Dynamics of juvenile fish assemblages in the Szigetköz section of the Danube since the operation of an artificial water replenishment system in the floodplain

By
G. GUTI*

Astract. At the end of 1992, the Szigetköz section of the Danube was diverted to the by-pass canal of the Gabcikovo Hydroelectric Power Plant and side arms became dry in the floodplain. Since 1995, an effective water replenishment system has been put into operation. The study was implemented in 6 sampling sites in the main channel of the Danube, in side arms of the active floodplain and in the water bodies of the protected floodplain. Fish assemblages were sampled by electric fishing. Evaluation of the data was based on the frequency distribution of juvenile fish species to monitor the investigated biotopes.

The Szigetköz section of the Danube runs on the Hungarian-Slovak border, deposting the largest stream alluvial cone in Europe. The Hungarian side of this braided hydrosystem is known as the Szigetköz floodplain, which is the area between the main channel of the Danube (r. km 1850-1794) and the meandering Mosoni-Danube arm. Its length is 52 km and its average width is 7-8 km. The Szigetköz floodplain played a prominent part in the recruitment of fish populations along the Middle Danube. In the spawning season numerous fishes of the main stream migrated instictively against the current, sometimes covering a distance of 100-200 km, before they found suitable biotopes for reproduction (GUTI, 1993). Since the second half of the 19th century, river regulation and flood control measures have altered the original floodplains. The inundated floodplains have been reduced to 4 % of their former area and the alluvial sediment accumulated on the narrow inundated part. This process accelerated the aggradation of the main channel and the silting up of the active branches in the 20th century.

At the end of 1992, the Szigetköz section of the Danube was diverted to the by pass canal of the Gabcikovo Hydroelectric Power Plant and 80 % of the side arms became dry in the floodplain for a long period, only the deeper beds remained watered. In 1993 and 1994 the missing connections between the main channel of the Danube and the branch systems, as well as the extremely low water level moderated and restricted the aquatic biotopes. In 1993 a mitigation plan was prepared and from August the branch systems in the floodplain and the canals in the flood protected area got a small amount of water, 5-15 $m^3.s^{-1}$ and 3-6 $m^3.s^{-1}$ respectively. In 1994 the artificial water supply was increased to 15-30 $m^3.s^{-1}$ in the floodplain. From June 1995, a more effective water replenishment system has been put into operation, with the capacity of 40-130 $m^3.s^{-1}$. The water supply is provided by gravitation from the dammed section of the main river bed, upstream of a bottom sill have been contsructed in the bypassed section of the Danube (at 1843 r. km), in this way the inlet of the water replenishment system created a limited connection between the main channel and the floodplain branches.

* *Dr. Gábor Guti*, MTA ÖBKI Magyar Dunakutató Állomás (Institute of Ecology and Botany of the Hungarian Academy of Sciences, Hungarian Danube Research Station), 2131 Göd, Jávorka u. 14, Hungary.

The biological monitoring of the Szigetköz floodplain has been one of the principal work of the Hungarian Danube Research Station since the operation of the Gabcikovo hydroelectric power plant. The application of juvenile (0+) fish assemblages to define the ecological condition of the floodplain biotopes offers a number of advantages: 1) The movement of fish between the biotopes is more dynamical than the movement of aquatic invertebrates. 2) Juvenile fish can tolerate a narrower range of environmental variables than adult fish, so their distribution indicates the ecological conditions of the biotopes more precisely. 3) The evaluation of juvenile fish assemblages species diversity provides a simple assessment of the reproduction potential of certain biotopes.

Sampling sites and methods

The presented study was carried out at 2-2 sampling sites in the main channel of the Danube, side arms of the active floodplain and in water bodies of the flood protected area:

1) Sampling site 1 was in the riparian zone of the main channel at 1834 r. km. It had a permanent flow with a depth of 0.3-1.2 m. Bottom was composed of stones and gravel. Turbidity was high, vertical stratification in temperature and oxygen was negligible. Macrophytes were missing.

2) Sampling site 2 was in the riparian zone of the Danube at 1843 r. km before the construction the bottom sill. The water depth was 0.2-1.5 m. Bottom was composed of stones and gravel. Since 1995, there is a special biotope on the downstream part of the bottom sill. The high gradient section had a permanent and turbulent flow. Depth was 0.2-0.5 m with a stony bottom. Turbidity was high, vertical stratification in temperature and oxygen was negligible. Macrophytes were missing, but there were some aquatic moss on the stones of the bottom sill.

3) Sampling site 3 was a lentic backwater connected permanently to the parapotamal type (AMOROS et al. 1987) Csákányi side arm in the Cikola branch system. It was dry in the first half of 1993. Its depth was 0.5-1.5 m and the bottom consisted of sand mixed with silt. Turbidity was high, vertical stratification in temperature and oxygen was detectable. Macrophytes grew in patches.

4) Sampling site 4 was in the Schiesler arm of the Cikola branch system. It was plesiopotamal permanent standing water. It had direct connection to other side arms for an average of 15 days per year during the period of 1961-1990. It became completely isolated after the Danube had been diverted in 1992. It was nearly dry in 1993, infiltered water gradually filled it up later. Its depth was 0.7-1.8 m, bottom consisted of silt. Turbidity was low and a vertical temperature and dissolved oxygen stratification was detected there. Macrophytes grew densely.

5) Sampling site 5 was a lentic section of the Gazfüi-Danube in the flood protected area. It was a paleopotamal type standing water before the operation of the Gabcikovo Hydroelectric Plant. It was dry in the first half of 1993 after the diversion of the Danube. Since its artificial replenishment there is a slow permanent flow at this site. In 1995 and 1996 the water level was raised according to the spawning period of fishes. The water depth was 0.5-1.5 m with a low turbidity. Vertical temperature and oxygen stratification was detected and the bottom consisted of silt. Macrophytes grew densely.

6) Sampling site 6 was a dredged section in the Lipót oxbow lake, a paleopotamal standing water before the diversion of the Danube. It was dry in 1993, but has a slow permanent flow since the operation of its water supply system. Its depth was 0.4-1.6 m and the bottom consisted of silt. Turbidity was moderate with a vertical temperature and oxygen stratification. Macrophytes grew densely.

Sampling was carried out at 20-40 sampling points per sites at a distance of approximately 10 m-s from each other in a random distribution. Fish were collected with a battery-powered electroshocker of a low output (80 W) and a 1 mm mesh size dipnet. A small boat was needed to reach the sampling points. The field works were accomplished at late summer and early autumn, when the composition of juvenile fish assemblages becomes stable. Data evaluation to monitor the investigated biotopes was based on the frequency distribution of fish species.

Results and discussions

The main channel of the Danube

1834 river km (Fig. 1)

In 1994, 1995 and 1996 3, 11 and 12 juvenile fish species were collected respectively in the sampling site. The diversity of fish species was great and assemblages were dominated by rheophilic species. The rheophilic character of the samples has become even more characteristic with the increasing species richness from 1994. There was no significant difference between the frequency distribution of fish in 1995 and 1996. In 1996 *Gobio albipinnatus* and *Rhodeus sericeus* were not found, but *Vimba vimba*, *Perca fluviatilis* and *Esox lucius* were new for this site, as well as 4 other species were identified among the adult (1+ or older) fishes: *Abramis brama*, *Cyprinus carpio*, *Carassius auratus* and *Pelecus cultratus*.

1843 river km (Fig. 2)

In 1994, 1995 and 1996 5, 2 and 5 juvenile fish species were found, respectively. Since the construction of the bottom sill, the assemblages has been dominated by rheophilic species. The juveniles of 3 new species for the site *Cottus gobio*, *Leuciscus leuciscus* and *Chondrostoma nasus* were found in 1996. *Proterorhinus marmoratus* was common every year. Among the adult fishes 13 other species were collected in 1995 (GUTI, 1996) and many of them are endangered in the Middle Danubian Basin (*Vimba vimba*, *Barbatula barbatula*, *Lota lota*, *Gymnocephalus baloni*, *Gymnocephalus schreatzer*, *Zingel streber*). In 1996, 2 other rare species were detected: *Salmo trutta* and *Neogobius kessleri*. The occurrence of the *N. kessleri* was proved for the first time in the Szigetköz section of the Danube (GUTI, 1997).

The side arms of the floodplain

Csákányi arm in the Cikola branch system (Fig. 3)

In 1992, 14 juvenile fish species were collected from this sampling site. The occurrence of the rheophilic species indicated a direct connection between the side arm and the Danube. In 1994, 9 juvenile fish species were found. Rheophilic species diminished and some phytophilic spawner limnophilic species (*C. auratus*, *Lepomis gibbosus*) appeared with the expansion of the aquatic macro vegetation. The artificial water supply has become more effective since 1995. Due to the lessening of the aquatic vegetation the juveniles of phytophilic fishes declined, and the number of detected species was 6. In 1996, juveniles of 8 species were identified. Some rheophilic species (*L. leuciscus*, *Abramis ballerus*) reappeared, which reflected to the limited connection of the branch system with the main channel. In 1996, *Tinca tinca* was caught among the adult fishes, which was its first record in the floodplain after the diversion of the Danube. Close to the sampling site, the presence of the *Gasterosteus aculeatus* was established in the Csákányi arm. The occurrence of the *G. aculeatus* had only been known from the Mosoni-Danube in the Szigetköz area, therefore its appearance in the floodplain branch system probably indicated the fish movement from the Mosoni-Danube through the water supply system.

Schiesler arm in the Cikola branch system (Fig. 4)

In 1992, juveniles of 8 fish species were collected from the sampling site. Probably some fish could survive the dry period in 1993 in the wet mud of the isolated arm. After the bed had been filled up with ground water, the aquatic vegetation grew densely in 1994 and the presence of 4 juvenile fish species (C. *auratus*, R. *sericeus*, *Scardinius erythrophthalmus*, *Leucaspius delineatus*) was proved here. The frequency of L. *delineatus* was relatively high regarding that it had only been recorded once in the area during the previous six years. In 1995, it greatly declined, only an adult specimen was caught and it disappeared in the samples in 1996. R. *sericeus* was a common species in 1992 and 1994, but it became rare in 1995 and its juveniles could not been collected in 1996. The juveniles of C. *auratus* have occurred in extreme abundance since 1994 and it became dominant in 1995. The diversity of fish assemblages have decreased with the complete separation of the biotope and in 1996 only C. *auratus* could be collected.

Water bodies in the flood protected area

Gazfüi Danube (Fig. 5)

In 1994, 1995 and 1996 6, 9 and 10 juvenile fish species were found respectively in the sampling site. In 1994, most of the species of the previous limnophilic fauna was collected and the scarce occurrence of the adult *Umbra krameri* and *Misgurnus fossilis* was documented. In 1995, the composition of juvenile fish assemblages changed because of the permanent flow. Limnophilic species became rare and some new neutrophilic species appeared. The endangered *U. krameri* has not been found in the samples since 1995. In 1996 limnophilic species became dominat in the assemblages.

Lipót oxbow lake (Fig. 6)

Most probably the former fish fauna could not survive the dry period of the oxbow lake in 1993 and the new water body was repopulated by fishes mainly from the floodplain side arms through the water replenishment system. In 1994, 1995 and 1996 4, 6 and 10 juvenile fish species were found respectively. Their compositions were similar to the juvenile fish assemblages of the branch systems in the floodplain. In 1996 rheofilic species (juvenile *V. vimba*, adult *L. leuciscus*) appeared in the sampling site, which indicated an indirect connection between the oxbow lake and the main channel of the Danube. The occurrence of the endangered fishes of the previous limnophilic fauna (*U. krameri* and M. *fossilis*) was not proved, but adult specimens of some characteristic species (*E. lucius*, *T. tinca*, *S. erythrophthalmus*) were found in the inside part of the oxbow lake.

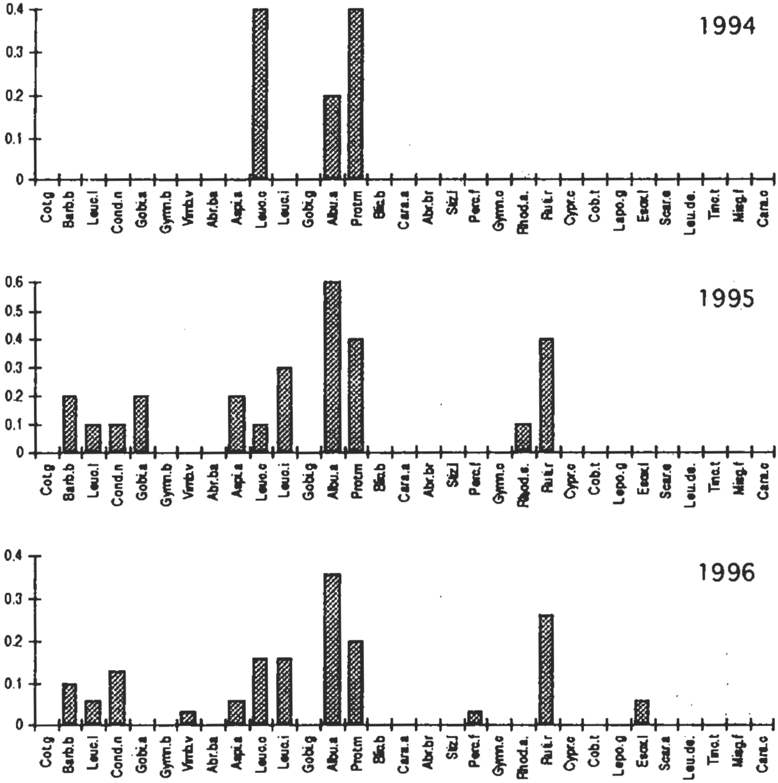

Fig. 1. Frequency distribution of juvenile fish species at sampling site 1 (main channel of the Danube at 1834 river km) in 1994, 1995 and 1996. The order of the species is determined by the velocity tolerance (rheophilic species are on left, limnophilic on right). – Abbreviations: Cot.g. = *Cottus gobio*; Barb.b. = *Barbus barbus*; Leuc.l. = *Leuciscus leuciscus*; Cond.n. = *Condrostoma nasus*; Gobi.a. = *Gobio albipinnatus*; Gymn.b. = *Gymnocephalous baloni*, Vimb.v = *Vimba vimba*; Abr.ba. = *Abramis ballerus*; Aspi.a. = *Aspius aspius*; Leuc.c. = *Leuciscus cephalus*, Gobi.g. = *Gobio gobio*; Albu.a. = *Alburnus alburnus*; Prot.m. = *Proterorhinus marmoratus*; Blic.b. = *Blicca bjoerkna*; Cara.a. = *Carassius auratus*; Abr.br. = *Abramis brama*; Stiz.l. = *Stizostedion lucioperca*; Perc.f. = *Perca fluviatilis*; Gymn.c. = *Gymnocephalus cernuus*; Rhod.c. = *Rhodeus sericeus*; Ruti.r. = *Rutilus rutilus*; Cypr.c. = *Cyprinus carpio*; Cob.t. = *Cobitis taenia*; Lepo.g. = *Lepomis gibbosus*; Esox.l. = *Esox lucius*; Scar.e. = *Scardinius erythrophthalmus*; Leu.de. = *Leucaspius delineatus*; Tinc.t. = *Tinca tinca*; Misg.f. = *Misgurnus fossilis*; Cara.c. = *Carassius carassius*

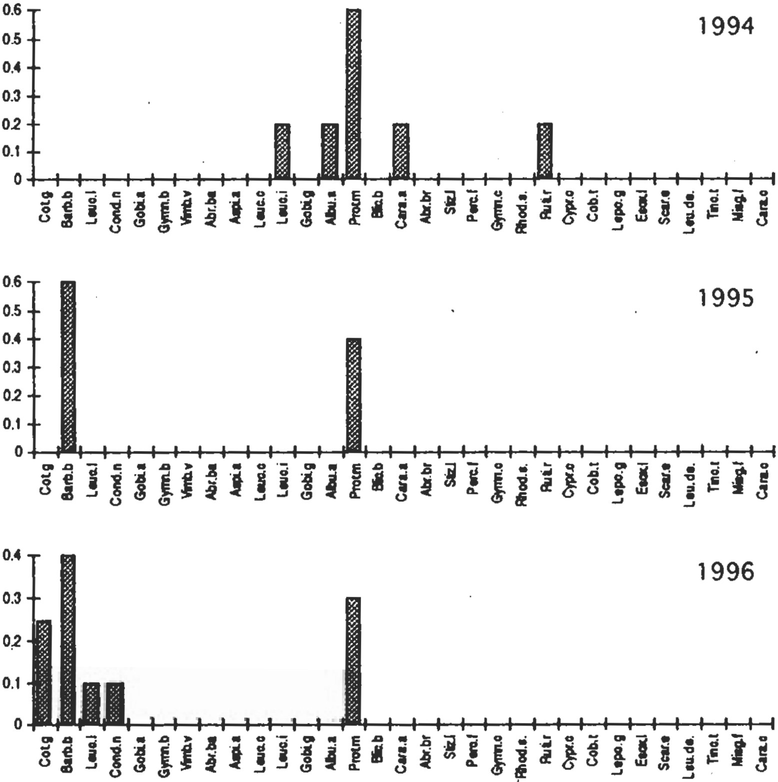

Fig. 2. Frequency distribution of juvenile fish species at sampling site 2 (main channel of the Danube at 1843 river km) in 1994, 1995 and 1996. (See other comments at Fig. 1)

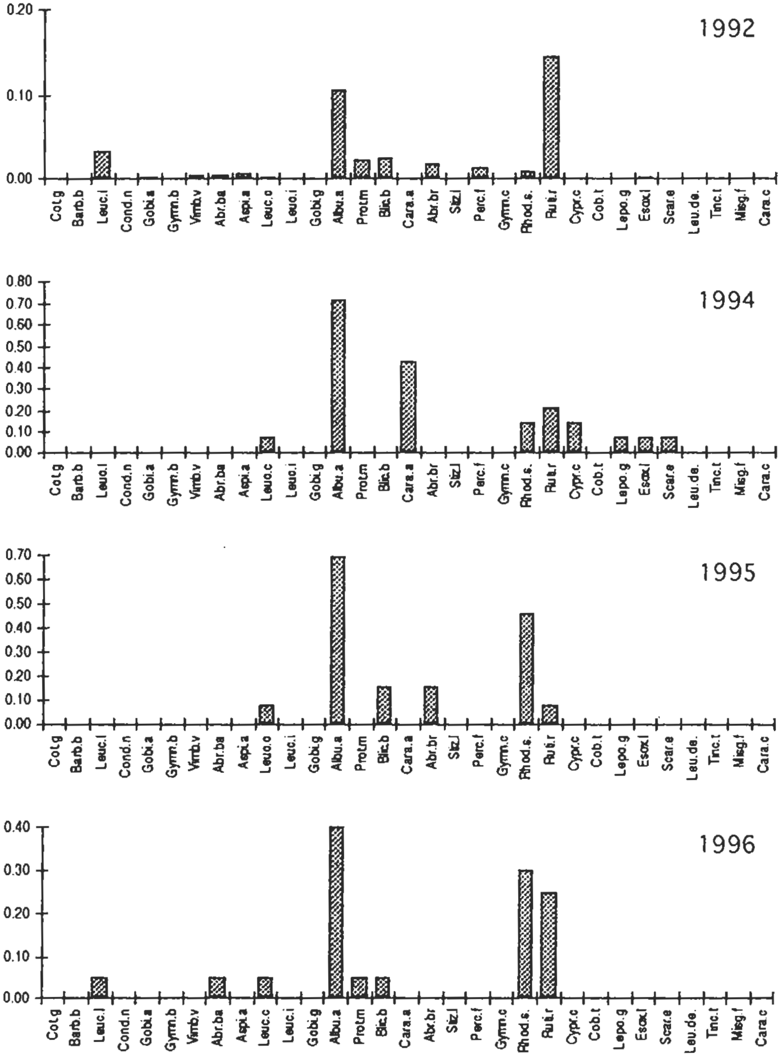

Fig. 3. Frequency distribution of juvenile fish species at sampling site 3 (Csákányi arm in the Cikola branch system) in 1992, 1994, 1995 and 1996. (See other comments at Fig. 1)

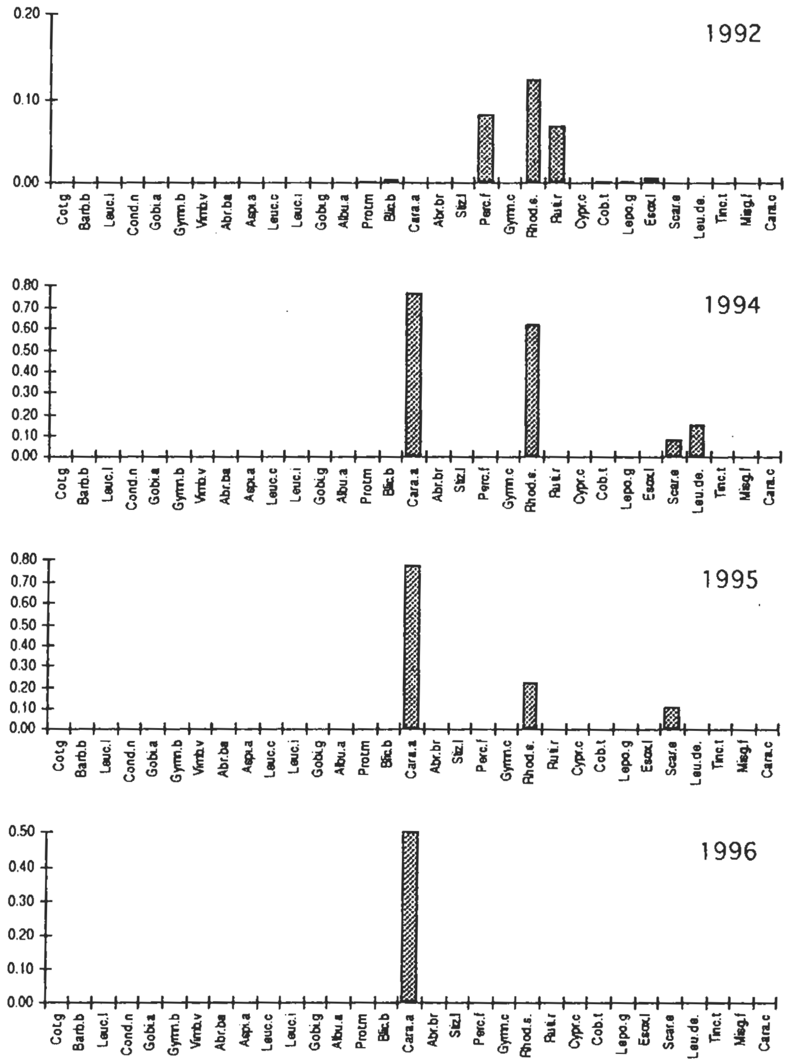

Fig. 4. Frequency distribution of juvenile fish species at sampling site 4 (Schiesler arm in the Cikola branch system) in 1992, 1994, 1995 and 1996. (See other comments at Fig. 1)

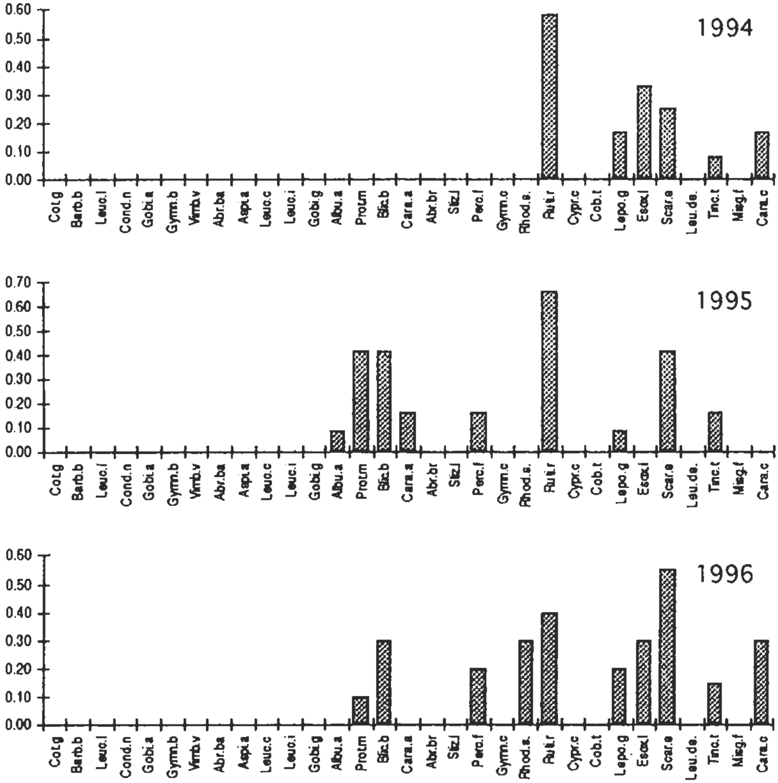

Fig. 5. Frequency distribution of juvenile fish species at sampling site 5 (Gazfüi Danube) in 1994, 1995 and 1996. (See other comments at Fig. 1)

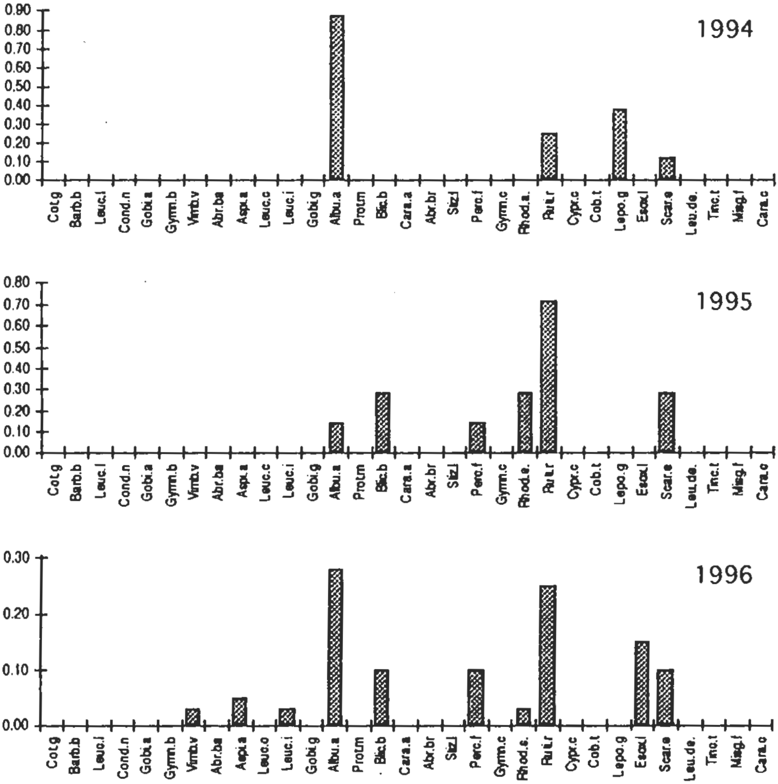

Fig. 6. Frequency distribution of juvenile fish species at sampling site 6 (Lipót oxbow) in 1994, 1995 and 1996. (See other comments at Fig. 1)

Conclusions

1) No fundamental changes in the fish fauna composition could be verified in the bypassed section of the Danube since the operation of the Gabcikovo Hydroelectric Power Plant.

2) The bottom sill was not an insurmountable barrier for most of the fish species in the main channel of the Danube.

3) The downstream slope of the bottom sill is an especially high gradient biotope of the Danube at 1843 r. km, where at least 20 fish species occurred in 1995 and 1996, many of them are endangered in the Middle Danubian basin.

4) The artificial water replenishment from the dammed upstream of the bottom sill created a limited connection between the main channel of the Danube and the floodplain side arm system. Some rheophilic species of the main channel appeared occasionally in the canal system of the flood protected area, too.

5) Fish movement is highly probable from the Mosoni-Danube to floodplain side arms.

6) A degradation process of the fish fauna was detected in the completely disconnected arms of the floodplain.

7) The regulated supply dynamics improved the spawning conditions of some phytophilic spawner fish species, but paleopotamal type of biotopes have become restricted in the canal system of the flood protected area.

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