Seasonal variation of fish abundance and biomass in gillnet catches of an East Mediterranean lake: Lake Doirani

Dimitra C. Bobori* and Ioanna Salvarina

Laboratory of Ichthyology, School of Biology, Department of Zoology, Aristotle University of Thessaloniki, PO Box 134, 541 24, Thessaloniki, Greece

(Received: August 19, 2009; Revised received: January 05, 2010; Accepted: February 27, 2010)

Abstract: The seasonal variation of fish species composition and abundance in gillnet catches (14-90 mm knot-to-knot) from the Greek part of the transboundary Lake Doirani was studied during the period 2006-2007. A total of 8,419 specimens weighting 182.3 kg and belonging to 9 species were caught. Catch composition differed with season. Thus, Rhodeus meridionalis dominated in terms of NPUE the spring, Perca fluviatilis the summer and Alburnus macedonicus the autumn and winter catches. Cyprinids were generally the most abundant, with the cyprinids:percids biomass ratio ranging from 1.7 in summer to 14.8 in winter, supporting the eutrophic character of the lake. Richness and Shannon-Wiener diversity and evenness indices differed seasonally (ANOVA; p < 0.05). The abundance-biomass comparative (ABC) curves showed that fish communities were dominated by one or a few opportunistic species (e.g. Rhodeus meridionalis, Alburnus macedonicus), which while dominated in number did not dominate in biomass, being small bodied.

Key words: Abundance, Biomass, Freshwater fish, Gillnet catches, Lake Doirani

PDF of full length paper is available online

Introduction

The distribution of fish communities in lakes is known to fluctuate over space and time (Matthews, 1998). Research has so far been focused on understanding these patterns, with emphasis, among others, on the seasonal variation of fish abundance, biomass and ecological indices such as species richness and diversity (Fischer and Eckmann, 1997; Grant et al., 2004; Gray et al., 2009). Most of these studies are based on multi-mesh gillnet sampling, which is by far among the most applicable method for assessing fish community composition, species abundance and biomass in lakes (Moss et al., 2003; Deceliere-Verges et al., 2009). Yet, multiple gillnet catches are used widely in several European countries for assessing and monitoring fish communities (Appelberg, 2000; Mehner et al., 2005; Lauridsen et al., 2008) in the frame of the implementation of the Water Framework Directive (WFD) 2000/60/EC (European Commission, 2000).

Fish abundance and biomass are usually expressed as the catch-per-unit-of-fishing effort (CPUE) which can also be used for assessing the degree of exploitation of fishery resources (Degerman et al., 1988; Ahmed and Hambrey, 2005). However, the reliability of CPUE for adequately expressing fish abundance and biomass is considered variable, since it strongly depends, among others, on the selectivity of gillnets as passive gears (Hamley, 1975). Thus, additional diversity indices (richness, evenness) or aggregate metrics (dominance or ABC curves), that emphasize the role of some important species in a community, are very common among ecologists for evaluating fisheries impacts (Rice, 2000).

The species composition of lake fish communities and the abundance or biomass of several species or functional groups have been used as descriptors for assessing the human pressures (Mehner et al., 2005; Zambrano et al., 2006) and for developing systems (Gassner et al., 2003; Moss et al., 2003; Freund and Petty, 2007) for the assessment of surface water ecological quality according to the WFD. Although the above have so far been studied in a number of European countries (Olin et al., 2002; Mehner et al., 2005; Diekmann et al., 2005; Kubeeka et al., 2009), similar data are not available for Greek lakes except Crivelli et al. (1997), although there is a vast demand for quantitative data concerning lake fish communities, towards the implementation of the WFD 2000/60/EC.

The objective of the present study was to address the lack of knowledge of gillnet quantitative data on fish communities in lake Doirani. Furthermore, we tested for seasonal changes in gillnet catch species composition and abundance and assessed the degree of disturbance of fish communities.

Materials and Methods

Study area: Lake Doirani (Fig. 1) is a transboundary lake, shared by the Former Yugoslavic Republic of Macedonia (FYROM) and Greece (East Mediterranean Sea). It is a tectonic, eutrophic (Temponeras et al., 2000) lake (altitude: 148 m above sea level, drainage area: 276.3 km², surface area: 28 km², maximum depth: 5 m).
The lake suffers from intensive water abstraction resulting in the reduction of its water volume, which in combination with the deterioration of its water quality (Pertsemli and Voutsa, 2007) has caused the reduction of its fisheries’ production. Moreover, cyanobacterial water blooms during the hot period have been reported, contributing to further degradation of its water quality (Cook et al., 2004).

**Sampling:** Fishes were sampled seasonally (two constantly days per season), from April 2006 to February 2007, by multi-mesh, monofilament gillnets, with different mesh sizes (14, 18, 22, 26, 30, 40, 45, 50, 65, 70, 75, 80 and 90 mm, knot-to-knot). Gillnets of 14-30 mm were experimental nets (2 m height, 100 m length) and were set close to the shallow areas (Station 1, depth 3 m). Nets of 40-90 mm mesh-sizes were of those used by local fishermen (2.2-4 m height, 100 m length) and were set in the deeper part of the lake (station 2, depth up to 5 m). Nets were set in late afternoon (18:00-20:00) and retrieved the following morning (6:00-8:00) in order to ensure a constant fishing effort. All fish caught were identified according to depth up to 5 m). Nets were set in late afternoon (18:00-20:00) and retrieved the following morning (6:00-8:00) in order to ensure a constant fishing effort. All fish caught were identified according to retrieval the following morning (6:00-8:00) in order to ensure a constant fishing effort. All fish caught were identified according to sampling season separately based on species NPUE and BPUE values after log (x+1) transformation for reducing the influence of rare or abundant species. For each curve the W-value was calculated. W ranges from -1 to +1 and when the biomass curve lies above the abundance curve it receives positive values, indicating disturbed communities, dominated by K-selected species. In contrast, negative W values (when the abundance curve lies above the biomass curve), implies disturbed communities, dominated by diversity index H'; species richness, expressed by Margalef’s D index; evenness, measured by Pielou’s J index (Maguran, 1988); and the number of species caught per season were calculated and compared by one-way analysis of variance (ANOVA) and Fisher’s least significant difference (LSD) procedure. The cyprinids:percids biomass ratio (Cyp/Per) was also calculated based on the BPUE values of all cyprinids and percids respectively. This index has so far been used to display the response of fish communities along an increased trophic gradient (Olin et al., 2002), with cyprinids dominating the catches in mesotrophic to highly eutrophic lakes and percids dominating the fish biomass only in small oligo-mesotrophic and large meso-eutrophic lakes of higher complexity. Additionally, the abundance-biomass comparison (ABC) method (Warwick, 1986) was applied, which plots the K-dominance cumulative curves (cumulative ranked abundances plotted against species rank; Lambshead et al., 1983) for species abundances and biomasses on the same graph, so disturbed communities might be evaluated (Clarke and Warwick, 2001). ABC curves were conducted for each sampling season separately based on species NPUE and BPUE values after log (x+1) transformation for reducing the influence of rare or abundant species. For each curve the W-value was calculated. W ranges from -1 to +1 and when the biomass curve lies above the abundance curve it receives positive values, indicating disturbed communities, dominated by K-selected species. In contrast, negative W values (when the abundance curve lies above the biomass curve), implies disturbed communities, dominated by altitude 1.45m.

**Statistical analysis:** Catches were analyzed separately for each season, and the total number and weight of specimens per species were recorded. For each species CPUE was calculated as the number (NPUE) and the weight (BPUE) of the individuals of each species caught 100 m² gillnet area per night. The Shannon-Wiener index; evenness, measured by Pielou’s J index (Maguran, 1988); and the number of species caught per season were calculated and compared by one-way analysis of variance (ANOVA) and Fisher’s least significant difference (LSD) procedure. The cyprinids:percids biomass ratio (Cyp/Per) was also calculated based on the BPUE values of all cyprinids and percids respectively. This index has so far been used to display the response of fish communities along an increased trophic gradient (Olin et al., 2002), with cyprinids dominating the catches in mesotrophic to highly eutrophic lakes and percids dominating the fish biomass only in small oligo-mesotrophic and large meso-eutrophic lakes of higher complexity. Additionally, the abundance-biomass comparison (ABC) method (Warwick, 1986) was applied, which plots the K-dominance cumulative curves (cumulative ranked abundances plotted against species rank; Lambshead et al., 1983) for species abundances and biomasses on the same graph, so disturbed communities might be evaluated (Clarke and Warwick, 2001). ABC curves were conducted for each sampling season separately based on species NPUE and BPUE values after log (x+1) transformation for reducing the influence of rarity or abundant species. For each curve the W-value was calculated. W ranges from -1 to +1 and when the biomass curve lies above the abundance curve it receives positive values, indicating undisturbed communities, dominated by K-selected species. In contrast, negative W values (when the abundance curve lies above the biomass curve), implies disturbed communities, dominated by altitude 1.45m.

**Table 1:** Fish species caught in Lake Doirani during the sampling period (2006-2007), number (NPUE) and weight (BPUE) of the individuals caught 100 m² of net per night and their percentages (%) per season and overall.

<table>
<thead>
<tr>
<th>Season</th>
<th>Species</th>
<th>Spring</th>
<th></th>
<th>Summer</th>
<th></th>
<th>Autumn</th>
<th></th>
<th>Winter</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NPUE</td>
<td>%</td>
<td>NPUE</td>
<td>%</td>
<td>NPUE</td>
<td>%</td>
<td>NPUE</td>
<td>%</td>
<td>NPUE</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td><em>Alburnus macedonicus</em></td>
<td>1.45</td>
<td>10.05</td>
<td>5.21</td>
<td>37.36</td>
<td>20.62</td>
<td>65.12</td>
<td>1.90</td>
<td>81.81</td>
<td>29.18</td>
<td>46.78</td>
</tr>
<tr>
<td></td>
<td><em>Carassius gibelio</em></td>
<td>0.57</td>
<td>3.95</td>
<td>0.44</td>
<td>3.14</td>
<td>0.42</td>
<td>1.31</td>
<td>0.10</td>
<td>4.15</td>
<td>1.52</td>
<td>2.44</td>
</tr>
<tr>
<td></td>
<td><em>Cyprinus carpio</em></td>
<td>0.04</td>
<td>0.26</td>
<td>0.03</td>
<td>0.21</td>
<td>0.03</td>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td><em>Pachychilon macedonicum</em></td>
<td>2.48</td>
<td>17.18</td>
<td>0.40</td>
<td>2.67</td>
<td>0.35</td>
<td>1.10</td>
<td>0.00</td>
<td>0.00</td>
<td>3.23</td>
<td>5.18</td>
</tr>
<tr>
<td></td>
<td><em>Perca fluviatilis</em></td>
<td>1.02</td>
<td>7.02</td>
<td>7.21</td>
<td>51.66</td>
<td>7.97</td>
<td>55.12</td>
<td>0.13</td>
<td>2.56</td>
<td>15.87</td>
<td>25.43</td>
</tr>
<tr>
<td></td>
<td><em>Rhodeus mendenlais</em></td>
<td>7.97</td>
<td>55.12</td>
<td>0.13</td>
<td>0.96</td>
<td>1.25</td>
<td>3.93</td>
<td>0.06</td>
<td>2.56</td>
<td>9.41</td>
<td>15.08</td>
</tr>
<tr>
<td></td>
<td><em>Rutilus rutilus</em></td>
<td>0.76</td>
<td>5.23</td>
<td>0.53</td>
<td>3.77</td>
<td>1.56</td>
<td>4.94</td>
<td>0.06</td>
<td>2.56</td>
<td>9.41</td>
<td>15.08</td>
</tr>
<tr>
<td></td>
<td><em>Scardinius erythrophthalmus</em></td>
<td>0.11</td>
<td>0.77</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.11</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td><em>Squalius vardarensis</em></td>
<td>0.06</td>
<td>0.41</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.06</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>14.40</td>
<td>23.16</td>
<td>13.95</td>
<td>22.38</td>
<td>31.66</td>
<td>50.74</td>
<td>2.32</td>
<td>3.72</td>
<td>62.32</td>
<td>91.58</td>
</tr>
</tbody>
</table>

*Note: The values are rounded to one decimal place.*
Fish abundance and biomass in Lake Doirani

r-selected species. Communities might be characterized as moderately stressed when the abundance and biomass curves are very close or intersect, represented by W values close to 0. All the above analyses were performed using Statgraphics plus 3.0 and PRIMER 6.0 (Clarke and Gorley, 2001).

Results and Discussion
Species composition and abundance: A total of 8,419 specimens, weighting 182.3 kg and belonging to 9 species (Table 1) and 2 families (Cyprinidae and Percidae) were caught. Eight out of the nine species recorded belonged to Cyprinidae, while Percidae family was represented by only one species, *Perca fluviatilis*. Three species (*Alburnus macedonicus, Pachychilon macedonicum* and *Squalius vardarensis*) are considered as endemic to Greece and the Balkan Peninsula, while one species (*Carassius gibelio*) is introduced. The most abundant species in the total annual catch, both in terms of number (NPUE) and weight (BPUE) was *Alburnus macedonicus* followed by *Perca fluviatilis* (Table 1). In general, total annual NPUE values varied widely, ranging between 0.1 individuals 100 m$^{-2}$ per night for *Cyprinus carpio* to 29.18 individuals 100 m$^{-2}$ per night for *Alburnus macedonicus* (Table 1). The later exhibited also the highest annual BPUE value (495.34 g 100 m$^{-2}$ per night), while *Scardinius erythrophthalmus* the lowest one (7.03 g 100 m$^{-2}$ per night).

Catch composition differed with season. More specifically, *Rhodeus meridionalis* made up in terms of NPUE 55.12% of the spring catch though the same season *Pachychilon macedonicum* was the dominant species in terms of BPUE (24.75%). *Perca fluviatilis* dominated the summer catch (51.66 and 37.29% in terms
Several abiotic (water temperature, water fluctuation, dissolved oxygen, transparency) and biotic (predation, food availability, maturation state) parameters (Craig et al., 1986; Fischer and Eckmann, 1997; Matthews, 1998; Linløkken and Haugen, 2006) as well as operational (mesh sizes, net length, set time) factors (Jensen, 1986; Minns and Hurley, 1988) are well known to drive this temporal variability suggesting that certain species become more or less catchable by gillnets in the course of the year (Grant et al., 2004; Olin et al., 2009). For example, the search and capture rates of *Perca fluviatilis* increase with the increase of temperature (Persson, 1986). This could explain the observed increase of NPUE and BPUE from spring to autumn. The same seems to be true also for *Alburnus macedonicus*. Moreover, some other abiotic factors like water transparency, which makes the gillnets more easily detectable by fish and thus affecting their catchability (Neumann and Willis, 1995), could account for the low NPUE and BPUE values observed during winter. Furthermore, seasonal trends in NPUE and BPUE may be due to differences in fish distribution, activity and habitat use related also to fish size and sex (Phiri and Shirakihara, 1999; Grant et al., 2004).

The Cyp: Per biomass ratio calculated during this study ranged from 1.7 in summer to 14.8 in winter, while the overall Cyp: Per ratio (i.e. based on the total annual catches) was 3.1, supporting the eutrophic character of the lake (Temponeras et al., 2000), even though some other factors such as species richness and lake size may also affect this ratio (Olin et al., 2002).

**Abundance-biomass comparison (ABC) curves:** The ABC curves are given in Fig. 2. For all seasons the abundance curves lay above the biomass dominance curves along their entire length indicating that fish communities were dominated by one or a few opportunistic species (e.g. *Rhodeus meridionalis, Alburnus macedonicus*) which whilst they dominated in numbers, did not dominate in biomass, since they are small bodied. W took negative values in all seasons, corresponding to disturbed or moderately disturbed conditions (Clarke and Gorley, 2001).

In conclusion, Doirani is one of about 20 transboundary European lakes (Noges et al., 2008), several of which, including the studied lake, are important as resource for recreation and fisheries e.g. lake Constance; (Fischer and Eckmann, 1997); lake Peipsi (Kosk, 2001). For this lake category, integrated transboundary lake catchment management is widely accepted and supported in aquatic and landscape ecology (Boon, 2005), requiring adequate information for the implementation of management measures. Thus, the quantitative data collected during this research could be useful: (a) as a “reference point” for comparing fish community structure and species abundance, (b) to formulate actions and measures for species protection and (c) to enforce the sustainable transboundary
Fish abundance and biomass in Lake Doirani

Diekmann, M., U. Brämick, R. Lemcke and T. Mehner: Habitat-specific and roughly been used for describing fish abundances (Olin 2006), such estimations based on gillnetting should only cautiously not always linearly related to fish density (Linløkken and Haugen, 2009), supplemented (if available) with time series data of CPUE (Stergiou et al., 1997). Nonetheless, gillnet catches under certain conditions could serve for estimating and monitoring changes in fish abundance (Olin et al., 2009) as they are also proposed by the Water Framework Directive 2000/60/EC.

Acknowledgments

The study was part of the ‘Transboundary cooperation for the waters in accordance to the Water Framework Directive 2000/60/EC’ research project, financially supported by the Hellenic Ministry of Foreign Affairs and the Greek Biotopo-Welland Center. The authors would like to thank Dr. K.I. Stergiou, Dr. A. Crivelli and Dr. A. Tsikliras for their constructive comments on the manuscript and the students who helped in field work.

References


