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Longitudinal and Vertical Spatial Gradients in the Distribution of Fish within a Canyon-Shaped Reservoir

key words: fish distribution gradient, large-scale spatial heterogeneity, reservoirs, cyprinids

Abstract

The large-scale spatial distribution of fish was investigated within a morphometrically simple canyon-shaped reservoir with a single major tributary and a longitudinal trophic gradient (Římov Reservoir, Czech Republic). Samples of fish were taken by Nordic survey gill nets (several mesh sizes from 8 to 70 mm knot to knot) installed as surface nets at several offshore areas located along the longitudinal axis of the reservoir. Surveys were carried out in late summer during 1999–2003. An obvious distribution gradient of fish was revealed along the longitudinal axis of the Římov Reservoir. The total relative fish abundance and biomass (catch per unit effort) decreased considerably from the upstream end of the reservoir toward the dam. Roach (*Rutilus rutilus*), bleak (*Alburnus alburnus*) and bream (*Abramis brama*) comprised the bulk of catches at all areas. Enhanced dominance of bream was observed in the fish assemblage at the uppermost, more eutrophic area of the reservoir. The highest number of fish species and the highest abundance of young-of-the-year fish were also observed in the tributary area. In the downstream part of the reservoir, gill net surveys along the vertical depth profiles indicated that offshore fish occupied mostly the epilimnion. Extreme flood events affected the Římov Reservoir, however, it seemed they had no significant impact on the gradients described.

1. Introduction

Physical and chemical gradients imposed by a river inflow are a typical feature of deep valley reservoirs (LIND *et al.*, 1993; STRAŠKRABA, 1998). These abiotic gradients directly or indirectly influence the distribution patterns of organisms and thus, numerous studies have described longitudinal spatial gradients in the distribution of phytoplankton (*e.g.*, FERNÁNDEZ-ROSADO *et al.*, 1994; DESORTOVÁ, 1998; HEJZLAR and VYHNÁLEK, 1998) and zooplankton (*e.g.*, HART, 1990; DOHET and HOFFMANN, 1995; SEĎA and DEVETTER 2000; FERNÁNDEZ-ROSADO and LUCENA, 2001; NOGUEIRA, 2001) within canyon-shaped reservoirs. Much less attention, however, has been paid to the large-scale spatial distribution of fish in canyon-shaped reservoirs (SILLER *et al.*, 1986), apparently due to the difficulties to obtain reliable estimates of fish abundance (*e.g.*, DAHM *et al.*, 1992). Knowledge of spatial distribution of fish within a water body is, however, one of the key steps to understand complex biotic interactions and processes in freshwater ecosystems, and moreover, beside fundamental interests of ecologists, reliable estimates of fish distribution patterns are also largely valuable for fisheries managers.

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Recently, some authors using modern hydroacoustic methods revealed fish most abundant close to the inflows of supply rivers within deep valley reservoirs (BROSSE *et al.*, 1999; ŚWIERZOWSKI *et al.*, 2000). Nevertheless, studies using direct samplings to examine large-scale spatial distribution of fish in such water bodies are still very limited. The present study, therefore, aimed to determine the large-scale spatial distribution of fish using direct sampling within a morphometrically simple canyon-shaped reservoir with a single major tributary and a longitudinal trophic gradient (Římov Reservoir, Czech Republic, Central Europe). A five-year gill net survey carried out during summer at different offshore areas located along the longitudinal transect of the reservoir allowed us to test the null hypothesis that relative fish abundance and biomass did not differ along the longitudinal axis.

2. Methods and Materials

2.1. Study Site

The research was conducted in the canyon-shaped Římov Reservoir, a narrow and deep man-made lake located in South Bohemia (48°50' N, 14°30' E), Czech Republic. Římov Reservoir was built for drinking-water storage in 1978 on the Malše River, which is a single major reservoir tributary. The annual mean water flow in this natural tributary varies between 2.8 and 7.0 m³ s⁻¹ (SEĎA and DEVETTER, 2000). The reservoir has a surface area of 210 ha, volume of 33.6 × 10⁶ m³, length of 12 km and maximum surface elevation of 471 m a.s.l.. The mean depth of the reservoir is 16 m, the maximum depth is 45 m and the mean theoretical retention time is approximately 100 days. The reservoir is dimictic, summer stratification develops from April to October. Thermocline depth in the lacustrine part of the reservoir is about 4 m throughout late summer (July–August). The trophic status of the reservoir can be characterized as moderately eutrophic to eutrophic, with phosphorus and chlorophyll-*a* concentrations decreasing downstream in the reservoir (SEĎA and DEVETTER, 2000). The littoral zone of the Římov Reservoir is deprived of aquatic macrophytes due to steep banks and water level fluctuations. Beside scientific research programs, there is no significant fisheries activity on the reservoir.

2.2. Fish Samplings

To assess horizontal fish distribution, fish were sampled in offshore areas at several locations between the dam and the major reservoir inflow using a modification of pelagic gill nets of Nordic survey type. Fishing was conducted during 1999–2003, *i.e.* over a period of five years. In each of these years, a late summer gill net survey was carried out at three different localities of the reservoir, hereafter referred as the “lower”, “middle” and “tributary” areas (see Fig. 1). Gill-netting took place during August, only in the year 2002 it was performed in July. At each area, one gill net series of eleven monofilament nylon nets of different mesh sizes (8, 10, 12.5, 16, 19.5, 24, 29, 35, 43, 55 and 70 mm from knot to knot) was installed at the surface above the maximum depth. The thread diameter and the hanging ratio of nets were kept as with original Nordic design (APPELBERG, 2000). Each net panel within the series was 25 m long and 3 m high and all eleven nets were tied in one string (the order of nets was randomized). As previous diel gill-netting indicated higher catches during twilight and night than during daytime (VAŠEK *et al.*, 2000), we set the gill net series shortly before dusk and hauled it the following morning (*i.e.*, it fished throughout one night) in each area. The different areas were always sampled on three to four consecutive dates with calm weather conditions. During late summer gill net survey in 2001–2003, an “upper” area located between the middle and tributary areas (see Fig. 1) was sampled in addition to the previously investigated localities. Gill-netting in this area was performed by the same manner as above mentioned. Maximum depths of the four investigated localities were approximately 40–30 m, 25–20 m, 20–15 m and 5–3.5 m at the lower, middle, upper and tributary areas, respectively. In the tributary area, the gill net series was installed about 150–300 m downstream the plunge point of the Malše River inlet in each year.

To assess vertical fish distribution, we carried out mid-water and above-bottom gill-netting in the lower and middle areas of the reservoir in 2000–2003, additionally to the surface gill-netting. At each

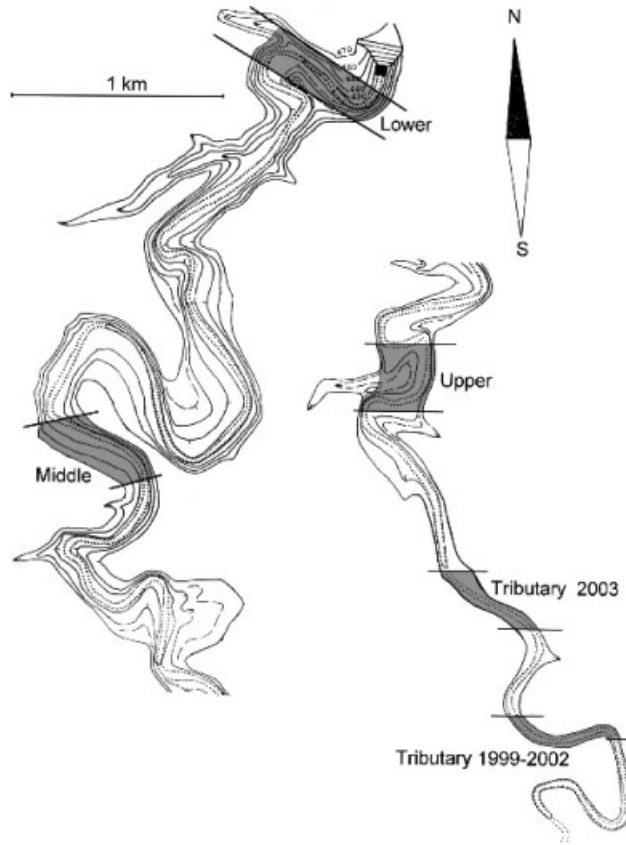


Figure 1. Contour map with water depth isolines (10 m range) of the Římov Reservoir, and locations of sampling areas. Note different position of samplings in the “tributary area” between the 1999–2002 period and the year 2003: the tributary area was always sampled 150–300 m downstream the plunge point of the Malše River inlet and since water level in 2003 was unusually low in the Římov Reservoir, the sampled “tributary area” moved more downstream along the longitudinal reservoir transect.

of these two areas, a mid-water gill net series was set 5 m below the surface (the distance between the float line and the surface) and an above-bottom gill net series was installed 5 m above the bottom (the distance between the lead line and the bottom). Both gill net series fished simultaneously with the surface gill nets over the maximum depths at the two areas and contained nets of the same mesh sizes like the surface series, except of the net 8 mm mesh size. Each net was 25 m long and 4.5 m high and all ten nets were tied in one string (the order of nets was randomized) in both series. Due to the missing net of 8 mm mesh size, the comparisons of total fish catch per unit effort (CPUE) between the surface and the mid-water or above-bottom nets were done after subtraction of the CPUE of 8 mm mesh size net from the total CPUE of the surface gill net series.

Fish from each catch were sorted by species, counted, measured and weighed. Catch per unit effort is expressed in terms of relative abundance (number of fish per 100 m² of gill nets per night) and biomass (kilograms of fish wet weight per 100 m² of gill nets per night), respectively.

2.3. Statistical Analysis

To test for differences in surface gill net CPUE at three reservoir areas (lower, middle, tributary) and in five years (1999–2003) we performed two-way analysis of variance (two-way ANOVA) with “area”

and “year” as explanatory factors. As only one reading is available for each area and year combination, the interaction can not be tested, interaction sum of squares must be considered remainder sum of squares, and interaction mean square is used in denominator of the F-test (see SOKAL and ROHLF, 1981, p. 344, two-way ANOVA without replication). It should be noted that the corresponding null hypotheses are related just to the reservoir tested, *i.e.* there are no consistent differences among the areas within the reservoir, and there are no consistent differences among the years within the reservoir.

3. Results

3.1. Horizontal Fish Distribution

An overview of total surface gill net CPUE at different areas along the longitudinal transect of the Římov Reservoir in 1999–2003 is presented in Table 1. In general, relative fish abundance and biomass were usually highest in the tributary or upper areas and declined considerably toward the lower area near the dam, where fish catches were the smallest. A two-way ANOVA of 1999–2003 data from the dam, middle and tributary areas indicated that total relative fish abundance and biomass, respectively, differed significantly among the areas (abundance: $F_{2,8} = 9.48$, $P = 0.008$; biomass: $F_{2,8} = 5.92$, $P = 0.026$). 1999–2003 mean total fish abundance (± 1 SD) was 15.47 ± 7.34 , 37.04 ± 10.61 and 62.98 ± 26.03 ind. $100 \text{ m}^2 \text{ net}^{-1} \text{ night}^{-1}$ in the lower, middle and tributary areas, respectively. 1999–2003 mean total fish biomass was 1.40 ± 0.75 , 3.70 ± 1.13 and 6.64 ± 3.70 kg $100 \text{ m}^2 \text{ net}^{-1} \text{ night}^{-1}$ in the lower, middle and tributary areas, respectively. No significant difference among years was detected for total fish abundance ($F_{4,8} = 0.83$, $P = 0.543$) as well as biomass ($F_{4,8} = 0.67$, $P = 0.631$).

3.2. Vertical Fish Distribution

In the lacustrine part of the reservoir (*i.e.* in the lower and middle areas) in 2000–2003, mid-water gill net CPUE was consistently lower than the surface gill net CPUE and the above-bottom CPUE was negligible or nought (Table 2, Fig. 2). Mid-water gill net CPUE

Table 1. Total surface gill net CPUE of fish at different areas of the Římov Reservoir in late summer 1999–2003. CPUE is expressed in terms of relative abundance and biomass, respectively.

| Year | Area | | | |
|---|-------|--------|-------|-----------|
| | Lower | Middle | Upper | Tributary |
| Abundance (ind. $100 \text{ m}^2 \text{ net}^{-1} \text{ night}^{-1}$) | | | | |
| 1999 | 25.94 | 44.48 | – | 70.66 |
| 2000 | 7.76 | 51.88 | – | 64.85 |
| 2001 | 15.51 | 30.18 | 30.33 | 34.30 |
| 2002 | 18.67 | 31.39 | 45.75 | 43.88 |
| 2003 | 9.45 | 27.27 | 95.76 | 101.21 |
| Biomass (kg $100 \text{ m}^2 \text{ net}^{-1} \text{ night}^{-1}$) | | | | |
| 1999 | 1.91 | 2.89 | – | 2.80 |
| 2000 | 0.37 | 5.16 | – | 5.46 |
| 2001 | 1.41 | 4.62 | 6.48 | 5.92 |
| 2002 | 2.30 | 2.58 | 5.91 | 6.20 |
| 2003 | 1.03 | 3.26 | 10.36 | 12.79 |

Table 2. Mid-water and above-bottom total gill net CPUE of fish, respectively, at two lacustrine areas of the Římov Reservoir in late summer 2000–2003. CPUE is expressed in terms of relative abundance and biomass, respectively.

| Year | Mid-water CPUE | | Above-bottom CPUE | |
|--|----------------|-------------|-------------------|-------------|
| | Lower area | Middle area | Lower area | Middle area |
| Abundance (ind. 100 m ² net ⁻¹ night ⁻¹) | | | | |
| 2000 | 1.33 | 1.24 | 0.00 | 0.00 |
| 2001 | 0.18 | 1.69 | 0.00 | 0.00 |
| 2002 | 2.84 | 2.40 | 0.18 | 0.62 |
| 2003 | 1.95 | 4.89 | 0.09 | 1.07 |
| Biomass (kg 100 m ² net ⁻¹ night ⁻¹) | | | | |
| 2000 | 0.26 | 0.29 | 0.00 | 0.00 |
| 2001 | 0.01 | 0.36 | 0.00 | 0.00 |
| 2002 | 0.69 | 0.34 | 0.06 | 0.09 |
| 2003 | 0.62 | 1.55 | 0.02 | 0.06 |

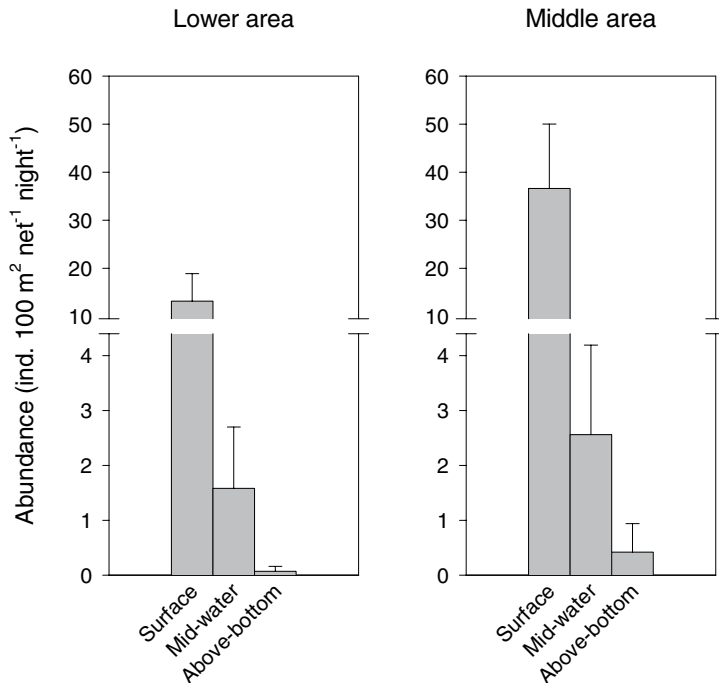


Figure 2. Relative numerical abundance of fish in three different water strata (surface: 0–3 m depth; mid-water: 5–9.5 m depth; above-bottom: 5–9.5 m distance over the maximum depth) at two lacustrine areas of the Římov Reservoir. 2000–2003 means (± 1 SD) of total fish CPUE are shown (note: CPUE of the net of 8 mm mesh size was subtracted from the total surface gill net CPUE to make possible the comparison among the different depth strata; see Methods for detailed explanation).

at the lower area represented 1–24% (mean 12%) and 1–65% (mean 28%) of the simultaneously taken surface gill net CPUE in terms of relative abundance and biomass, respectively. Above-bottom gill net CPUE at this area reached only 0–1% and 0–2% of the simultaneous surface gill net CPUE in terms of relative abundance and biomass, respectively. At the middle area, mid-water gill net CPUE represented 2–18% (mean 7%) and 5–43% (mean 15%) of the simultaneous surface gill net CPUE in terms of relative abundance and biomass, respectively. Above-bottom gill net CPUE at the same area varied between 0–4% and 0–3% of the simultaneously taken surface gill net CPUE in terms of relative abundance and biomass, respectively.

3.3. Fish Community Composition

We captured a total of 17 fish species and one hybrid during the five years of summer gill-netting in the Římov Reservoir (Table 3). The highest number of fish species (13 species

Table 3. Relative abundance (ind. 100 m² net⁻¹ night⁻¹) of individual fish species in three areas (Lower; Middle; Tributary) and two water strata (surface: 0–3 m depth; mid-water: 5–9.5 m depth) of the Římov Reservoir. Surface CPUE values are 1999–2003 means, young-of-the-year fish (YOY) are shown separately from the older fish. Mid-water CPUE values are 2000–2003 means. In addition to the listed species, *Leuciscus leuciscus* was caught in one specimen at the “upper” area of the reservoir in 2001, but not at the other locations, and therefore is not shown in the table.

| Species | Surface CPUE | | | Mid-water CPUE | |
|---|--------------|--------|-----------|----------------|--------|
| | Lower | Middle | Tributary | Lower | Middle |
| Fish older than 0+ | | | | | |
| <i>Rutilus rutilus</i> | 3.90 | 8.22 | 8.44 | 0.82 | 1.80 |
| <i>Alburnus alburnus</i> | 8.05 | 19.54 | 11.66 | 0.04 | 0.11 |
| <i>Abramis brama</i> | 0.78 | 2.28 | 15.83 | 0.04 | 0.24 |
| <i>Perca fluviatilis</i> | 1.09 | 1.79 | 0.51 | 0.56 | 0.27 |
| <i>Aspius aspius</i> | 0.12 | 1.14 | 1.77 | 0.02 | – |
| <i>Scardinius erythrophthalmus</i> | 0.17 | 0.17 | 0.12 | – | – |
| <i>Blicca bjoerkna</i> | – | 0.02 | 0.15 | – | – |
| <i>Leuciscus cephalus</i> | – | 0.02 | 0.02 | 0.02 | – |
| <i>Gymnocephalus cernuus</i> | – | – | 1.72 | 0.02 | 0.04 |
| <i>Sander lucioperca</i> | – | 0.07 | 0.53 | – | 0.02 |
| <i>Esox lucius</i> | – | – | 0.07 | 0.02 | – |
| <i>Cyprinus carpio</i> | – | – | 0.12 | – | 0.02 |
| <i>Carassius auratus</i> | – | – | 0.12 | – | – |
| <i>Oncorhynchus mykiss</i> | 0.02 | – | – | 0.02 | 0.02 |
| <i>Salmo trutta</i> | 0.05 | – | – | – | – |
| <i>Coregonus</i> sp. | – | 0.02 | – | – | – |
| <i>Rutilus rutilus</i> × <i>Abramis brama</i> | 0.02 | 0.56 | 2.45 | – | 0.02 |
| 0+ fish (YOY) | | | | | |
| <i>Rutilus rutilus</i> | 0.68 | 1.89 | 9.41 | | |
| <i>Alburnus alburnus</i> | 0.29 | 0.48 | 0.17 | | |
| <i>Abramis brama</i> | – | 0.68 | 8.41 | | |
| <i>Perca fluviatilis</i> | 0.19 | 0.02 | 0.99 | | |
| <i>Aspius aspius</i> | 0.10 | 0.12 | 0.15 | | |
| <i>Gymnocephalus cernuus</i> | – | – | 0.19 | | |
| <i>Sander lucioperca</i> | – | – | 0.15 | | |

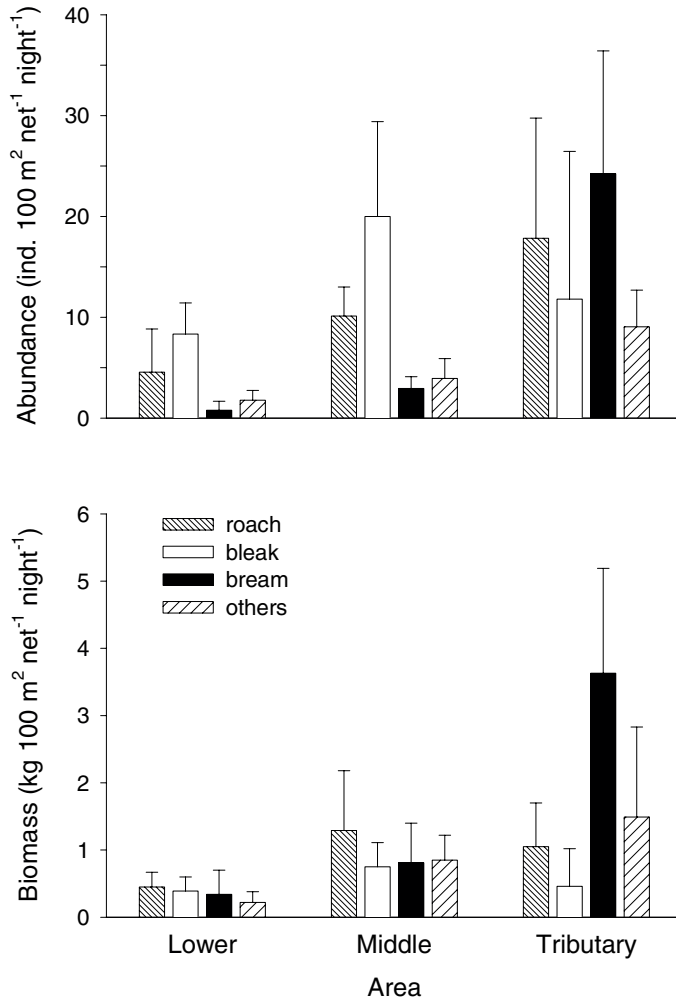


Figure 3. 1999–2003 mean (± 1 SD) surface gill net CPUE of three dominant cyprinid species at three areas of the Římov Reservoir. CPUE is expressed in terms of relative abundance and biomass, respectively.

and one hybrid of fish older than 0+, 7 species of 0+ fish) was captured in the tributary area, the lowest number was found near the dam. Surface gill net catches were clearly dominated by three cyprinids: roach (*Rutilus rutilus*), bream (*Abramis brama*) and bleak (*Alburnus alburnus*). These species together accounted for 69–93% of total CPUE by number and 66–96% of total CPUE by weight, at each reservoir area in particular years. Most frequently captured piscivorous fish in the surface gill nets were asp (*Aspius aspius*) and large perch (*Perca fluviatilis*). In mid-water gill net catches roach and perch prevailed, and occasional above-bottom catches consisted mostly of roach, at the lacustrine part of the reservoir. The highest relative abundance of young-of-the-year fish (mainly roach and bream) was recorded in the tributary area.

The 1999–2003 mean surface gill net CPUE of the three dominant cyprinids at the lower, middle and tributary areas, respectively, are depicted in Figure 3. Bream strongly dominat-

ed, both in terms of abundance and biomass, the fish community in the tributary area and its mean five-year CPUE at this location was substantially higher than the mean five-year CPUE values of bream at the lower and middle areas. Mean roach five-year CPUE by number was highest in the tributary area and smallest in the lower area. In term of weight, however, the mean roach five-year CPUE at the middle area was slightly larger than that at the tributary area. Mean five-year CPUE of bleak (both by number and weight) tended to be highest at the middle area.

4. Discussion

The present study revealed an obvious distribution gradient of offshore fish along the longitudinal transect of the canyon-shaped Římov Reservoir. Total fish abundance and biomass in late summer decreased considerably from the upstream end of the reservoir toward the dam. Comparable investigations of large-scale spatial distributions of fish within deep valley reservoirs in Europe are rather rare. Using hydroacoustics in several such reservoirs, enhanced fish abundance was recorded in areas close to the supply rivers during summer season (FERNANDO and HOLČÍK, 1991; BROSE *et al.*, 1999; ŚWIERZOVSKI *et al.*, 2000). A longitudinal gradient with fish density decreasing downstream in the reservoir was mentioned, though not described in more detail, by PONT and AMRANI (1990) from a French deep valley reservoir. By means of direct sampling, a pronounced longitudinal gradient in fish abundance was found by URABE (1990) in a Japanese canyon-shaped reservoir. He reported that open water gill net catches of planktivorous fish in warm-water season increased from the dam toward the upstream part of the reservoir. A similar longitudinal gradient was observed in a U.S. deep valley reservoir by SILLER *et al.* (1986), who found increasing harvest of anglers and increasing trawl catches of a clupeid, *Dorosoma petenense*, from downstream to upstream areas of the reservoir. The cited results, as well as the results of our study, indicate that enhanced total fish abundance can be a common ecological phenomenon in upstream, tributary parts of deep valley reservoirs throughout the growing season. We think there are at least two possible explanations for the large-scale distribution pattern observed. At first, the fish fauna in reservoirs is usually composed by species of riverine origin: they are not well adapted to lacustrine conditions and therefore they prefer relatively shallow inshore areas and mouths of inflowing rivers as suitable habitats within the deep reservoirs (FERNANDO and HOLČÍK, 1991). Secondly, the upstream parts of canyon-shaped reservoirs are usually more eutrophic than more downstream areas (LIND *et al.*, 1993; STRAŠKRABA, 1998) and gradual downstream decline in chlorophyll-*a* concentrations and zooplankton densities is often observed in such reservoirs (URABE, 1989; FERNÁNDEZ-ROSADO *et al.*, 1994; DOHET and HOFFMANN, 1995; THYS *et al.*, 1998; FERNÁNDEZ-ROSADO and LUCENA, 2001). Consequently, if the open water of a reservoir is foraged by fish populations (usually zooplanktivorous fish) their distribution may reflect the longitudinal productivity gradient.

The riverine origin of reservoir fish populations is markedly expressed especially during the reproductive period. Among the dominant fish in the Římov Reservoir, bleak use the only major tributary, the Malše River, as an obligatory spawning habitat, whereas roach and bream spawn both in the tributary and inside the reservoir. In 2000–2002 seasons, peak spawning of the three cyprinids in the Malše River above the reservoir and in the Římov Reservoir occurred at the end of April and early May and considerable numbers of mature fish of the given species migrated through the reservoir tributary zone at this time (HLADÍK and KUBEČKA, 2003). Weaker subsequent spawning migrations of bleak and bream through the reservoir tributary zone were observed during the May–June period (HLADÍK and KUBEČKA, 2003). However, we performed our samplings later in the season (mostly in August) and we suppose, therefore, that increased fish abundance revealed in the tributary area at this time may not be directly attributed to the reproductive behavior of fish. Nevertheless, it is notable that relatively high catches of young-of-the-year (YOY) fish

partly contributed to the enhanced total fish abundance at this site (Table 3). Relative YOY catches varied among the years. They comprised between 6.0–64.3% (mean 30.9%) of surface net CPUE by number in the tributary area, whereas in the lower and middle areas YOY fish accounted for 0–21.8% (means 8.2 and 8.6% at the lower and middle areas, respectively) of surface net CPUE by number. On a biomass basis, however, YOY share on total CPUE was negligible throughout the whole reservoir (even in the tributary area, it accounted for only 0.1–4.5% in particular years). Higher YOY catches at the upstream areas than at the more downstream areas within the Římov Reservoir have been also recorded during night-time trawling surveys of the open water in August (VAŠEK *et al.*, 2002). The higher YOY catches indicate that the upper end of the reservoir can be an important nursery area and/or that YOY fish forage the offshore habitat of the relatively shallow and narrow part of the reservoir more rigorously compared to the downstream, lacustrine areas. However, there is an alternative explanation for the fish density gradient along the reservoir that should be mentioned. Supposing that the fish density per unit shoreline length is the same all around the reservoir, and that the YOY fish move to the open water at dusk and return to the littoral at dawn, then the YOY density during the night would be higher in the narrower upstream parts of the reservoir, simply because the available open water area per unit shoreline length is much lower compared to the broader downstream parts of the reservoir. In much larger, deep valley U.S. reservoirs, other investigators (BECKMAN and ELROD, 1971; NETSCH *et al.*, 1971; STORCK *et al.*, 1978) have found longitudinal distribution patterns of fish larvae and juveniles which seem to be consistent with our results.

The three most common fish species in the open water of the Římov Reservoir (*i.e.* the roach, bleak and bream) preyed predominantly on planktonic microcrustaceans along the entire longitudinal transect (VAŠEK *et al.*, 2003) and since the same study found zooplankton increasingly abundant upstream in the reservoir, it is appropriate to expect that total offshore abundance and biomass of fish in the Římov Reservoir responded to the gradient in planktonic production. When considering spatial variation in abundance of individual fish species, however, more complex mechanisms (*e.g.* competition and predation) probably shape the actual distribution patterns beside the factors above discussed. Interspecific competition between roach and bream, for instance, seems to favour bream in more eutrophic environment (LAMMENS *et al.*, 1987) and actually, we revealed enhanced dominance of bream in the fish assemblage of the more eutrophic tributary area.

Approximately one month after our gill net survey in 2002, Římov Reservoir was affected by two extremely high flood events within a week. Peaks of discharge in the Malše River above the reservoir were ~ 350 and $500 \text{ m}^3 \text{ s}^{-1}$ during the two subsequent floods (long-term average water flow is $\sim 4 \text{ m}^3 \text{ s}^{-1}$) and the amount of water flowed through the reservoir during the two events represented approximately three times higher volume compared to the total volume of the reservoir. We have no direct data concerning the amounts of fish flushed from the reservoir or into the reservoir from the river and its catchment. It seems, however, that even such drastic events had no significant impact on the total fish stock in the Římov Reservoir, since both mean total abundance and biomass of fish one year after the floods (*i.e.*, in 2003) did not differ significantly from mean total fish abundance and biomass in the years before the flood events (1999–2002), see Results. Considering the estimates at respective areas, total fish abundance and biomass at the dam and middle areas in 2003 were similar to those obtained at the same areas in the previous years. At the tributary area one year after the floods, however, both total abundance and biomass of fish were the highest during the studied five-year period (Table 1). The water level in the Římov Reservoir in late summer 2003 was unusually low (Fig. 1 shows where samples in the tributary area were taken during 1999–2002 and in the year 2003) and thus, rather than an effect of flood, the highest catches in the tributary area might simply reflect more pronounced concentration of fish at this upstream part of the reservoir. One year after the flood events, roach, bleak and bream comprised again the bulk of gill net catches at all areas in the Římov Reservoir, like

in the previous years. Increased catches of fish (carp, *Cyprinus carpio*, gibel *Carassius auratus*) apparently flushed from carp ponds of the Malše River catchment were detected in the Římov Reservoir compared to the situation before the flood event (KUBEČKA *et al.*, in press). These species had, however, only a minor share on the total fish abundance and biomass.

Gill net surveys along the vertical depth profiles at lacustrine areas (*i.e.*, the lower and middle areas) of the Římov Reservoir provided evidence that offshore fish inhabited mostly the surface stratum in late summer, since the mid-water catches (5–9.5 m depth stratum) were consistently lower than the surface ones (0–3 m depth stratum) and the above-bottom catches near the maximum depths were negligible or absent. The thermocline was located 3–5 m deep during our surveys and thus, surface nets sampled the epilimnion, whereas mid-water nets sampled mostly the metalimnetic stratum. Oxygen concentrations varied between ~0–3 mg l⁻¹ at 5–9.5 m depths and attained <5.5 mg l⁻¹ in the deep hypolimnion during our surveys (data from the databank of HBI, České Budějovice). The open water fish, therefore, preferred the surface stratum apparently due to the appropriate temperature and oxygen conditions (7.9–14.9 mg O₂ l⁻¹ in the epilimnion; databank of HBI, České Budějovice) as it has been observed elsewhere (*e.g.*, KUBEČKA and WITTINGEROVÁ, 1998; BROSSE *et al.*, 1999) throughout summer stratification.

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