ASSESSMENT OF THE ECOLOGICAL FUNCTIONALITY OF ANTHROPOGENICALLY CREATED HABITATS IN THE IMPOUNDMENT OF THE HYDROPOWER PLANT FREUDENAU (VIENNA, AUSTRIA) WITH BI - AND MULTIVARIATE STATISTICAL ANALYSES

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INTRODUCTION

In potamal rivers of the hill or lowlands hydropower plants represent especially ecological problems. Due to the low descent large dimensioned impoundments become necessary. Monotonous habitats arise as in the retention areas as in tailwaters. Hinterland detachment and groundwater isolation lead to impairments of the riperian forest. The diminution of dynamic processes, such as one - sided directional developments, which gets recognizable by aggradation and obsolescence of the vegetation is distinctive. The river bed erosion connected to the river bed load detention represents another problem (Jungwirth *et al.*, 2003).

Originally the Danube in the range of Vienna corresponded to a braided river system with numerous mainstreams and tributaries. As a result of the regulation in the 19th century remained a single river mainstream. The typical fish fauna therefore confines itself to the main arm. The regulation consecuence caused a higher flow velocity and river bed erosion. Since then rheophilic fish species dominate (Waidbacher *et al.*, 1996).

During the construction of the hydropower plant Freudenau natural structures and habitats were implemented first time in history and a bypass channel created, according to the requirements of the European Water Framework Directive. In advance to this project research of the Institute of Hydrobiology and Aquatic Water Management, University for Natural Resources and Applied Life Sciences, the context of the ecological preservation in the range of hydropower plant Freudenau was executed (WAIDBACHER *et al.*, 1996).

Both benthic long - term relationships and fishbiocenosis were the basis of the previous examinations. Chief attention of the study was the fish ecological condition. Due to various ecological claims fish species are excellent indicators for hydromorphological changes which are decisive for the assessment of the fresh water ecology. Both as indicators for continuum conditions and for habitat equipment fish are particularly predestined (Schmutz *et al.*, 2000).

The ecological functionality is the ability for the maintenance of the ecological integrity between waters and its occurrence organism in the surrounding area, according to the natural markedness of the respective water body type (Admicka *et al.*, 1992).

OBJECTIVES

The objective of this project was to determine the composition, richness and the diversity of the fish species in the impoundment of the hydropower plant Freudenau (Vienna - Austria), through the Catch Per Unit Effort (CPUE). In the context fish ecological data were processed and evaluated from the examination years 1999 to 2000 as well as 2003 till 2004 with the aim of the fish ecological functionality of anthropogenic shore structures and analyzing with multivariate statistical methods.

MATERIAL AND METHODS

Study area

The hydropower plant Freudenau, built within the years 1992 to 1998 was the first large and most modern power plant of the world in a metropolis.

For a detailed investigation the study area was divided into five parts (Stream kilometer 1914.50 to 1994.60). Each part contains various habitat structures located on the left river side. Those mentioned five river sections are: Tailwater (Stkm. 1914,50 to 1921,05), Impoundment (Stkm. 1921,05 to 1928,00), Transition Zone (Stkm. 1928,00 to 1935,00), Head of Reservoir (Stkm. 1935,00 to 1945,50) and Free Flowing Stretches (Stkm. 1945,50).

During the construction of the power plant the habitats A to I were installed newly on the left river bank. These shall simulate tributaries and bays.

Habitat A (Strkm. 1921,90 to Strkm. 1922,40), B (Strkm. 1923,90 to Strkm. 1924,50), C (Strkm. 1926,20 to Strkm. 1926,70) and D (Strkm. 1927,35 to Strkm.1927,50) are situated in the Impoundment. In the Transition Zone are located habitat E (Strkm. 1928,80 to Strkm. 1928,90), F (Strkm. 1929,90 to Strkm. 1930,10) and G (Strkm. 1930,90 to Strkm. 1931,10). The Head of Reservoir is characterized by the habitat H (Strkm. 1932,20 to Strkm. 1932,50) and I (Strkm. 1934,80 to Strkm. 1935,50).

E - fishing

The principle of the E - fishing is the creation of an electric externally applied dc field in the water to which fish react. The individual situated in the electric field lines up actively to the anode. Due to the electrotype taxies the fish approaches the anode and is deadened (electrotype narcosis). The efficiency and the domain of this method are dependent on the conductivity of the water. The E - fishing is a quantities and species selective fishing (COWX & LAMARQUE 1990).

The captured fish still are determined on the spot, measured and weighed. Those individuals which escape a in time determination (primarily juvenile), are fixed in 4% formol and afterwards examinated binocularly. In most cases N/10 min are regarded as sampling unit of the "CPUE"(Catch Per Unit Effort) which is determined by number of individuals per ten minutes fishing.

Analyses

The bases formed the Access databases "Freudenau"(1999 to 2000) and "FIDON"(2003 to 2004) of the institute for Hydrobiology and Aquatic Ecosystem Management. It was aim to process for further statistical bi and multivariate analyses and to analyse in the temporal course. To this merely fish data of the E - fishing were treated to get values of an efficient statistical evaluation with binary data, frequencies, "Catch Per Unit Effort"(CPUE). SPSS 16.0 was used for the bi and multivariate analyses on hand for Windows.

In this project only the hierarchical cluster analysis was used. The Ward method as a cluster method and as measuring standard the interval of squared euclidean distance was chosen. At this juncture the discriminant analysis was used for the check of the cluster analysis.

To visualize the membership of the fish data in the cluster solutions, the mean average values of the frequencies and binary data of the fish were compared with each other after the cluster analysis.

With the formation of rankings an optimal comparison could be carried out and illustrated graphically in the reference to the frequencies of the juvenile and adult fish. The rank variance analysis was carried out by the test of Friedman and the calculation of the coefficient of concordance by the test of Kendall - W.

RESULTS AND DISCUSSION

Fish Species of the Austrian Danube

In the period from April 1999 until November 2000 as well as from July 2003 until October 2004 could be caught 24680 individuals by E - fishing and evaluated in the area under investigation. Altogether, 52 species of fish were proved. The most frequent species in the study area were Bleak (*Alburnus alburnus*, Linnaeus 1758), Nase (*Chondrostoma nasus*, Linnaeus 1758) and Roach (*Rutilus rutilus*, Linnaeus 1758). The rarest caught fish species were e.g. Mediterranean Barbel (*Barbus peloponnesius*, Valenciennes 1842), Stone Loach (*Barbatula barbatula*, Linnaeus, 1758) and Spirlin (*Alburnoides bipunctatus*, Bloch, 1782).

Evaluating of the section in the reservoir with CPU

The most fish in summary were caught in the Transition Zone or Head of Reservoir. This can be reduced to the better framework conditions with respect to food supply and reproduction spaces. The abiotic factors create excellent conditions, such as varying velocities of flow as well as the structural variety for fish - biocenosis.

Comparison of the guilds in each section

By the formation of the median the dominance is confirmed to the euryoecious taxa in the Impoundment and Transition Zone. The rheophilic and euryoecious species are available in Tailwater, Transition Zone and in the Free Flowing Stretches in similar dimensions.

Evaluation of pooled habitats by fish frequencies

For these cluster analysis the pooled habitats were used as cases and the fish frequencies as variables. The cases are caracterized by the fact that the pooled habitats can be compared with the respective Danube mainstream section. The partial clusters describe connectivities between the habitats and the Danube mainstream in the Impoundment as well as the habitats in the Transition Zone. A close relation can be established by Danube Transition Zone and Danube Free Flowing Stretches, too. These connections can be explained by migration of the fish species as factors in regard on food, reproduction and velocity of flow.

Ranking comparison of juveniles and adults

The sense of formation of rankings is to carry out and to illustrate graphically an optimal comparison with respect to the frequencies of the juvenile and adult fish. Primarily with Barbel (*Barbus barbus*, Linnaeus 1758), Schraetzer (*Gymnocephalus schraetser*, Linnaeus 1758) and Zingel (*Zingel zingel*, Linnaeus 1766) great divergences can be recognized.

CONCLUSION

Elevations of the last years showed 62 species in the Austrian Danube (ZWEIMÜLLER *et al.*, 2000) whereupon 52 of those are autochthonous species (SCHIEMER 1998). The Danube River as a migration way for Caspian and Asian fauna as well as for Neobiota from the Black Sea features a high bio diversity due to these. In addition, some species of fish, e.g. Danube Roach (*Rutilus pigus virgo*, Heckel 1852), Zingel (*Zingel zingel*,Linnaeus 1766) or White Finned Gudgeon (*Gobio albipinnatus*, Lukash 1933) are exclusively endemic in the Danube river basin. Historical fish data show that the present fish spectrum corresponds to the original one for the most part (JUNGWIRTH 1975).

The power plant construction and the habitat changes seem to have effect on the biocenosis. The migration was stopped for e.g. the Sterlet (*Acipenser ruthenus*, Linnaeus 1758) and other species like Common Minnow (*Phoxinus phoxinus*, Linnaeus 1758) and Volga Zander (*Sander volgensis*, Gmelin 1788) do not find any corresponding framework conditions

for reproduction. Anadrome species, such as Acipenseridae (real sturgeons), have disappeared due to water structural obstacles (e.g. dam "Iron Gate") and overfishing in the Austrian Danube. In this case worth mentioning: Beluga (*Huso huso*, Linnaeus 1758) and Ship Sturgeon (*Acipenser nudiventris*, Lovetzk, 1828).

The deceleration of the velocity of flow, the change of the sedimentation and the dominance of ripraps had an advantageous effect on the successful settlement of stable populations of stagnophil and primarily alien species.

An analysis of the species of fish list and its guild membership shows that primarily euryoecious types dominate the spectrum. Important factors like velocity of flow, shore vegetation, water temperature, increased food supply, spawning grounds, reproduction spaces and shelters create optimal prerequisites to go through complete life cycles.

The Impoundment contains a wide range of 39 fish species. By the deceleration of the velocity flow after the power plant construction a change from the rheophilic Ichthyofauna to a stagnophil and euryoecious guild membership was verified.

Actually 33 of the 52 recorded species in the examination area can be proved in the immediate Tailwater (without riperian forest). This also can be reduced to predator pressure as well as compensation and spawn migration. The lowest number of fish species shows the Free Flowing Stretches which mainly consists of rheophilic species.

In principle, stagnophil - euryoecious species dominate the Impoundment and the Transition Zone. The Head of Reservoir and the Free Flowing Stretches are preferred by rheophilic fish primarily. In this project it could be proofed the acceptance of habitats by fish species.

Statistical analyses demonstrated a connectivity between each habitat. This suggests accessibility to the habitats and connection under each other. The newly - created habitats are at the moment good replacement environments which do not reflect any natural, persistent water ecosystem. There is a great difference compared with the original spectrum of fish species although a high acceptance and functionality is given.

The construction of a hydropower plant causes drastic changes of the natural structure and in consequence impairs fauna, flora and hydrologic conditions. Anthropogenically created habitats are limited substitutes for natural environments. Further examinations must follow and a monitoring be prepared to be able to describe and understand processes better. It would be desirably to consider mentioned analyses to improve or optimize anthropogenical structures in future.

REFERENCES

Admicka, P.; Bretschko, G.; Danecker, E.; Hinteregger, J.; Imhof, G.; Jungwirth, M.; Leichtfried, M.; Moog, O.; Moritz, C.; Müller, G.; Pechlaner, R.; Pipp, E.; Polzer, E. & Schulz, N. 1992. Zur Gewährleistung, Beeinträchtigung und Beurteilung der ökologischen Funktionsfähigkeit von Gewässern. **Österreichs Fischerei 45**; 120 - 121.

Cowx, I.G. & P. Lamarque. 1990. Fishing with Electricity. **Fishing New Books.** Oxford, 248 S.

Jungwirth, M. 1975. **Die Fischerei in Niederösterreich.** Wissenschaftliche Schriftreihe Niederösterreich. Nö Pressehaus, St. Pölten/Wien, 31 S.

Jungwirth, M.; Haidvogel, G.; Moog, O.; Muhar, S. & Schmutz, S. 2003. **Angewandte Fischökologie an Fließgewässern.** Facultas Universitätsverlag, Wien, 547 S.

Schmutz, S.; Kaufmann, M.; Vogel, B. & Jungwirth, M. 2000. **Methodische Grundlage und Beispiele zur Bewertung der fischökologischen Funktionsfähigkeit österreichischer Fließgewässer.** Wasserwirtschaftskataster des BMFUW, Wien.

Waidbacher, H.; Haidvogel, G. & Wimmer, R. 1996. **Beschreibung der räumlichen und zeitlichen Verteilung der benthischen Lebensgemeinschaften und der Fischbiozönosen im Projektbereich des KW Freudenau (Limnologische Beweissicherung).** Institut für Hydrobiologe und Gewässermanagement der Universität für Bodenkultur,Wien.

Zweimüller, I.; Guttmann, S.; Singer, G.; Schober, E. - M. & Weissenbacher, A. 2000. Eine neue Fischart für Österreich-Neogobius syrman (Normann 1940). **Österreichs Fischerei 53**, 186 - 189.