

ABSTRACTS

1. ORAL PRESENTATIONS:

**MACROINVERTEBRATE COLONISATION OF THE RHINE DELTA IN THE PROCESS OF
ECOLOGICAL REHABILITATION**

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Improvement of the ecological quality of the Rhine delta resulted in an increase of the number of macroinvertebrate species and their densities. Ecological quality improvement has been the result of the improvement of water and river bottom quality on one side, and nature development - the reconstruction of riverine biotopes that were lost during the process of river engineering - on the other side. However, not only recolonisation of the Rhine delta by indigenous species was important for the increase of the number of macroinvertebrate species. Non indigenous species contributed to that as well, specially if biomass of species is taken into account. Important are species from the Ponto-Caspian area. Since the Main-Danube canal (connecting the Rhine and Danube basins) was opened in 1992 for shipping, an extra and more direct route was created for species from the Ponto-Caspian area to extend their territory.

**CHANGES OF THE MACROZOOBENTHOS-COMMUNITY DURING THE LAST 30 YEARS IN THE
LOWER RHINE**

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The macrozoobenthos-community in the North Rhine-Westphalia stretch of the Rhine has been investigated in the bank area since 1969 to evaluate the water quality class. The quality assessment since 1976 follows the criteria published by the LAWA (Länderarbeitsgemeinschaft Wasser) for a standardised evaluation of running waters in the Federal Republic of Germany. The evaluation is based on the saprobic system. The data show that the Rhine in the early seventies was biologically impoverished or devastated caused by heavy sewage pollution. Since the mid seventies an increasing recreation of the macrozoobenthos-community could be observed. This is the result of rehabilitation measures inside and outside of North Rhine-Westphalia. Since 1994 the entire North Rhine-Westphalia stretch of the Rhine belongs to water quality class II which is the objective of the water protection policy. The recreation of the macrozoobenthos-community shows an enormous dynamic. It was attended not only by the reestablishment of populations from native species but as well by increasing introduction of neozoans.

The changes of the macrozoobenthos-community and the water quality of the Rhine are presented and discussed.

BIOMONITORING OF FAUNISTIC CHANGES – TRENDS IN SPECIES COMPOSITION OF MACROZOOBENTHOS OF THE UPPER RHINE RIVER DURING THE PAST CENTURY

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The macrozoobenthos of the upper River Rhine has been surveyed for several times since the beginning of the past century, at last in the period 1995-1999 within the scope of a regular biocoenotic surveillance programme of the federal state agency for environmental protection of Baden-Württemberg in diverse rivers and brooks.

Macrozoobenthos (except Oligochaeta and Diptera) was sampled during the last 5 years at 6 suitable sites between Basel and Mannheim using the classic kicksampling method and additional collecting of adults at the banks, both four times a year.

Results are compared to faunistic data from former investigations especially to the data yielded by intensive collections in context with the Sandoz accident in 1986, and are also compared to results received from two sampling sites of the River Rhine between Lake Constance and Basel. There is an immense increase in species richness in the last 15 years in the River Rhine, not only contributed by neozoa, but also by autochthonous species, indicating the general increase in water quality in this area.

CHANGES OF MACROFAUNA IN THE RIVER IJSSEL SINCE 1975

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In the seventies chemical and biological monitoring in the river IJssel started and continued until today. Nutrients, toxic substances, dissolved oxygen, chlorophyll and suspended matter were monthly monitored and macrofauna yearly using stones in a basket as substratum. The change in the composition and biomass of the macrofauna is quite dramatic. From 1975 to 1985 the macrofauna exponentially increased from ca 50 individuals per m² stone surface area to ca 20.000, particularly chironomids, oligochaets and *Asellus aquaticus*. In the same period toxic substances decreased exponentially. After the Sandoz disaster the density had completely collapsed, but recovered in a few years. However the composition drastically changed and filter feeders such as *Dreissena polymorpha* and *Corophium curvispinum* dominated the biomass. The decrease in organic load provided less food for the detritivores and increased the possibilities for *Dreissena* and *Corophium* to settle. *Dreissena* collapsed in response to *Corophium* in the beginning of the nineties. *Corophium* in its turns collapsed at the end of the nineties for unknown reasons. In contrast to what may be expected the diversity did not increase but decreased in this period of water quality improvement.

THE SEASONAL SUCCESSION OF MACROINVERTEBRATES IN THE RIVER RHINE AND TWO

NEIGHBOURING GRAVEL-PIT LAKES MONITORED WITH ARTIFICIAL SUBSTRATES

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Biological monitoring is a main aspect of today's water quality assessment of rivers and lakes. In this sense we used artificial substrate samplers (ASS) to study the seasonal succession of macroinvertebrates in the River Rhine and two neighbouring gravel-pit lakes, one permanently connected to the River Rhine (B-RW), and the second which is flooded only during high waters of the Rhine (AKG). In two experimental series nearly all macroinvertebrates normally to be found on each site settled on the ASS. Demonstrated by the aid of examples, the detailed analysis of the results offered that the ASS is an adequate tool to study (1) different aspects of the life cycle of species that settle frequently on the plates, (2) the seasonal succession of a macroinvertebrate community, and (3) aspects of competition and support within a macroinvertebrate community. In addition, especially the growth rates of juvenile zebra mussels (*Dreissena polymorpha*), and the total biomass of macroinvertebrates on the ASS reflected quite well the productivity of the different waters, with highest values for the B-RW, somewhat lower ones for the Rhine, and very low biomass values for the AKG. The results demonstrated that artificial substrates may be an optimal studying tool for biological monitoring programs.

INSECTS IN POLLUTED RIVERS: AN EXPERIMENTAL ANALYSIS

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In large European rivers, the number of aquatic insect species has been strongly reduced during the last century, and therefore they could play a key role in assessing the ecological status of recovering aquatic communities. However, river insects are rarely used as ecotoxicological test organisms, which makes an effective use of distribution data very limited. This project aimed therefore to develop test schemes with riverine insects as sensitive tools for eco(toxico)logical management of inland waters. To this purpose, three representative river insects (the caddisflies *Hydropsyche angustipennis* and *Cyrtus trimaculatus* and the mayfly *Ephoron virgo*) were selected and laboratory cultures and standardized ecotoxicity tests were developed. To gain insight in the sensitivity of these species and discern potential key factors limiting the distribution of these species, the effects of several stress factors (copper, diazinon and low oxygen) were determined in experiments with increasing complexity and environmental relevance: from acute single compound tests to behavioral, mixture toxicity and multi stress experiments. For copper and diazinon, it was demonstrated that the sensitivity of these species is very high in comparison with aquatic insects traditionally used in ecotoxicity tests and adverse effects were demonstrated at ecologically relevant concentrations. The joint toxicity of copper and diazinon was significantly higher compared to the toxicity of the single compounds. Finally we demonstrated that larvae kept under low oxygen conditions were significantly more sensitive to toxicants. Our results demonstrated that mixture toxicity and multi stress may prevent the revitalization of benthic communities and underline the importance of using indigenous species in defining water quality conditions for ecological rehabilitation.

BIODIVERSITY AND NICHE PARTITIONING OF CHIRONOMID COMMUNITIES IN RELATION TO ENVIRONMENTAL FACTORS IN A LARGE, DEEP RIVER

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The larval chironomid community of the bed sediments was examined at four sites along a cross-section in the River Danube in Austria between September 1995 and August 1996. Jack-knife technique was applied to calculate means and confidence limits for species richness, diversity (H'), evenness, spatial niche width and overlap, aggregation, temporal persistence and beta-diversity. Bonferroni corrected, Jack-knifed confidence intervals were used to test for significant differences between sites or dates. Species of chironomids were assigned to functional feeding groups.

A RDA (redundancy analysis) including the above community properties and six environmental key variables obtained by a PCA revealed that abundance, species richness and diversity were negatively correlated to water current and pore space. Temporal persistence and resource width were negatively, beta diversity and aggregation were positively correlated to temperature, sediment turnover and sediment heterogeneity. Grazers preferred larger grain sizes whereas all other feeding groups dominated at sites with smaller grain sizes.

ZOOPLANKTON GRAZING ON ALGAE IN A DANUBE FLOODPLAIN SYSTEM – ASSESSMENT BY THEORETICAL ASSUMPTIONS.

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Carbon flow and grazing impact on algae by metazooplankton were calculated using clearance rates from literature applied to quantitative zoo- and phytoplankton samples from 1997 and 1998. Size of algae, temperature and the most abundant zooplankton taxa were considered. Two different floodplain sections characterised by either low (Lobau) or high (Regelsbrunn) connectivity to the River Danube were compared. Theoretical water retention time was used to define hydrological conditions.

Community grazing of zooplankton at Lobau was relatively constant during the study period. At Regelsbrunn the carbon flow fluctuated strongly and collapsed at flood pulses. However, in periods of low water some zooplankton species reached very high abundance, thus stimulating the material transfer to higher trophic levels considerably.

In the dynamic section at retention times up to 10 days rotifers, mainly *Synchaeta* sp., *Polyarthra* sp, *Brachionus* sp. and *Keratella* sp., dominated community grazing. Highest grazing rates could be determined between retention times from 10 to 17 days caused primarily by the smallbodied cladoceran, *Bosmina longirostris*.

THE FOOD WEB IN THE RHINE: FILTER FEEDERS, OMNIVORES AND PREDATORS

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The food web relations in the Rhine river have been analysed by means of stable isotopes (^{13}C and ^{15}N). ^{13}C and ^{15}N were measured for particulate organic matter (POM), silt material, macro-algae, muddy tubes of *Corophium*, 17 macroinvertebrate species and 10 fish species. ^{13}C indicates the carbon source, ^{15}N indicates the trophic level. Considerable ranges in both carbon (from -31.97 to -22.53 ‰) and nitrogen stable isotopes ($+9.08$ to $+17.36$ ‰) were found in the aquatic food web. Using cluster analysis seven clusters were identified. Some species show an ontogenetic diet shift. Omnivorous and piscivorous fish were at the top of the food web. The observed high ^{15}N values at the base and top of the food chain suggest significant anthropogenic influence

over the channel's nitrogen input.

FILTRATORS IN BENTHIC BIOCEANOSES OF THE URAL RIVERS AND TRENDS OF THEIR CHANGES CAUSED BY WATER POLLUTION

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The biocenoses of rivers consist of a number of functional groups, each of them playing the certain role in aquatic food webs. Nevertheless, the benthic filter feeders is distinguished among others by special significance, because along with the performance of initial biological role in the creation of the certain trophic connections, it has great importance in self-purification processes in rivers polluted. These animals remove actively dangerous toxicants from the process of substances circulation, resulting in water purification, and creating species diversity biocenoses. Filtrators of Ural rivers consist of molluscs, sponges and some insects. In studies on the rivers Salda, Iset and Chusovaya it was found that the structure of filtering group had been sensitive to pollution of water and it strongly fluctuated depending on a type of contamination. In some cases, the benthic filtering biocenoses function so intensively, that they have time to filter whole water in the river while it passes the channel of 2 km long. According to the River Continuum Concept the filtering biocenoses in the Ural rivers reach the maximal abundance in river's downstream, in some places forming the so-called "biofilters". It was concluded, that in self-purification processes in rivers the filtrators play an important role, and species structure of filter feeders is a good tool to judge about the most hazardous type of contamination, which most likely caused degradation of river ecosystems.

RETENTION TIME DETERMINING ZOOPLANKTON BIOMASS AND COMMUNITY STRUCTURE IN A DANUBE FLOODPLAIN SYSTEM.

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Zooplankton biomass and biodiversity were examined in a Danube floodplain system of high hydrological dynamic. Temporal patterns were used to assess the significance of water retention time for the

regulation of zooplankton population dynamics. The sampling period covered a broad range of hydrological conditions ranging from lotic to lentic situations.

Retention time could be identified as the driving variable governing total zooplankton biomass following a sigmoidal relationship. It also proved to have different effects on rotifers and crustaceans. Rotifer biomass followed a polynomial 2nd order relationship showing a maximum at medium retention time while crustacean biomass was positively linear related.

Biodiversity patterns of the two taxonomic groups differed significantly. Rotifer species number declined linearly along the hydrological gradient while crustacean species number increased exponentially, showing a maximum at periods of long lotic conditions.

We explained this "hydrological succession" by the alternation of flood caused mortality (e.g. washing out effects) and taxa specific potential of reproduction along the hydrological gradient. Periods of long retention, favoured crustacean development, most likely due to competitive advantages, whereas rotifer biomass and species number declined.

CHANGES IN THE BIOTIC COMMUNITY AFTER REESTABLISHING LOTIC CONDITIONS IN THE 'VÉN-DUNA' SIDE CHANNEL IN THE DANUBE RIVER (BAJA, HUNGARY)

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At the beginning of the 1990s rehabilitation measures have been identified for the Gemenc floodplain along the Danube River in Hungary. Over the years due to river normalisation works this floodplain has terrestrialised and side channels have silted up or cut off from the main channel. The Vén-Duna side arm was cut of the main river arm by a constructed rock dam that permitted the water flow through the channel only in peak flood conditions. The reopening of the Vén-Duna side channel was the first concrete act of restoration. Hydrological, river morphological and ecological monitoring was carried out in this region prior to and after the reopening in order to follow the effects of the rehabilitation work. The former lentic conditions turned to almost permanent lotic situation throughout the whole year. The effects of the engineering intervention on hydrology, morphology, water quality, plankton, macroinvertebrates and fish will be evaluated. The changes in abiotic processes and the consequences for biotic components one year after reopening will be presented.

THE ECOLOGY OF THE RIVER RHINE – TODAY AND IN FUTURE

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During the past two centuries, the River Rhine has increasingly suffered from heavy waste-water pollution, engineering works for shipping traffic, and settlements in the former floodplain, as in several other European large rivers. With regard to drinking water production, in the past three decades the pollution was remarkably reduced by the implementation of sewage treatment plants. This reduction resulted in a resettlement by both generalist and neozoan macrozoobenthos species (MZB) as well as by fish. However, the current species abundance pattern of MZB and of fish may change from year to year, which demonstrates that the biocoenosis is still impacted by detrimental environmental conditions. Examples of these conditions are chemical spills, extreme fluctuations between high and low water levels, lack of connected still waters in the floodplain, dispersal of foreign dominating MZB species, oxygen-deficient sediments and weirs, among others. In 1987, the Rhine Action Programme was initiated and focused on the recolonisation of wild salmon in the ecosystem of the River Rhine, including the salmonids' breeding grounds in its catchment area. Migrating fish and their successful reproduction function as an ecological signpost for an optimal rehabilitation of the river ecosystem in total. The lecture will be focused on open ecological problems, on promising monitoring and field study work, as well as on recommendations for environmental decision makers.

THE POTAMAL FOOD WEB

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While the trophic interactions in lakes are well known, our knowledge about the potamal food web is fairly scarce. Previous results suggest that most biotic fluxes are established in the pelagic environment and that the importance of the pelagic turnover increases downstream. New investigations allow insights to factors such as mixing, turbidity and water retention time, which influence the structure and function of the potamal food web in near-natural and anthropogenically influenced parts of rivers.

Top down predators determine whether filter feeders, omnivores or predators dominate the aquatic community. Similar to lakes, we find seasonal and spatial differences in the pelagic community, especially concerning the importance of the various components of the microbial food web. According to the River Continuum Concept the filtering communities reach their maximal abundance downstream. But new investigations show, that such "biofilters" are not typical for all types of rivers.

The transport of pelagic products into the sediment has for a long time only been considered theoretically. New investigations on suspended and settled aggregates, consisting of pelagic and benthic products, seem to open new insights in the coupling between pelagic and benthic processes of large rivers.

PHYTOPLANKTON IN THE LOWER RHINE

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According to the long flow time and richness in nutrients the Rhine can develop high quantities of plankton. This development is at its peak in the lower Rhine which is about the Northrhine-Westphalia stretch between km 600 to 800. The plankton is monitored since about 20 years, weekly at 4 stations in the Rhine and the main tributaries at their mouth. Significant changes in quality and quantity exist between the beginning of the 20th century, the time of highest pollution in the 50th, and in the last 20 years. The phytoplankton is characterised by centric diatoms and green algae, the zooplankton by rotatoria. Up to 150 µg per litre chlorophyll-a were measured in 1979. Over some time oxygen production was inhibited by heavy metal discharges. Seasonal changes follow the solar radiation, modulated during high flow. Plankton studies are part of the monitoring program of the International Commission for the Protection of the Rhine.

STRUCTURE AND CONTROL OF HETEROTROPHIC NANOFLAGELLATES (HNF) IN THE PELAGIAL OF A LARGE RIVER (RIVER RHINE) WITH ATTENTION TO THE GRAZING IMPACT OF BIOFILM-DWELLING CILIATES AND ROTIFERS

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The pelagic HNF were investigated in the Lower River Rhine over a 20 month period, with respect to their abundance and taxonomic structure (live counting technique), their production and grazing loss to planktonic predators (size-fractionation experiments) and their downstream loss. Abundance ranged from 7 to 4889 HNF/ml. High HNF growth rates were measured in the laboratory. The grazing loss to planktonic predators was generally low (30 % of gross production). Two features indicated an important role of benthic predators in the control of pelagic HNF in the River Rhine: (1) A high loss rate was recorded in the river during the downstream passage, which could not be explained by pelagic predators. This loss rate was positively correlated to temperature, indicating biotic interactions. (2) HNF abundance increased with rising water discharge. This could be explained by the concomitant decrease of grazing intensity of benthic predators (higher water volume to river bottom ratio). Modelling this indirect impact of water discharge on planktonic HNF resulted in a good fit between the model and the field data. Characterisation of benthic predators will be discussed in context with data from feeding experiments, implying a significant impact of biofilm-dwelling ciliates and rotifers on pelagic HNF.

CILIATES IN THE POTAMOPLANKTON OF THE RIVER RHINE: TAXONOMIC COMPOSITION, SEASONAL DYNAMICS AND LOSS TO MACROZOOBENTHOS

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We investigated the abundance and structure of the ciliate fauna in the potamoplankton of the River Rhine in combination with several abiotic and biotic factors for one year.

The resulting data showed that beside benthic ciliates numerous pelagic organisms could be found in the potamoplankton. We suggest the development of an independent pelagic ciliate community in the River Rhine. This will be discussed in consideration of the development of ciliates.

Increased discharge leads to an increase of sessile ciliates in the plankton (which is mainly a drift phenomenon) and second the phytoplankton bloom in spring positively affected the abundance of ciliates. Therefore food limitation may be a reason for the comparable low abundance of ciliates (100 – 1200 Ind./l) in the plankton of the River Rhine which will be compared with the results of growth experiments. Feeding experiments with filter feeders (*Corbicula spec.*) clearly revealed the strong grazing pressure of benthic macroinvertebrates on ciliates.

SEASONAL DYNAMICS OF PHYTOPLANKTON, FLAGELLATES, CILIATES AND ROTIFERS IN THE RIVERS RHINE, MOSELLE AND SAAR IN 1999

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In the rivers Rhine, Moselle and Saar, abundance and biomass of phytoplankton, heterotrophic nanoflagellates, ciliates and rotifers were investigated fortnightly in 1999. Mean abundance and biomass of phyto- and zooplankton were lower in the free-flowing part of the river Rhine (Rhine-km 590, Koblenz) and in the Moselle close to the confluence with the Rhine (Moselle-km 8, Koblenz) than in the polluted region of the Saar (Saar-km 48, Fremersdorf).

In Rhine and Moselle, phytoplankton showed a typical spring maximum and low biomass in summer. Phyto- and zooplankton seasonal dynamics were correlated in both rivers. In contrary in the Saar, no seasonal patterns of phyto- and zooplankton can be identified.

MODELLING THE CHLOROPHYLL A CONTENT OF THE RIVER RHINE –INTERRELATION BETWEEN RIVERINE ALGAL PRODUCTION AND POPULATION BIOMASS OF GRAZERS, ROTIFERS AND ZEBRA MUSSEL (*DREISSENA POLYMORPHA*).

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The chlorophyll a content of the German part of the river Rhine is simulated with the aid of a deterministic model (QSIM). At the upper boundary of the investigated river stretch at km 363 (Karlsruhe) low chlorophyll a concentrations (< 25 µg/l) were measured throughout the year 1990, while at the lower river region at km 865 (Bimmen) high chl.-a concentrations (> 50-100 µg/l) occurred in spring time and late summer. The model-based analysis of the algal biomass shows, that beside inoculation by the main tributaries Neckar, Main, Lahn and Moselle, algal production in the Rhine itself is of major concern. By including the grazing losses by zooplankton and benthic filter feeders, the algal standing crop is calculated. Depending on the algal food content the biomass of rotifers and *Dreissena polymorpha* population, respectively, is simulated and compared with observed abundance of rotifers and estimated zebra mussel biomass derived from measured densities and size structures of local populations.

GROWTH AND LOSSES OF RIVERINE PHYTOPLANKTON IN RELATION TO DISCHARGE

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Growth and losses of phytoplankton have been studied at different discharge along the lowland rivers Spree and Warnow. The mean depth of the river courses ranged from 0.3 to 3 m, the mean velocity of flow from 0.05 to 0.5 m s⁻¹. We compared changes in phytoplankton biomass in a water parcel flowing downstream with those in simultaneously incubated dialysis chambers. The difference between rates of change along the river and in the vertically moved chambers was used as an estimate of loss rates by sedimentation and grazing of benthic filter feeders. These loss rates increased with lowered water depth and exceeded usually the potential growth rate of riverine phytoplankton. Longitudinal growth of phytoplankton was observed only in periods of high discharge or along deep river courses. The fitness of the suspended algae was never impaired by turbulent downstream transport. The found inverse relationship between water depth and plankton losses to the river bottom should cause reduced exchange between water and sediments and increased importance of zooplankton in larger rivers. It also explains growing phytoplankton biomass after regulation or impoundment of river courses.

FISH AS BIOINDICATORS AND CONSERVATION TARGETS IN LARGE RIVERS

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The deterioration of riverine habitats due to pollution, river engineering and land use is reflected by the high number of endangered taxa. The conservation of riverine biota, a stronger incorporation of ecological aspects in river engineering and the development of restoration programmes to improve the existing situation became a main aim in river management. In order to achieve these goals it is necessary to develop practical criteria for habitat evaluation and the structural quality of rivers. In this respect it is apparent that fish communities are good indicators for habitat quality as well as for the ecological integrity of large river systems. Their study can give detailed insight, a more precise understanding and "meat" to theoretical frameworks on river ecology.

A detailed understanding of autecological requirements of species will improve their indicator and monitoring value. It is well accepted that the reproductive and the early juvenile phase are critical stages and the match/mismatch between requirements and environmental conditions will decide on success or failure of a population. In order to obtain insight into these relationships, research is required on fitness both on the level of the individual fish and species populations. It is necessary to combine both ecophysiologicaly orientated experimental studies and field work on various aspects and scales.

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The ecological characteristics of the Danube section in Vienna (Austria) have been greatly impaired due to urban development, regulation, channel straightening and impoundment by the construction of a hydroelectric power plant. The ecological management objective of this river stretch is to improve the longitudinal connectivity by creating a riverine corridor through the municipal area of Vienna. This corridor should connect the isolated floodplain areas in the north-west and south-east of Vienna. In 1997, the shoreline of the Danube in this area was restructured by artificial side channels, coves, gravel banks, pools and temporary waters which represent the key elements of the landscape linkage. A monitoring programme has been established focusing on the investigation of the functional integrity of this greenway: First results show that the sites isolated from the Danube serve as stepping stone biotopes for dragonflies and amphibians. Particularly amphibians are suitable indicators of the ecological functioning of riparian migration linkages on a (macro-) habitat and regional scale. Rheophilic fish species (e.g. *Chondrostoma nasus*) colonise side channels connected with the Danube and indicate a longitudinal connectivity on a landscape scale. The investigation of the terrestrial vegetation and macrophytes provides information on hydrological aspects and the development of habitat structures.

ABUNDANCE AND DISTRIBUTION OF JUVENILE 0+ FISH IN MAIN CHANNEL HABITATS OF THE LOWER RHINE RIVER

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The Rhine River has been subject to intensive river engineering works for the purposes of flood control and the facilitation of navigation activities. Since the former floodplain has been drained or separated from the main channel, fish reproduction has to take place within the river, where heterogeneity and dynamics of physical habitat conditions have been deteriorated by artificial embankments. In order to evaluate the functioning of inshore areas as nursery habitats, a late summer monitoring programme was conducted in the entire 220 km long reach of the potamal Lower Rhine. 0+ fish were sampled by means of point abundance electrofishing at 76 stations, equally distributed along the water course and chosen in a random fashion. Qualitative and quantitative aspects of 0+ fish occurrence as well as spatial distribution patterns are described in relation to habitat conditions. Main feature of 0+ fish community in the Lower Rhine River is the predominance of the rheophilous and lithophilous guild represented by *Barbus barbus*, indicating a recent recovery of the River Rhine's ichthyocoenosis due to essential improvements of water quality. The structure of 0+ fish community is also discussed in relation to the present state of adult fish community.

COMPLETE DOMINANCE OF EURYTOPIC BREEM *ABRAMIS BRAMA* IN FLOODPLAIN LAKES ALONG THE RIVER RHINE

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To study succession in fish communities in floodplain lakes and to assess how inundation affects the process of succession, fish communities in 5 lakes in floodplains of the River Rhine in The Netherlands were sampled 5 times from March 1997 to April 1999. In two of these lakes, densities present and numbers of fish in- and outmigrating during inundation were estimated using mark recapture techniques. In all lakes, bream was the dominating fish species. In some lakes, bream made up 99% of the fish biomass present. Fish from 10-35 cm were virtually absent. In general, species composition and size structure of the fish community did not change greatly over time. During inundation, 0+ group bream emigrated from the lakes and adult bream immigrated the lakes resulting in high standing stock biomass up to 650 kg/ha. Condition of bream that was already resident, was significantly better than condition of immigrating bream. Floodplain lakes along the lowland part of the River Rhine offer favorable conditions for reproduction of bream. Heterogeneity of waterbodies present in the river-flood plain system makes it possible that a deep bodied cyprinid like bream is completely dominant in specific parts of the river ecosystem.

MIGRATION AND DIEL PATTERN OF ACTIVITY OF ASP, *ASPIUS ASPIUS*, IN THE RIVER ELBE, GERMANY

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To describe migratory behaviour, home range and habitat use, temporal and spatial variability of migrations of the asp, was observed in the large River Elbe.

41 asp were tagged with internal radio transmitters (operational life 12 to 15 months). Fish were hand-tracked once per week in the main study area during the whole observation time. In different seasons some fish were hand tracked at 2-h intervals around the clock for 5 days.

Adult asp lived in home ranges of 1 to 30 km in the main channel. Some of them left their home range after spawning to migrate up to 180 km downstream. If air temperature decreased below 0°C, fish prefers deep groyne fields or harbours. Seldom fish were detected in natural backwaters.

Daily activity level of asp peaked from sunrise to sunset in all seasons. Most changes of prefers areas with higher current speed (heads of groynes, stone linings). In August the bank structure use was more variable (13 different structures) than in March (7 different structures) in case of high water level.

Results show that asp use different water bodies at different environmental conditions within a surprisingly long river section.

ABIOTIC FACTORS STRUCTURING THE JUVENILE FISH COMMUNITY IN A LARGE LOWLAND RIVER: AN ANALYSIS IN SPACE AND TIME.

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Fish-species - habitat relationships in the middle Elbe river have been the subject of intensive studies in the framework of a fish ecological research project supported by the German Ministry of Education and Research. Abiotic data, e.g. water depth, substrate type, conductivity, temperature, oxygen content, turbidity and pH and abundance, biomass data of YOY fish based on beach seine netting in late summer and autumn 1997 and 1998 were analysed and related using multivariate ordination methods.

The analyses focussed on different spatial structures, e.g. river flood plain, backwater and river channel. Time scaling was performed based on monthly collected data.

FISH COMMUNITY STRUCTURE IN THE DANUBE DELTA LAKES RELATED TO CHANGES IN HYDROLOGICAL INFRASTRUCTURE AND WATER QUALITY

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The Danube Delta has hundreds of lakes interconnected by river branches and man-made canals. Man-induced changes comprise the improvement of the hydrological infrastructure for navigational and fish production purposes and a elevated nutrient load of inflowing Danube river water. A 40-year time-series of the commercial fishery indicates a shift from limnophilic or clear water (*Tinca tinca*, *Carassius carassius*, *Esox lucius*) towards eurytopic or turbid water species. Since the 1970s dominant species caught are *Rutilus rutilus*, *Scardinius erythrophthalmus* and the exotic *Carassius auratus gibelio*. The effect of these changes have been studied in a multidisciplinary approach encompassing a 1-D hydrological model, remote sensing and monitoring of water quality, phyto- and zooplankton, aquatic vegetation and fish community. The fish community, which is addressed in this paper, has been sampled in June from 1996 through 1998 using gillnets and electrofishing. The species composition shows a gradient from predominant eurytopic or "grey fish" to limnophilic or "black fish" species. This gradient corresponds with lake morphometry, substrate type and hydrological distance from the river. The mosaic of lakes in the delta range from pristine to moderately influenced by human interventions and all together holds its biological diversity with regard to fish communities in floodplains

2. POSTERS

VALIDATION OF NEWLY DEVELOPED ECOTOXICITY TESTS USING TYPICAL RIVERINE INSECTS, THE CADDISFLIES *HYDROPSYCHE ANGUSTIPENNIS* AND *CYRNUM TRIMACULATUS* AND THE MAYFLY *EPHORON VIRGO*.

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During the last century, diversity of aquatic insects in large European rivers has strongly declined. Typical riverine insects, like caddisflies, mayflies and stoneflies are nowadays hardly found in polluted river systems. Therefore these insects can be used for monitoring water quality and indicating ecological recovery of large rivers. However, indigenous riverine insects have rarely been included in ecotoxicological test schemes and there is a lack of data on the autecology of these insects. Therefore, short-term ecotoxicity tests were developed with the caddisflies *Hydropsyche angustipennis* and *Cyrtus trimaculatus* and the mayfly *Ephoron virgo*. Two model toxicants were tested, the metal copper and the insecticide diazinon. It was demonstrated that the sensitivity of these species to both compounds is very high compared to aquatic insects traditionally used in ecotoxicity tests. Application of these tests as bioassays was validated by testing water and pore water samples from several contaminated field locations.

INVADING MACROINVERTEBRATES IN NAVIGABLE CANALS: THE ROLE OF ARTIFICIAL STRUCTURES.

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Navigable canals are important for the dispersal and expansion of the range of aquatic invading species, by connecting rivers as well as offering an artificial habitat with new ecological niches. In the Salzgitter branch canal of the Mittellandkanal in Lower Saxony near Braunschweig, Germany, the main bank structure consists of steel sheet piling and stone-embankment made of loose boulders. The temporal and spatial distribution of several macroinvertebrate taxa was investigated by applying different sampling methods including experimental substrates.

Areas surrounding harbours and locks are hot spots in species diversity and abundance of aquatic macroinvertebrate species. The sheet-pile- and stone-embankment-sections look very monotonous and do not show a high species richness. They have however a distinct microdistribution in the different investigated taxa. Dominant species were *Cordylophora caspia*, *Corophium curvispinum*, *Dikerogammarus villosus*, *Dreissena polymorpha* and *Tinodes waeneri*.

The important structures and factors for maintenance of species diversity in canals and large rivers are compared.

MACROINVERTEBRATE ASSEMBLAGES IN THE RHINE-MEUSE DELTA (THE NETHERLANDS) WITH RESPECTS TO SEDIMENT CONTAMINATION AND SEDIMENT QUALITY.

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The Rhine-Meuse estuary drastically changed after it was closed off from the sea in 1970. Tidal movement almost disappeared, current velocities lowered and consequently, sedimentation characteristics changed. This resulted in the deposition of millions of cubic meters of highly polluted sediment. Some years ago, an investigation started on the effects of these contaminated sediments on aquatic organisms. Bioassays in sediment pore water showed effect on survival, development or reproduction. Also the macrozoobenthic community in the Rhine-Meuse delta seems to be poorly developed. However, little is known on the effects of sediment in the field, especially the effects on the structure of macrozoobenthic assemblages. The main purpose of this study was firstly to describe different biotopes and their macrozoobenthic assemblages by means of use clustering techniques (FLEXCLUS and TWINSPAN) and ordination analysis methods (CANOCO). Secondly the influence of sediment quality on macrozoobenthic community structure was examined. Totally 297 sites were selected in the study area to represent a variety of environmental conditions. Fourteen biotopes were identified, including four solid substrate and ten bottom substrate biotopes. The biotopes of solid were dominated by *Dreissena polymorpha*, *Corophium curvispinum* and *Gammarus* sp., and especially *Glyptotendipes pallens* on snag. Most bottom biotopes were dominated by tubificids *Limnodrilus claparedeanus*, *L. hoffmeisteri* and the snail *Valvata piscinalis* and *Potamopyrgus antipodarum*. A number of characteristic species show a site-specific occurrence which is related to differences in depth, silt fraction, current velocity and wind erosion. Within each biotope characteristic species were related to sediment contamination parameters.

THE INFLUENCE OF RIVERBED MANAGEMENT ON THE HABITAT STRUCTURE AND MACROINVERTEBRATE COMMUNITY OF A NINTH ORDER RIVER, A FREE FLOWING SECTION OF THE RIVER DANUBE IN AUSTRIA.

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To overcome the problem of bed deepening of a river, the addition of coarse material to form a cover layer is one possibility. Therefore an 1:1 experiment in the River Danube was performed to overhaul this method and examine its effects on the macroinvertebrate community. The parameters of the habitat were Q1, Q2, Q3, the coefficients of sorting and skewness and the pore space. Those of the macroinvertebrate community were the total number of individuals, the Oligochaeta and the Hydracarina. After an increase of the sediment parameters Q2 and Q3 and a decrease of the coefficient of sorting in the top layer as consequence of the addition of the coarse material, the particle size in the top layer decreased and the coefficient of sorting increased, after more than one and a half year. The change of the depth habitat structure, e. g. decrease of pore space, is followed by a change in the vertical distribution of the animals, while >90% of the total number of individuals colonise the pore space between 0 and 90 cm at sampling date 1, the depth distribution change between 50 and 40 cm at the other sampling dates.

MONITORING OF THE FAUNA IN THE RIVERS ELBE, RHINE AND DANUBE ON AN ECOLOGICAL BASIS

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The Elbe, Rhine and Danube are considered as rivers of international importance. This is mainly due to their size and to the fact that they are used in many ways by man. At the same time they present a unique habitat for animals and plants. Directed by the Federal Ministry for the Environment, Conservation and Security of Nuclear Reactors the BfG has examined the macrozoobenthos of the navigable parts of the rivers since 1986.

The river Rhine is populated by more than 400 macrozoobenthos-species. The rivers Elbe and Danube provide a habitat for about 300 species each. Characteristic for all three rivers are many common and abundant species as well as rarer species and those recommended for protection. Some species are still endemic in the Danube, other species used the Main-Danube-Channel to reach the river Rhine where they have established in their new habitat. Also some species immigrated into the Danube from the Rhine.

In the rivers Rhine and Elbe the numbers of species declined drastically with increasing sewage disposal. Insects were particularly affected. In consequence of a more recent decrease in sewage load the oxygen content of the rivers increased. As a result, a continuing increase in species diversity can be observed in the river Rhine since 1975. The momentary situation of the river Elbe can be compared with the conditions found in the river Rhine before rehabilitation started. The development of the community in the river Danube has not been completely documented during the past 6 decades. Nevertheless, it is obvious that the Danube was not as polluted as the rivers Rhine and Elbe.

The communities populating all three rivers do not have the same composition of species as about 100 years ago. Changes in water quality as well as in the rivers flow, navigation, and colonisation by neozoa changed the composition of the aquatic communities.

TYOLOGY AND TYPE SPECIFIC REFERENCE CONDITIONS FOR MEDIUM-SIZED AND LARGE RIVERS IN NORTHRHINE-WESTPHALIA: BIOLOGICAL ASPECTS

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According to the "EU Water Framework Directive" the assessment of streams and rivers should be based on type specific reference conditions. Stream sections suited to serve as reference sites for the high ecological status of rivers can rarely be found due to long lasting anthropogenic impact on virtually all

rivers in Central Europe. Therefore, the development of biological reference conditions can only partially be based on detailed faunistic investigations in reference streams and rivers and must be completed by the evaluation of historical literature data on the fish fauna and the benthic macroinvertebrate fauna. Furthermore, theoretical considerations on near-natural habitat-conditions in rivers should be taken into account.

BACTERIA AND HETEROTROPHIC FLAGELLATES IN THE LONGITUDINAL PROFILE OF THE RIVER ELBE

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In 1999, detailed studies were carried out in the potamal of the river Elbe concerning the communities of bacteria and heterotrophic flagellates (HF). Ten stations along a longitudinal profile over 550 km were examined at different seasons. Because of the occurrence of aggregates in the water column we differentiated between aggregate-associated and not aggregate-associated bacteria and HF. For the fractionation of the sampling water into aggregates and surrounding water we used a sedimentation funnel.

We found that aggregates occurred with an abundance of several thousands per ml and a size of up to 1 mm in the water column. Bacteria and HF were about two to four times enriched within the aggregate fraction compared to the surrounding water. Their abundance decreased from the lower to the upper stretches of the river. The taxonomic composition of the HF's community differed also widely in the longitudinal profile. In June, we noticed a remarkable shift in their community between the stations Magdeburg and Aken, probably due to the influence of the River Saale which is polluted by waste products of potash mining.

SPATIAL DISTRIBUTION OF PLANKTONIC ROTIFERS IN THE POTAMAL OF THE RIVER ELBE (GERMANY).

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The longitudinal distribution of planktonic rotifers was investigated on 4 surveys from April to October, 1999. Samples were taken at 10 stations from Geesthacht (river km 583) to Dresden (river km 46). At each station three water samples were collected from the main stream at a depth of 0.5 m using a horizontal tube constructed by HYDROBIOS, Kiel. Each water volume was filtered through a 30 µm sieve and organisms were fixed in 200 ml of 5% formaldehyde. Additional abiotic and biotic parameters were determined and correlated with rotifer abundance and biomass.

During the whole investigation period, rotifer abundance was low at the upstream stations and increased sharply towards the lower stations. In June and August grasping species such as *Synchaeta oblonga* and *Trichocerca pusilla* dominated the rotifer community and attained densities over 2000 Ind. l⁻¹ at the most downstream station.

A COMPARISON OF METHODS FOR COLLECTING BACTERIA AND INVERTEBRATES IN THE SEDIMENTS OF A LARGE LOWLAND RIVER (ELBE, GERMANY)

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Invertebrate fauna, bacteria and sedimentary organic matter were sampled down to 1 m depth in the sediments of River Elbe at Magdeburg in 1996. Three techniques were used in parallel: freeze-core technique, air-lift sampler and powered grab sampling. The benthic community was dominated by *Hydropsyche contubernalis* (36.2%), chironomids (35.8%) and oligochaets (23.2%). The most speciose groups were crustaceans (28), oligochaeta (21) and chironomids (19). Invertebrates colonized the sediments to the greatest depth examined except at those stations where mean particle size was smaller than 0.1 mm. Bacterial densities varied between 1.3×10^9 cells per cm³ of sediment in coarse sands at the 0-30 cm sediment layer and a tenth of this number at the 60-100 cm layer.

The results for bacteria and organic matter showed no differences between the methods. The air-lift sampler collected most animals per sediment volume. Freeze-core sampling of invertebrates was hampered by the fact that no electro-positioning could be done due to high water depth. The percentages of oligochaeta were markedly lower in the grab and freeze-core samples than in the air-lift samples.

Our investigations revealed that even in a sand-bottomed large river hyporheic sediments are colonised by invertebrates and bacteria.

ZOOPLANKTON AS GRAZERS ON COMPONENTS OF THE MICROBIAL FOOD WEB IN DIFFERENT TROPHIC GRADIENT (NAKDONG RIVER, KOREA)

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Bacteria and phytoplankton grazing by two size of zooplankton (microzooplankton: MICZ, 35-157 μ m, rotifers and nauplii, but protists were excluded; macrozooplankton: MACZ, >157 μ m, cladocerans and

copepods) were evaluated on three monthly intervals at three sites in Nakdong River. Results of feeding experiments and the analysis of the food size spectrum on MICZ and MACZ suggest that bacteria were a common part of the food in MICZ community. Average MICZ biomass was much higher than that of MACZ biomass at all stations. Filter-feeding of MICZ seem to be significant feeders on small organisms rather than MACZ which efficient grazers on large organisms in the microbial food web. MICZ provide degraded algae and bacteria to the microbial food web and may promote microbial activity. High bacterial carbon-flux (C-flux) to zooplankton was estimated in the upper part of the river, while phytoplankton carbon-flux to zooplankton were much higher in lower and middle part of the river. Additionally, experimental works of this study should be present that for the better understanding of the function of the zooplankton at the regulated river ecosystem

VERTIKAL, LATERAL AND DIURNAL DRIFT PATTERNS OF FISH LARVAE

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Although there is little knowledge on diurnal aspects of drifting fish larvae, vertical and lateral gradients of larval drift patterns are almost unknown. A homogenous distribution of drifting larvae was often supposed. The truth of this hypothesis was tested in the middle Elbe River.

To investigate the vertical and lateral distribution of drifting fish larvae in the main channel of the Elbe a new fishing method using a 90 cm ring net having a mesh size of 1000 µm was applied. A pair of two ring nets was exposed into the current at distinct depth between an anchor and a buoy. The nets were brought out backwards with a rope tied to their cod ends. After half an hour each net was closed with a second rope which clasped the net in the middle and than the nets were hauled off. The water flow through the nets was quantified using digital flowmeters (Hydrobios, Modell 438110). The flowmeters were positioned in the middle of the mouth of the nets.

Using the described sampling design, the fisheries were carried out at two depth: 1m below the water surface and 1m above the bottom (referring to the middle of the mouth of the nets). In May 1998, a cross-section of the Elbe River near Schnackenburg (stream-km 475) was investigated at three sampling sites during day, followed by a 24-hours-fishery which was performed at that sampling site having the maximum density of drifting fish larvae. After each haul the catch was quantitatively fixed within 4% formaldehyde solution.

The flow conditions in the main channel were measured using an Ultrasonic-Profile-Currentmeter (1,5 Mhz Basic ADP).

The maximum lateral densities of drifting fish larvae as well as the maximum current velocities were found at the right side of the main channel. In general, the highest vertical values of the densities and the maximum current velocities of the sampling sites were found closed to the water surface. The highest concentrations of drifting fish larvae were found during night.

IMPORTANCE OF LARVAL DRIFT FOR PRESENCE OF 0+ GROUP RHEOPHILIC CYPRINIDS IN FLOODPLAINS OF THE RIVER RHINE IN THE NETHERLANDS

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In order to rehabilitate the population of rheophilic cyprinids in the River Rhine in The Netherlands, secondary channels were created in the floodplains. In these secondary channels, no coarse substratum is found so spawning of rheophilic species like barbel is not likely. In 1997 and 1998 however, large numbers of 0+ group barbel *Barbus barbus* of 2 cm and larger were observed. To investigate whether passive larval transport into these secondary channels could explain the presence of 0+ group rheophilic fish, larval drift was sampled in the opening and halfway a secondary channel. Samples were taken overnight, twice a week from April to June 1999. Catches were compared with samples from the secondary channel and several breakwaters in the main channel. In the driftnets around 10.000 larvae were caught of which 200 belonged to the rheophilic guild. Species composition in the breakwaters, in the opening of the secondary channel and halfway the secondary channel were nearly the same. Therefore, drift of larvae from the breakwaters into secondary channels seems to be a completely random process. For rheophilic cyprinids, finding suitable nursing areas in the floodplains depends on the possibility to drift passively into that area. Therefore, design of future nature areas should be aimed at maximising this possibility.

EFFECT OF WATERTEMPERATURE AND FOOD ON THE GROWTH OF 0+ GROUP PIKEPERCH *STIZOSTEDION LUCIOPERCA* IN SHALLOW FLOODPLAIN WATERBODIES ALONG THE RIVER RHINE

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In lowland rivers, shallow floodplain waterbodies are important nursing areas for fish since conditions for growth are favorable due to higher temperatures and food availability. The effect of these beneficial conditions for 0+ group fish was investigated on 0+ group pikeperch. Date of hatching and growth rate of 0+ group pikeperch were assessed in three floodplain waterbodies of the River Rhine (1997-1998) and compared with data obtained earlier from a 2000 ha. Dutch lake (1976-1984). In the floodplain waterbodies, 0+ group pikeperch were sampled at three weeks intervals, from May to September by using small seines and trawls. Date of hatching and growth rate were analysed by using linear models. 0+ group pikeperch from the floodplain waterbodies hatched in May, three weeks earlier than pikeperch from Tjeukemeer. Depending on the availability of preyfish in Tjeukemeer, cohorts of pikeperch diverged in a slow-growing, planktivorous group and a fast-growing piscivorous group. Growth rate of pikeperch from floodplain waterbodies, which feed on zooplankton and macrofauna, is lower than of piscivorous, but higher than of planktivorous pikeperch from Tjeukemeer. Still, due to the higher water temperature in the River Rhine, 0+ group pikeperch had a longer growing season and reached the same length as

piscivorous pikeperch from Tjeukemeer.

THE INTRODUCED FISHES IN LARGE RIVER SYSTEMS OF S. KOREA: CURRENT STATUS OF DISTRIBUTIONS AND ROLE IN FOOD WEB.

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National survey on fish fauna of the large river systems of S. Korea (28 sites, 5 major rivers, total area 75,000 km²) were conducted from July 1999 to January 2000. A total of 12,317 individuals of fishes were collected from two sampling programs. These were about 28% of 222 known freshwater ichthyofauna of S. Korea (16 families, 62 species). Dominant species were *Zacco platypus* (RA 16.2%), *Acheilognathus intermedia* (10.6%), and *Carassius auratus* (9.4%). Twelve exotic species were introduced since 1950s. Five introduced species were collected from this survey (*Carassius cuvieri* (24 sites), *Micropterus salmoides* (13 sites) *Lepomis macrochirus* (7 sites), *Oreochromis niloticus*, and *Cyprinus carpio nudus*). *M. salmoides* and *C. cuvieri* are most common (subdominant at 5 sites) and followed by *L. macrochirus*. Relatively small *M. salmoides* (< 100 mm, T.L.) depended upon invertebrate organisms but thereafter, fish and crustaceans became increasingly important the larger size of them. *L. macrochirus* feed on invertebrate organisms. Combined with scattered previous distributional data, the result obtained from this survey clearly indicated that introduced species play an important role in food web structure of river ecosystem in 1990s. Detailed studies on the population dynamics of introduced species and role in ecosystem are strongly needed.

THE EFFECT OF WATER QUALITY ON COARSE FISH MOVEMENT AND PRODUCTIVITY

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Manchester, UK

A reduction in waterside industry, storm sewage overflows and improved sewage treatment has produced a gradual improvement in the water quality of a major urban waterway and industrial canal; the lower River Irwell and upper Manchester Ship Canal (MSC), Manchester, UK. However despite decreasing BOD and ammonia levels, anoxic events still occur in the MSC regularly, during warm, low flow conditions. It has been established that fish have recently colonised the area from upstream, and despite organically polluted waters, oxygen levels allow a mixed coarse fish population, dominated by roach and perch, to exist. However anthropogenic impact upon fish distribution, migration, growth and possibly fecundity appears to significantly influence the recovery of the fish population.

The invertebrate community is detrital based and dominated by very high numbers of the crustacea *Asellus aquaticus* (1998/99 mean population density 1304 individuals per litre colonising substrate \pm 761). *Asellus* constitutes the basis of both adult perch and roach diets in this environment, and roach show very high growth rates. It is proposed that roach feed preferentially in the MSC but are excluded during anoxia, escaping upstream. The tracking of fish movements between the river and canal has been attempted with radio telemetry and monthly SONAR surveys. Summer dry weather flow conditions exacerbate water quality problems, when over 92 % of the flow consists of sewage effluent. Further, histological investigation of 61 roach show a female to male ratio of 3.5 : 1, and 12 : 1 for fish aged 4 years and older. 71 % of males showed egg development in their gonads. In this case the impact of high fish productivity may be moderated by oestrogenically derived intersex changes within the population since both are associated with high sewage derived organic loads.

