D. lumholtzi*, the larger species of cladocerans, copepods, and rotifers of Kentucky Lake are dominated by a small set of easily distinguishable taxa common to the Midwest and Great Lakes regions that have become established in most Midwestern reservoirs (Balcer et al. 1984; Yurista and White 2001; Havel and Shurin 2004). The net tows did not produce any additional or novel taxa for Kentucky Lake that had not been previously identified in the trap samples.

One determinant of the success of nets is the speed at which they are towed and their potential for clogging (Kane and Anderson 2007). However, studies have found that even substantial differences in tow speeds

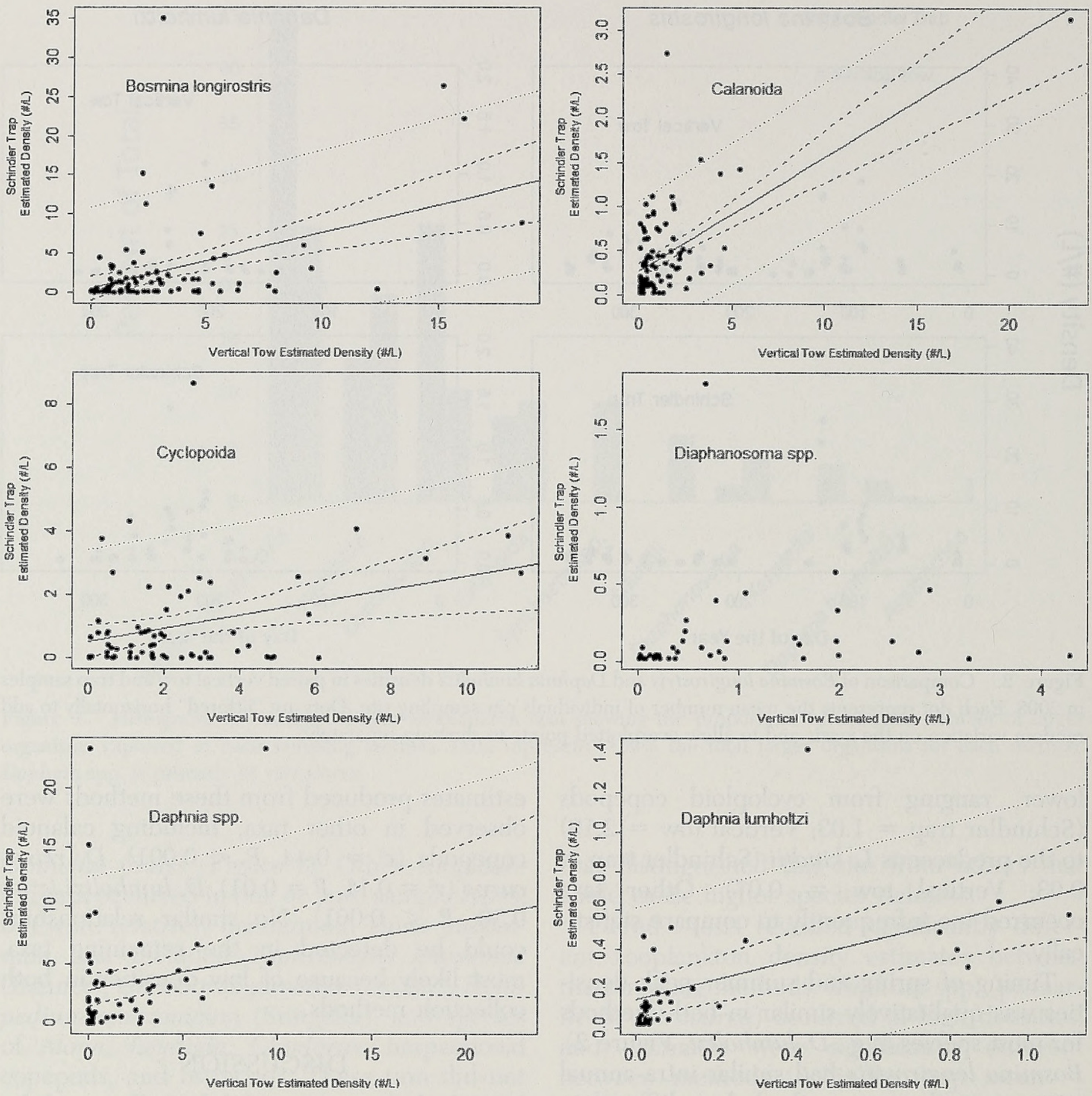

Figure 3. Density comparisons of the six most common taxa of zooplankton captured by the two methods. Regression estimates (solid line), prediction intervals (dashed lines) and confidence intervals (dotted lines). There were no significant similarities for *Diaphanosoma*.

for bongo nets towed horizontally do not yield significant differences in the zooplankton community nor in population data (Kankaala 1984). Likewise, DeVries and Stein (1991) had similar results in a comparison of Schindler-Patalas traps, nets, and tube samplers. The overall lower average densities of organisms per L in the net tows for Kentucky Lake may in part be due to net clogging by blooms of filamentous diatoms, green algae, and blue-green cyanobacteria that are located primarily in the upper 1–2 m of the water column during spring and summer months; thus the actual volume of water filtered might be much lower than determined by net tow distance alone. Because the mesh size was smaller in the vertical tow nets, we assumed that they would capture many smaller and possibly different organisms than traps. The larger number of rotifers in the net tows most likely reflected the differences in net mesh size and, consistent with previous studies, that the greatest concentrations of small rotifers occur directly on or above the bottom in Kentucky Lake (Albritton and White 2006).

The most significant difference between the two sampling methods was the discovery of a broad autumnal density peak for *B. longirostris* that had not been observed in the trap collections. *B. longirostris* is the only cladoceran collected year-round from Kentucky Lake (Schram and Marzolf 1993; Yurista et al. 2000). The distinct spring peak usually occurs at approximately the 120th day of the year in trap samples (Figure 2, also see Yurista et al. 2000). *Bosmina* exhibits similar autumn peaks in other systems (e.g., Mason and Abdul-Hussein 1991), but an autumn peak had not been documented for Kentucky Lake. Zooplankton may migrate considerably throughout the water column on a daily basis (Kerfoot 1980; DeVries and Stein 1991; Hays 2003), so it is somewhat surprising that so much difference between sampling methods would be observed, unless the *Bosmina* population remains closer to the bottom particularly during colder months while other taxa continue to remain further up in the water column.

Schindler-Patalas trap and Wisconsin net samples produced slightly different views of the Kentucky Lake zooplankton community. Vertical net tows captured more species, particularly those living near the bottom of the water column, and revealed the presence of an additional density peak for *B. longirostris*, but most likely underestimated water column densities because of potential clogging. Schindler-Patalas traps most likely overestimated water column populations because samples were taken at a depth where greater densities were expected. Because traps capture at a discrete mid-water depth, they avoid clogging algae and allowed us to focus on the primary goal of monitoring the cladoceran/copepod community. Further, as the number of organisms captured in the nets was much greater, there was a substantial effort in analyzing these collections, particularly for long-term monitoring programs over large areas such as ours.

Our data suggest that Schindler-Patalas trap samples, despite sampling a relatively smaller portion of the water column, present a reasonably accurate representation of most features of the zooplankton community (Mason and Abdul-Hussein 1991), particularly in Kentucky Lake. In summary, the advantages of using the Schindler-Patalas trap in a large, shallow mesotrophic reservoir are 1) similar water volumes at similar depths are sampled at each monitoring site independent of the total water depth, 2) the larger mesh size of the filter is effective in capturing cladocerans and other larger taxa, a primary focus of the long-term monitoring program, and 3) samples are fairly easy and quick to process. A disadvantage of traps is that may miss components of the populations that are smaller or that have different depth requirements during the year. Nets do have the advantage of capturing near-bottom taxa. Primary disadvantages of nets are the potential for clogging and that a different volume of water is sampled at each site. Even at a single site, the water depth may differ from one sampling date to the next altering the volume of water filtered. Kentucky Lake is regulated to have a summer pool 2 m deeper than the winter pool. Flood and drought conditions over the past few years have produced a 5 m range in surface elevation.

Collecting Wisconsin net vertical tows at each site does not require much time, but processing them is labor-intensive compared with trap samples. Net samples will continue to be collected and archived but not processed unless there is a specific need. Net samples along with trap samples and the zooplankton database are available to researchers. Further information is available through the Hancock Biological Station website: www.murraystate.edu/hbs.

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