

EUROPEAN INLAND FISHERIES ADVISORY COMMISSION

Report of the

**SYMPOSIUM ON INLAND FISHERIES MANAGEMENT AND THE
AQUATIC ENVIRONMENT**

The effects of fisheries management on freshwater ecosystems

Windermere, United Kingdom, 12–15 June 2002

held in connection with the

EUROPEAN INLAND FISHERIES ADVISORY COMMISSION

Twenty-second Session

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PREPARATION OF THIS DOCUMENT

The present text is the final version of the report adopted on 15 June 2002 by the participants in the Symposium and presented to the Twenty-second Session of the European Inland Fisheries Advisory Commission.

A selection of papers presented at the Symposium will be published in a dedicated issue of the journal “*Fisheries Management and Ecology*”.

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SUMMARY

The Symposium on Inland Fisheries Management and the Aquatic Environment: The effects of fisheries management on freshwater ecosystems was held in Windermere, United Kingdom, from 12 to 15 June 2002, in concomitance with the Twenty-second Session of the European Inland Fisheries Advisory Commission (EIFAC). One hundred and fourteen participants from 27 countries attended the Symposium; 29 experience papers and 29 posters were presented. The Symposium considered biological, environmental, social and economic impacts of fisheries management of lakes and rivers. Fisheries management has produced clear benefits to the ecosystem and to stakeholders over and above benefits to the fishery itself. It highlighted that traditional fisheries management is not always implemented successfully in European inland fisheries. At the same time, the trend away from traditional management of fisheries resources towards integrated management of the ecosystem emphasizes the need to develop new participatory approaches.

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INTRODUCTION

1. A Symposium on Inland Fisheries Management and the Aquatic Environment: The effects of fisheries management on freshwater ecosystems, was organized in conjunction with the Twenty-second Session of the European Inland Fisheries Advisory Commission (EIFAC) in Windermere, United Kingdom, from 12 to 15 June 2002. Mr D. Gerdeaux (France) convened the Symposium, which was chaired by Mr I.G. Cowx (United Kingdom). The Symposium was attended by 114 participants from 27 countries.

2. The Symposium objectives were:

- to bring together inland fisheries experts to exchange knowledge among countries and to present, in reviews, an appraisal of fisheries management activities and their impact on the environment, constraints on their application, issues and options regarding their utilization, and the benefits and problems associated with these activities.
- to identify constraints and gaps in our knowledge that affect the application of fisheries management activities in inland fisheries.
- to recommend and promote action to improve the management of inland fisheries to the benefit of the aquatic environment.
- to provide guidelines for the policy formulation, planning methodology and evaluation of future fisheries management activities.

SESSION 1: IMPACT OF STOCKING AND INTRODUCTIONS ON THE ENVIRONMENT

Approach

3. Stocking and introduction of non-native species are widespread management techniques. Such manipulations of fish populations frequently aim at improving the quality and diversity of angling. There has been increasing demand in the United Kingdom for large non-native fish while stocking has been developed in Spain to support trout (*Salmo trutta*) populations in the face of increasing angling intensity. Creation of new angling opportunities, increased variety, different challenges and larger trophy fish are expected benefits of stocking and introductions in Newfoundland and Labrador.

4. Another objective of manipulation can be to influence food webs in order to restore water quality and ecosystem health.

5. Some introductions are also made illegally because they are not authorized because of policy constraints although angling demand is high and commercial benefits override the small penalties incurred. It is also likely that some established non-native populations could be attributed to discarded or escaped live-bait used by anglers during recreational angling.

Evaluation

6. Species-poor fish communities, such as those of European freshwater fish, favour the establishment of non-native populations and are vulnerable to invaders. The potential for non-native species to become established in European waters is confirmed by the importance of these species in fish communities of French reservoirs. Direct assessment of their impact is seldom possible but the local increase in species richness is likely to increase niche overlap, and therefore inter-specific interactive relationships. Interactions could result from competition with indigenous fish (food, cover or spawning sites) or direct predation on native populations.

7. Competitive impacts of roach (*Rutilus rutilus*) on vendace (*Coregonus albula*) and perch (*Perca fluviatilis*) on Arctic charr (*Salvelinus alpinus*) were assessed in lakes of the English Lake District on the basis of spatial distribution and diet analysis. It was concluded that roach did not constitute a competitive threat to native species but this conclusion may need to be revised following recent increases in abundance of the species. In the same area, predation by ruffe (*Gymnocephalus cernuus*) and dace (*Leuciscus leuciscus*) on vendace eggs or larvae are currently being analysed. Under some situations, the colonization of British waters by zander (*Stizostedion lucioperca*) can more or less annihilate the juvenile components of prey population. In Newfoundland waters, predation by brown and rainbow trout has impacted forage fish populations and also affected species diversity and invertebrate communities. Moreover, these exotic salmonids appear to have the competitive advantage over the native brook trout in some disturbed systems.

8. Genetic effects of introductions and stocking are also significant. Goldfish (*Carassius auratus*) introduced in rivers and lakes in southern England hybridize and compete directly with native crucian carp (*Carassius carassius*). In Spain, where rivers have been highly stocked with non-native trout (*Salmo trutta*), introgression of foreign genes was measured. Introgression and reduction of the number or range of native populations has also been described in natural populations of salmonids in Newfoundland.

9. Co-introduction of parasites is another risk associated with stocking or introduction of fish. This has proved especially severe in the case of *Anguillicola crassus*, a parasite of eel (*Anguilla anguilla*) that has become widespread in Europe.

10. Despite these negative aspects, successful introductions of whitefish (*Coregonus lavaretus*) and arctic charr (*Salvelinus alpinus*) have been made in large alpine lakes. No detrimental effect was registered while the introduced species now support sustainable fisheries.

11. Fish introductions should not be systematically assumed to be negative but risks are higher with exotic species than those made with transplants.

12. There is often insufficient information on impacts of introductions and stocking programmes particularly because there is no network for monitoring. Causal relationships are, therefore, difficult to distinguish from indirect correlation with environmental parameters. Managers have a double role in that they have to maintain, improve and develop fishing at the same time as having to protect the environment. Such a situation can lead to conflicts.

13. Nevertheless, the threat posed by fish introductions is particularly insidious because restoration management tools are not available. Therefore, the precautionary approach should be adopted with regard to the introduction of species, particularly in the case of non-native fishes.

14. In the English Lake District, preventative management of communities is based on new legislation banning the use of live and dead freshwater fish, salmonids and eel for bait. At a national scale, management solutions proposed by the Environment Agency can be presented in five points: education through articles in the angling press, Web site, etc., legislation, policies, enforcement and audit in order to check the success or failure of management operations.

15. Strong policy and guidelines have also to be developed in order to protect wild fisheries in Spain, and in Canada in Newfoundland and Labrador.

16. Increasing scientific understanding of fish and their habitat will be required to support legislation. More research is needed on behaviour and the mechanism involved in the spread of non-native species. There is also a need for more information on the ecological and dynamic impacts of stocking, the economic evaluation of inland fisheries and the impact of introduced parasites on fish stocks.

SESSION 2: FISH BIOMANIPULATION AS AN ENVIRONMENTAL MANAGEMENT TOOL

Approach

17. Several biomanipulation approaches are used in Europe:

(a) The traditional approach to biomanipulation by enhancement of predators and reduction of planktivorous and benthivorous fishes without participation of local stakeholders, and

(b) Advanced approaches:

- (i) Biomanipulation considering water quality and the socio-economic demand of anglers and commercial fishermen;
- (ii) Biomanipulation conducted mainly by means of the fishery.

18. The German Saldenbach water supply reservoir is an example of the classic approach. Lake trout (*Salmo trutta f. lacustris*) of less than 1 kg (15 – 20 ind./ha) was chosen as top predator in this reservoir as summer temperature rarely exceeds 20°C. However, because the proportion of fish in the diet during one summer was only 11 percent, the trout only consumed 2-3 percent of the roach and perch biomass.

19. Fish stocks are not always the cause of algal blooms. For example, during summer, the hyper-eutrophicated Salford Quays, a freshwater system in the north of England, used to be anoxic with frequent mass fish kills. The Quays were de-stratified using a mixing system and stocked with a variety of fish species. In this case, de-stratification was an effective tool against algal blooms. The introduction of fish has not been detrimental to water quality here.

20. A newer approach to biomanipulation includes the socio-economic interests of recreational and commercial fisheries. This involves stakeholder analysis. Based on a literature review of the key parameters, a step-by-step guideline for lake restoration by biomanipulation described, *inter alia*, as maximum thresholds for external P-load and internal P-concentrations, and the critical maximum fish biomass necessary for a significant reduction of phytoplankton. Successful biomanipulation can be better achieved by using the experience and the motivation of the recreational and commercial fishermen.

21. Specialized carp anglers can effectively reduce carp populations. A mail and internet survey found that experienced German carp anglers catch on average 332 kg per year. There was a positive correlation between catch and amount of bait used, effort and experience. The amount of bait used was high, about 215 kg of “boilies”, cereals and other substances per angler year for ground baiting. This corresponds to a gross P-input of 1.018 kg P per angler year. This gross input would become balanced at a harvest of 212 kg carp per year. This is an unrealistic figure where catch-and-release is practised, indicating that specialized carp angling may contribute to anthropogenic eutrophication, especially in smaller, nutrient poor water bodies at high angler densities. Specialized carp angling on the one hand may reduce carp biomass and improve water quality, while at the same time it may lower water quality through excessive ground-baiting.

22. In Denmark there are no substantial differences between lake fish management for biomanipulation and for the fishery. The fishery uses a whole set of fishing gears suitable for effective control of fish stocks, thereby assuring the integration of the fishermen in the biomanipulation process. This ensures that at least 80 percent of planktivorous fish biomass can be removed within one to two years. Furthermore, heavy stocking with pike fry (1 000 – 1 500 ind./ha) will help to reduce the numbers of 0+ cyprinids and, after 3 to 5 years, can significantly affect the reproductive potential of the cyprinids.

Evaluation

23. The classic approach using small brown trout at low stocking densities as a predator for deep and cool reservoirs does not seem to be effective for biomanipulation in central Europe. The influence of higher stocking densities and higher individual weight of trout on the proportion of fish consumed needs to be further investigated.

24. The example of Salford Quays showed that fish stocks are not always the cause of algal blooms. Whether or not there are mechanisms for effective phosphorous fixing in the sediment, such as high iron content, should be taken into account in planning a biomanipulation project. In such cases, aeration and de-stratification may be more suitable than fish stock manipulation.

25. The proposed step-by-step guideline for lake restoration by biomanipulation is a valuable attempt at reconciling fisheries and water quality management by integrating all stakeholders interests. It provides advice for the use of biomanipulation as a regular tool in water quality management. It has to be tested in practice, and the technological parameters have to be completed. The power of the approach lies in the integration of traditional fisheries management measures such as stocking of piscivorous fish with ecosystem-based management. The continuity of interventions is paramount for the long-term success of biomanipulation programmes.

26. The inclusion of experienced carp anglers in biomanipulation projects can be recommended in cases where dense carp stocks lead to a resurgence of eutrophication. Catch and release should be avoided in biomanipulation projects.

27. Data on the amount of baiting should be included in further projects. Bait seems to be a substantial P-source in some cases but more experienced anglers increase their catch without increasing the amount of ground-bait used. Further investigations on P-reduced baits are necessary. Furthermore, specific management guidelines for ground- and pre-baiting are needed because ground-baiting is generally common among coarse fish anglers.

28. The long-term inclusion of fishermen seems to be necessary for the success of biomanipulation projects that depend on continuous fishing pressure and should be adopted especially in countries with significant commercial fisheries such as Poland, eastern Germany and other east European States.

SESSION 3: REHABILITATION OF INLAND FISHERIES

Approach

29. In lakes, fish such as salmonids require satisfactory DO concentrations. Deep-water salmonid habitat can be expanded in lakes suffering from depleted summer oxygen levels by artificial mixing and raising hypolimnetic DO levels by oxygenation to at least 4-5 mg/l.

30. Utilizing cutaway bogs in areas where peat extraction has been terminated can create new fishing opportunities. The size and shape of the created lakes is dictated by the intended purpose of the fishery.
31. Experience in Ireland demonstrates the importance of having an overview of the entire catchment in establishing programmes for the restoration of salmonid riverine catchments. Baseline studies are needed for an understanding of the relative importance of imbalances in individual channels relative to the overall catchment.
32. Stocking programmes represent a major element of fisheries management in the United Kingdom. The relative merits and cost effectiveness of stocking rivers with different life stages and at different times of the year could be useful in determining if stocking contributes to stock enhancement.
33. No net loss of productive capacity of habitat can be achieved through a wide variety of actions that protect fish habitat yet still allow engineering works to take place in and around water. Focusing on redesign and relocation of projects and mitigation of harmful effects can result in a net gain of fish habitat.
34. Artificial ponds (borrow pits) with limited habitat in the Czech Republic could be improved by managed flooding during the spring and summer to act as nursery areas for flood plain species.
35. Rehabilitation and enhancement activities are often unsuccessful due to lack of understanding of the biotic and abiotic factors influencing the fish populations under study. Rehabilitation schemes often fail to address the wider catchment problems and issues affecting fish communities.

Evaluation

36. Rehabilitation of lakes by artificial oxygenation has shown varied results. Oxygen levels can be elevated resulting in recolonization by fish and invertebrates. This also reduces the chance of fish kills from upwelling of anoxic hypolimnetic water. Experience has shown however, that continuing input of nutrients to lakes continues the eutrophic condition and the chance of fish kills from toxic algae production persists. Furthermore, sediments continue to be anoxic and mortality of whitefish eggs will continue. Experience from three lakes in Switzerland has shown that as long as lakes stay eutrophic, oxygenation will be necessary to maintain 4 mg/l DO levels.
37. Research has shown that water quality in newly created lakes in cutaway bogs is excellent and that plant colonization in the newly created lakes was nearly 95 percent within three years. Plant colonization is essential for creating a basis for a productive food chain. The explosion of invertebrate populations is coincident with the establishment of the macrophyte community. Although self-sustaining populations have not yet been observed, it is estimated that a stocking rate of 200 kg/ha can maintain a healthy population and provide excellent catch and release fishery for tench and carp. These artificial fisheries can have a considerable amenity value.
38. Baseline studies of salmonid catchments in preparation for river restoration have identified problem areas, allowing the generation of habitat enhancement procedures that will restore a natural balance. Key problem areas include arterial drainage programmes for flood relief, removal of riparian vegetation to extend grazing opportunities and sheep overgrazing. A combination of use of natural materials, fencing out cattle and riparian plantings have been successful in mimicking natural conditions in all three categories of damaged channels. It is

recommended to leave one subcatchment aside as a control to monitor effectiveness of restoration.

39. When stocking rivers with fed salmon fry, a net gain can be realized when natural survival rates from egg to smolt are in the region of 1 percent or less. At high survival rates in the wild, the advantage of rearing and stocking fish is diminished. For coarse fish, chub, dace and roach, stocking either 1+ or 2+ is unlikely to make a significant difference to catches. In river restoration situations, however, with no existing population, stocking older fish of 2+ years is likely to be more cost effective and lead to faster establishment of self-sustaining population. Knowledge of survival rates is still lacking.

40. Reduction of impacts to fish habitat by development and resource extraction can be achieved by a number of activities but can not be made by government intervention alone. Agency partnerships as well as legislation enforcement and compliance are necessary but greater emphasis must be made on advice to clients, public education and outreach activities to engender stakeholder participation in conserving habitat.

41. Long term flooding of floodplain ponds (borrow pits) increased species richness and relative abundance of fishes showing that borrow pits represent valuable spawning and nursery habitat. However, nursery habitat appears to be limited due to untimely recession of the floodwaters, which could negate any positive effects. Improved control of duration of flooding could be a useful tool but requires further study.

42. Often fisheries do not improve as expected following rehabilitation works. Additionally, improvements achieved often do not warrant the expense of the scheme. Restoration works in many cases can not achieve the desired results because fisheries managers' expectations are too high. Furthermore, identification of bottlenecks to viable fish populations in the whole catchment is essential for the planning of individual restoration projects and should be undertaken before their initiation. Post project monitoring of rehabilitation works is essential if unsuccessful schemes are not to be duplicated.

SESSIONS 4 AND 5: IMPACT OF FISH COMMUNITY MANAGEMENT

Approach

43. The scientific community employs a range of methods including modelling, literature reviews and case studies. However, there is also a clear need for increased stakeholder involvement in practical management. Social sciences use quantitative methods in combination with interviews, SWOT-analysis (Strengths, Weaknesses, Opportunities and Threats) and Rapid Rural Appraisals to find out stakeholders' views on topics, including sturgeon management. Indicator fish species populations were similarly used to quantify the level of the disturbance under the Water Framework Directive (WFD).

44. A French project aimed at involving fisheries management in the application of the WFD divides the national hydrographic network into "contexts", defined as the minimum geographic area/unit able to sustain a complete life cycle of an indicator species population. One case study distinguished five contexts and showed that many aquatic ecosystems are disturbed. The quantitative approach, using indicators, gives the opportunity to propose priorities for action by managers in line with the WFD requirements. This method should be further developed for use in other EU countries.

45. Computer modelling using an eco-hydrological approach in combination with computer analysis of literature data, was used to describe various effects of physically degraded fish habitats in a whole catchment. The results indicate that restoration to a pristine

level is not necessary. Rather, the target should be a quality of environment that achieves a compromise between maximum biodiversity and maximum productivity of fish. Impacts on fish habitats are either technological and can be controlled technically, or environmental, such as deforestation, urbanization and canalization. This approach is similar to that adopted by the French on WFD and future cooperation is therefore recommended.

46. Problems are being encountered in Lake Peipsi-Pihkva arising from differences in the species targeted by the fisheries of Estonia and the Russian Federation. Traditional fisheries management may be used to reach the objective of raising the stock, and thereby the actual and potential catch, in a confined lake shared by two nations with shared fish stocks. The choice of technical/physical measures to increase the selectivity and lower the efficiency of the fishing gear, for instance, by larger mesh-sizes, and imposing quotas limiting the total annual catch have successfully raised the catch potential of the stock to cater for higher demand.

47. Similar problems were encountered with the current conservation strategy for sturgeon in the Lower Danube River, which may largely be responsible for the collapse of fisheries and the extinction of the species. The results call for classical remedies including a decrease of fishing effort, catch control, protection of spawning areas, etc. Monitoring and stock assessment measures are needed for better management policies, as is also the enforcement of any regulations.

48. Finnish experience with the conservation of native crayfish (noble crayfish) and the French experiences on the contribution of native and non-native species to fish communities both analysed the impact of non-native species on native species and biodiversity in inland waters. The Finnish example shows the strength of clear and well-defined management rules and practices. It also emphasizes the incentives for local stakeholders not to comply with the rules, as the introduced signal crayfish, that are now restricted, are resistant to crayfish plague and have better growth and reproducing potentials than the native noble crayfish.

49. Classification of species as native and non-native, and mapping the species richness in French reservoirs in a larger scale opens new possibilities of comparing development in fish communities. The underlying ethical objective states that native species *per se* are of higher value to society than introduced or stocked non-native species. The results of this study therefore add new dimensions to this statement in that it has shown statistically that the introduction of non-native species leads to lower species richness and a reduction in species-biodiversity.

50. In Finland institutional changes have induced changes in fisheries governance closely related to changes in society. The attitude towards the Saimaa ringed seal has changed from that of a competitor to the fishermen and now the seals are partly perceived as part of a diverse fauna in need of conservation. Private ownership of waters is an important factor when regulations are needed on a large scale.

51. Management of fish communities and its impact on the lower trophic levels in shallow ecosystems in Hungary aims at investigating how bio-manipulation in the lakes can lower the nutrient load of the lakes. Different levels of fish stock influence the lower trophic levels differently. Traditional means of reducing external nutrient loads may be aided by a reduction in the biomass of cyprinid fish in shallow waters dominated by these species and thereby decrease phytoplankton biomass. The results build on manipulated pond experiments, food web studies and studies in a smaller lake, as well as studies on the very large Lake Balaton.

52. A conservation project in Lithuania studied socio-economic developments subsequent to the integration of inland fisheries with other aspects of wetland management. The views of the public towards poachers and fish eating birds as a threat to fish stocks are influenced by a number of factors including insider/outsider status, their perceived needs, greed and their aesthetic value. The stakeholders in the Ramsar conservation area, the Regional Park of the Nemunas Delta, rely largely on fishing, agriculture and peat cutting. Their attitudes towards threats to fish indicate that there are human predators in the form of poachers, as well as non-human ones in the form of birds. Individuals are classified as insiders, who are looked upon positively, or outsiders who are considered negatively. This indicates that cultural and social aspects should be recognized and evaluated when conservation policies are established.

53. The review of USA/Europe literature describes the role of constituencies in resolving problems for fishery and biodiversity management, as well as their role in decision making when taking remedial action. The ecocentric approach of biodiversity, consisting of management aiming at restoring a “natural” native fish population, immediately raises problems of definition. Any scientifically based policy statement on biodiversity issues, therefore, needs a more pragmatic stance to be able to gain broad stakeholder support. Ecosystem-based management systems represent a paradigm shift and may best be described as adaptive management, which may be applied to both “altered” or “original” freshwater ecosystem fishery.

54. The democratic process necessary to protect, restore or fund programmes for biodiversity of fish faunas calls for regulations which are accepted and complied with to reduce risk or prevent damage. This goal is most often reached only if the incentive is either positive self interest or a feeling of collective moral and social obligations. Effective fisheries management therefore depends on public support and very often the perception of personal as against collective value trade-offs. For example, the issue of protecting against both intended and unintended introductions of exotic species is a biological, political and economic problem that raises conflicts of value between different stakeholder groups and needs political mitigation to succeed.

Evaluation

55. Traditional fisheries management is still not implemented successfully in many aspects of European inland fisheries. Further, there is a lack of incentive-based regulations in practical fisheries management, even though the scientific knowledge for implementation of more efficient management tools is available.

56. The change in perception of natural, as well as artificial waterbodies, is slowly changing traditional fisheries management into eco-system management. This calls for new management tools to cater for legitimate human demand for recreation, as well as alternative commercial use of waterbodies such as bathing, boating, tourism. At the same time there is an opposing trend towards the intensive management of artificial water bodies as put-and-take fisheries.

57. This session has presented initial work on bio-manipulation in shallow lakes, which may in the future lead to more applicable methods for large-scale implementation.

SESSION 6: ROLE OF FISH CONSERVATION IN ENVIRONMENTAL MANAGEMENT

Approach

58. Fresh waters have suffered the most intense intervention of all ecosystems over the past 100 years. Many fish species are now extinct, rare or endangered and many species are now protected by active management of the environment, as well as more traditional conservation methods of management, including regulation of exploitation, nature reserves, captive breeding programmes. A management plan for the conservation of *Anaecypris hispanica* in Portugal illustrates this approach.

59. The survival of rare sturgeons and conservation of their genetic diversity is of great economic and biological significance. Because the possibilities for management and protection of wild populations are limited, it is important to develop and implement measures for the conservation of a wide diversity of world sturgeon populations under artificial conditions.

60. Long-term ecological and physiological monitoring of sturgeon populations showed the positive role of artificial propagation, and suggests a simplified strategy aimed only at increasing the number of released juveniles. The imperfections of traditional biotechnologies considerably transform species, as well as the population structure of sturgeons.

61. Research in the Sea of Azov on seasonal regime dynamics, food sources in brackish lagoons and rearing ponds of sturgeon hatcheries, index of survival and rates of growth of various age-graded Russian sturgeon (*Acipenser gueldenstaedtii*) and stellate sturgeon (*A. stellatus*) juveniles produced by natural and artificial reproduction in different conditions resulted in a proposal for a new scheme to release juveniles to natural water bodies.

62. In the United Kingdom the bittern (*Botaurus stellaris*), a red data listed species with currently only around 30 booming males, is restricted to a few wet reedbeds. The favourite prey species of the bittern are eel (*Anguilla anguilla*) and rudd (*Scardinius erythrophthalmus*). The importance of fish in the bitterns' diet make it imperative that the ecology of fish in wetlands is understood in order to enable habitat and fish population management to benefit the conservation of bitterns in wetlands.

63. Fish stock assessment surveys at Minsmere reedbed reserve (Suffolk, United Kingdom) revealed the dynamic nature of cyprinid fish distribution in wetlands. After reedbed rehabilitation roach (*Rutilus rutilus*) sometimes became the dominant species although the species has not yet been described as a food item of the bittern. Replacement of rudd by roach may reduce food availability to bitterns.

Evaluation

64. Implementation of the management plan for the conservation of *Anaecypris hispanica* in Portugal might have benefits both to fisheries and to ecosystems that include:

- raising the profile of conservation issues through education and public awareness campaigns;
- protection and improvement benefits to other endangered fish species;
- improved ecosystem health;
- reduced pressure on the ecosystem, and
- improved social and economic benefits.

65. One of the most urgently needed measures for conservation of sturgeon biodiversity is the establishment and maintenance of collections of live sturgeon as gene banks.

Conservation of complicated population systems requires an assessment of total genetic variability, including intraspecies variability. The adequate conservation of genetic resources according to the population structure of different species must be ensured.

66. Different release locations of sturgeon juveniles of various sizes and ages in various conditions would help maintain populations and minimize the selective consequences of artificial propagation. Migration of juvenile sturgeon to the sea in natural conditions at different ages has a deep adaptive significance and confirms the biological importance of intrapopulation differentiation. The conservation of a variety of Russian sturgeon, stellate sturgeon and giant sturgeon (*Huso huso*), released at different dates, permits a gradual and more rational use of food resources of brackish lagoons and marine coastal areas, compared with traditional large-scale and simultaneous standard release of juveniles into rivers.

67. Research work carried out in Minsmere reedbed reserve (United Kingdom) have identified the potential application of fish population management as a key component to the suite of tools available to enhance the conservation status of bitterns and probably that of other fish-eating birds.

CONCLUSIONS AND RECOMMENDATIONS

68. The Symposium considered biological, environmental, social and economic impacts of fisheries management of lakes and rivers. Fisheries management has produced clear benefits to the ecosystem and to stakeholders over and above benefits to the fishery itself. However, such activities as stocking and introduction can produce negative impacts, but this is not always the case.

69. The Symposium highlighted that traditional fisheries management is not always implemented successfully in European inland fisheries. At the same time, the trend away from traditional management of fisheries resources towards integrated management of the ecosystem emphasizes the need to develop new participatory approaches.

70. Many of the issues and approaches highlighted have fundamental implications to the EU Water Framework Directive because of the need to improve the status of fresh waters in the future. The implications of global environmental change should be recognized and given due consideration in future management approaches.

- The unwillingness of elements of the public to respect fisheries regulations was noted. It was therefore recommended that improved communication and education programmes on protection and conservation be developed for inland waters.
- There is a general need for guidelines that are readily understandable to stakeholders as well as to fisheries administrators. It was recommended that new guidelines be developed for biomanipulation and that existing guidelines for stocking and introductions be updated and incorporated into national and local level policy. In certain species, such as the sturgeons, it was recommended that improved protocols for stocking be developed and implemented.
- It was recommended that all stakeholders be included in the consultative and decision-making processes for management and conservation of inland fisheries resources. Ideally this should develop into a full participatory management process.
- When contemplating restoration works or enhancement activities it was recommended that the catchment basin be fully evaluated to see what other factors may affect the project and what problems may still persist.

- It was recommended that opportunities for artificial fisheries as well as restoration and enhancement of existing fisheries be identified. Often these fisheries can furnish more cost effective alternatives to traditional fisheries.
- It was recommended that goals for restoration projects should be fully evaluated and realistic targets set that project managers and the public find acceptable. It is further recommended that post project monitoring of rehabilitation projects is a component of the evaluation procedures and the effectiveness thereof, and the results should receive wide dissemination.
- It was recommended that a risk assessment based approach be adopted for all fisheries management activities. The strength of legislation and regulation should relate to the potential risk of the management interventions.
- It was recommended that mechanisms be established for the common management of international water bodies where these do not already exist; where international mechanisms already exist, these need to be reinforced in order to concentrate better on fisheries and environmental issues.
- It was recommended that mechanisms be developed for the *in vivo* conservation of endangered fish species; sturgeons are priority.

Appendix A

List of Participants

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Appendix B

Abstracts of Contributions Submitted to the Symposium

(E- EXPERIENCE PAPERS; P – POSTERS)

*Selected papers will be published in a dedicated issue of
“Fisheries Management and Ecology”*

EIFAC/XXII/2002/Symp. E 01

Fish introductions and their consequences in the English Lake District

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Although the English Lake District comprises 14 major lakes of varying trophic status and many smaller standing water bodies, its location in the north-west of the country means that for largely biogeographical reasons its fish communities are relatively poor in species number. Nevertheless, recreational angling makes a significant contribution to the local tourism industry and the area is also important for fish biodiversity and conservation because it contains both of the UK's only surviving vendace (*Coregonus albula*) populations, four of only seven U.K. whitefish (*Coregonus lavaretus*) populations, and all of the English populations of Arctic charr (*Salvelinus alpinus*). In recent years, a number of fish species including roach (*Rutilus rutilus*) and ruffe (*Gymnocephalus cernuus*) have been introduced without consent into some of these lakes. This paper documents these introductions, explores their consequences where available data permit, and considers the management of this complex issue.

Keywords: Species introductions; Live-baiting; English Lake District

EIFAC/XXII/2002/Symp. E 02

Current status of brown trout *Salmo trutta* in Spain: Effects of fishery management on conservation of wild stocks

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Brown trout is an important resource in Spain that supports valuable sport fisheries. A gradual increase in licence sales during the last decades has increased the public demand for more fish. Consequently, populations are currently overexploited and their genetic uniqueness is threatened by introgression of foreign genes due to artificial stocking. The cumulative effect of habitat destruction, water pollution and introduction of exotic species is also responsible for the decline of trout stocks. There is an urgent need for a survey of the current status of wild brown trout in Spanish rivers. We review the available investigations aimed at evaluating the effects of fishery management on trout populations in Spain. Angling effects differ from area to area and seem to depend on the environmental and biological conditions of the populations. Genetic interactions between wild and stocked brown trout also vary between river basins. The ecological and genetic consequences of cessation of stocking in some rivers and the effects of modern harvest regulations are assessed. Mathematical models are applied for evaluating the effect of different fishery regulations on wild stocks. Finally, management guidelines are proposed for the maintenance and conservation of brown trout.

Keywords: Brown trout management; Stocking impact; Introgression; Spain

EIFAC/XXII/2002/Symp. E 03

**Restoration of sustainability of physically degraded fish habitats –
Ecohydrological approach**

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Freshwater ecosystems are situated in depressions in the landscape. As a consequence, the quality of fish habitats to a great extent depends on human population density and a whole range of human activities.

Anthropogenic impacts on fish habitats can be defined in two dimensions: technological and environmental - emission of pollutants which can be controlled by technologies, and environmental (primarily physical) modifications of hydrological and biogeochemical cycles due to deforestation, urbanization, channelization.

Concerning the physical modification of freshwater fish habitats, restoration can be achieved using as a framework the Ecohydrology Concept. That concept distinguishes between direct and indirect restoration, and mitigation actions. Restoration is connected with integrated catchment management, including landscape planning, afforestation, phytotechnologies and finally restitution of water flow and pattern of nutrients dynamics. Mitigation is more traditionally linked to fisheries management, including restoring habitat diversity and connectivity e.g. by renaturalization of the river bed and floodplains.

All these measures have to be integrated toward the control and regulation of the dynamic pool of nutrients against eutrophication, considering biota and especially fish communities as important tool (biomanipulation).

What should be a target for restoring physically modified fish habitats in a broad sense, considered as biogeochemical cycles modification?

The general conclusion from papers presented at the EIFAC Workshop "Ecohydrology as a tool for restoration of physically degraded habitats" is that the target should be highest biodiversity and productivity of fish communities achieved at an intermediate level of human disturbances of the biogeochemical cycle. This can be interpreted as a result of nutrient enrichment and improved energy access to the river, due to partial opening of the land nutrients cycling and intermediate complexity of riparian ecotones.

There are two conclusions:

- restoration of a river systems to pristine conditions is not only unrealistic but also not necessary;
- the target for restoration should be within the range between maximum biodiversity and maximum productivity of fish communities.

Further investigations are needed to develop standards for fish habitat restoration in different geographic regions and types of catchment areas.

Keywords: Fish habitats; Physical modifications; Ecohydrology; Restoration

EIFAC/XXII/2002/Symp. E 04

The effects of stocking and introductions in Newfoundland and Labrador inland fisheries

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Stocking and introduction of fishes began in Newfoundland and Labrador in the early 1880's. Introduced non-native fishes and stocking have established populations in many areas. The ecological effects of stocking and introductions have included competition, predation on native salmonids and other fishes and the introduction of parasites and disease. Interbreeding with native species causes direct genetic effects. Indirect genetic effects may have resulted from selective forces, genetic drift and inbreeding. Aquaculture and the creation of transgenic fish also pose a new threat to native fish. The effects of introductions stocking as a mitigation or enhancement tool are also discussed. Although Newfoundland and Labrador is still relatively pristine safe guards must be introduced to eliminate the potential detrimental effects of these management practices.

Keywords: Newfoundland; Introduction; Stocking

EIFAC/XXII/2002/Symp. E 05

Fisheries for non-native species: Angling or the environment?

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The increase in popularity of “big game” type angling in the UK has led to a proliferation of waters stocked with non-native species. Many introductions have been illegal and the potentially irreversible ecological consequences are yet to be realized. Some case histories are presented and show the potential impacts of these species to involve the effects of predation, competition, disease, hybridization and habitat degradation. Responding to anglers demands whilst controlling any illegal spread of non-native fish in the wild is a major challenge. The legislation that governs the movement of fish into and within England and Wales is shared between the Environment Agency and other Government organizations, a situation which engenders significant management difficulties and enables less scrupulous movers of fish to exploit any weaknesses in the enforcement system. The problem is being addressed in a number of ways. A fully co-ordinated approach to the regulation of fish movements is being facilitated by a new shared database and the Environment Agency has reviewed the policies through which it regulates movements of fish into the wild. The guiding principle is that fish introductions should not jeopardize the well being of naturally established ecosystems i.e. there should be no detriment to the donor or receiving fisheries or to the fish being introduced. This approach was endorsed by a recent Government review of fisheries legislation, which recommended strengthening controls over inappropriate movements of fish.

Keywords: Angling; Introductions; Non-native fish; Legislation

EIFAC/XXII/2002/Symp. E 07

Management of lake fish populations and lake fisheries in Denmark - History and current status

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Lake fisheries in Denmark is controlled by legislation in order to protect fish populations of commercial and recreational interest and prevent overfishing. Management measures include stock enhancement by stocking e.g. with eel, trout and pike and, previously, by introduction of new species. Lately the management of the aquatic environment has been in focus, since most wanted lake fish are suffering from eutrophication in lakes. Biomanipulation has been carried out as a lake restoration measure during the last decade by either stocking with pikes or removal of planktivorous fish.

The development in lake fisheries can be followed through 100 years of catch records. It shows a decrease in eel catches especially during the 1970's and an increase in catches of bream, which is in line with the increased eutrophication of Danish lakes over the last decades.

Keywords: Lake fisheries; Biomanipulation; Lake fish management

EIFAC/XXII/2002/Symp. E 08

Angling as an efficient method for common carp (*Cyprinus carpio* L.) management and its possible contribution to anthropogenic eutrophication in Germany

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Many freshwater ecosystems suffer from dense common carp (*Cyprinus carpio* L.) stocks. From the ecological point of view, high carp densities are not desirable because of several negative impacts (e.g., bioturbation, competition). A mail and internet survey among carp anglers (n=705) suggests that in Germany carp anglers' catch exceeds commercial carp harvest by up to 1717 percent (averages from angler survey data: catch 332.7 kg angler⁻¹ a⁻¹, effort 1447.6 h angler⁻¹ a⁻¹, CPUE/EIFAC/XXII/2002/SYMP. E 0.23 kg h⁻¹). This indicates that carp angling may reduce carp stocks efficiently. Moreover, the high economic impact of carp

angling (mean expenditures: 5490 € angler⁻¹ a⁻¹) offers a great potential for marketing (tourism, commercial fishermen). Thus, specialized carp angling provides a means for inland (carp) fisheries management worldwide. However, input-output balances for total phosphorous revealed that under certain conditions carp angling may contribute significantly to anthropogenic eutrophication if ground baiting is used in excess.

Keywords: Cyprinus carpio; Recreational fisheries management; Ground baiting; Eutrophication

EIFAC/XXII/2002/Symp. E 09

**Food-web manipulation of drinking water reservoirs with salmonids:
Vertical distribution of prey and predator**

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In a novel biomanipulation experiment salmonids are used as a tool to improve water quality. The manipulation was initiated in spring 2000 as a response to non-point sources of phosphorus in a drinking water reservoir in Saxony, Germany. Salmonids (brown trout, *Salmo trutta f. lacustris*) were chosen as predators, as the reservoir has a large hypolimnetic water body and surface temperatures rarely exceed 20°C. While the dominant planktivore (roach, *Rutilus rutilus*) was caught exclusively in the epilimnetic layer during the stratification period, trout seemed to be confined to deeper water layers. However, diet analyses revealed that the trout performed vertical migrations to feed in the epilimnetic layer. In order to estimate the range of effective food intake a bioenergetic model was used and consumption was calculated at three temperature levels.

Keywords: Food-web manipulation; Spatio-temporal distribution patterns; *Salmo trutta*; *Rutilus rutilus*

EIFAC/XXII/2002/Symp. E 10

**Salford Quays revisited – The impacts of fish introductions on
water quality 1987 to 2001, a fifteen year data-set**

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Salford Quays, was isolated from the grossly polluted Ship Canal in May 1987 and an artificial mixing system (Helixors) introduced several months later to prevent thermal stratification and associated anoxia. The 8 hectares of enclosed water were effectively devoid of fish life prior to implementation of this combined management strategy. However, by 1989 water quality had improved dramatically allowing introduction of a variety of species including roach, perch, rudd, bream, carp, dace, tench and chub. The stocking was extremely effective with good survival, high growth rates and eventually successful spawning and recruitment of several species following introduction of artificial spawning media and macrophytes on appropriate structures. Hence, a range of species and age classes with a variety of feeding strategies, notably zooplanktivores, were present.

Following isolation in 1987, algal blooms, dominated by the cyanobacteria *Oscillatoria agardhii* became a common feature in the Quays. Over the next few years chlorophyll *a* concentrations increased relentlessly peaking at over 300 µg/ml. Several algal control techniques were investigated including intermittent destratification, barley straw and bio filtration using the freshwater mussel *Dreissena polymorpha*, but none were successful in effectively reducing the blooms. However, during the late 1990's algal biomass began to gradually reduce. Chlorophyll *a* concentrations are dramatically lower, mean values of less than 40 µg/ml being recorded throughout the seasons for the past four years.

Using a 15-year data set, the paper examines the relationship between algal biomass, nutrient concentrations, bottom water oxygen concentrations and fish abundance at Salford Quays. It concludes that the main influence on the development of troublesome algal blooms was water column phosphorus, possibly augmented by sediment releases during low oxygen bottom water phased immediately following isolation in the late 1980's. Subsequently maintenance of oxygen rich conditions has resulted in an overall reduction in available phosphorous leading to the long-term reduction (10 years) in algal concentrations observed. The work challenges the assumptions from studies elsewhere, notably the Norfolk Broads, that fish introductions promote algal blooms and hence compromise previously macrophyte-dominated systems. Conversely, the rationale behind fish removal as a still water restoration strategy is called into question.

Keywords: Biomanipulation; Still water restoration; Algal blooms; Phosphorous availability

*EIFAC/XXII/2002/Symp. E 11***How to link biomanipulation and sustainable fisheries management –
A step-by-step guideline for lakes in the European temperate zone**

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Due to the existence of strong top-down effects in limnic systems, food web manipulation experiments in terms of using the systems response to reduction of zooplanktivorous fish have been run to mitigate symptoms of eutrophication. The influence of nutrient load, lake morphometry and biomanipulation measures on efficacy and success relating to temporal and spatial extension is discussed. However, the ongoing focus on sustainable use of aquatic resources offers the chance to perform lake restorations by a combined strategy of nutrient load reduction and fisheries management.

Based on results of stock assessment investigations, water quality measurements and evaluations of commercial and recreational fishery demands carried out in the course of long-term whole-lake biomanipulation experiments in Germany, we highlight how biomanipulation can be used to support lake restoration programmes where fisheries' stakeholders have to be considered.

Keywords: Inland fisheries; Anthropogenic factors; Biomanipulation; Lake restoration

*EIFAC/XXII/2002/Symp. E 12***Fish habitat requirements as the basis for objectives
in the rehabilitation of eutrophic lakes by artificial oxygenation**

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Eutrophic lakes normally suffer from hypolimnial oxygen depletion during summer and autumn, leading to accumulation of reduced substances in the deep parts of the lake. The space that fish can occupy is therefore reduced, and the potential of fish kills caused by the upwelling of de-oxygenated water increases. Fish, such as salmonids, require at least 4 mg of oxygen per litre in order to survive in the long term. The standard of 4 mg O₂/l at any time and anywhere in the lake has been postulated as one of the major goals for the rehabilitation of several eutrophic Swiss lakes. It was hoped that this oxygen criterion would enable the survival of coregonid eggs on the lake sediment. Rehabilitation measures were applied using hypolimnial oxygenation during summertime, i.e. during stratification, and forced circulation using compressed air during wintertime. These lake-internal measures carried out for more than ten years have shown that the 4-mg O₂/l-criterion can be met. The measures have led to an expansion of the usable fish habitat into greater depths. However, other goals were not attained, such as the restoration of natural reproduction of coregonids in these lakes. It was found that excessive oxygen consumption at the sediment-water interface, arising from the decomposition of settled organic matter produced during the vegetation period, is causing the death by suffocation of coregonid eggs resting on the sediment. This shows that rehabilitation of eutrophic lakes by merely oxygenating the hypolimnion cannot be successful, unless it is accompanied by lowering the nutrient loading of the lake and thus lowering primary production and oxygen consumption on the sediment surface.

Keywords: Eutrophication; Lake rehabilitation; Artificial oxygenation; Fish reproduction

*EIFAC/XXII/2002/Symp. E 13***Coarse fishery creation in Irish cutaway bogs**

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Angling is a popular recreational pastime, and a valuable contributor to the national and local economies. Two lakes, each approx. 3.5 ha, were created in 1996 at Finnamoses, Cloghan, Co. Offaly. Residual peat was removed, exposing a calcium-rich marl substrate. Lake depth and shoreline profiles were specified to

meet the known requirements of both fish and angler. The lakes were filled from an adjacent alkaline stream. An extensive planting programme expedited aquatic plant colonization. By summer 2000 *circa* 95 percent aquatic plant cover of lake substrate was achieved. The lakes were stocked with carp, tench and bream, and were frequented by local and visiting coarse anglers. It was not uncommon to have 20 anglers fishing the water at any one time. Individual angler catches of up to 45 kg have been recorded and, generally, anglers are satisfied with the status of fish stocks in these new fisheries. The ecology and angling status of the lakes will continue to be monitored.

Keywords: Angling; Transplantation; Stocking; Fish growth

EIFAC/XXII/2002/Symp. E 14

The habitat enhancement programmes required by the Salmonid fisheries in the Republic of Ireland

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Surveys of many of Ireland's salmonid riverine fisheries since the 1980's indicated that various land management practices, over several centuries, had impacted negatively on the productivity of these rivers in fishery terms. This paper describes the fisheries management practices, which have been adopted in Ireland over the last two decades to help restore the natural salmonid productivity of these habitats. Procedure in relation to designing these programmes is outlined. An inventory of work practices used is provided. The relative success of programmes is documented.

Keywords: Fisheries management practices; Salmonids; Habitat enhancement

EIFAC/XXII/2002/Symp. E 15

Does stocking contribute to enhancing stocks?

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The stocking of fish represents a major element of current fisheries management practice. In order to maximize benefit to the environment in general and to fisheries in particular optimal stocking strategies need to be developed. Examples from two studies, one involving Atlantic salmon (*Salmo salar*) and the other involving three coarse fish species, are used to illustrate how such strategies might be developed.

Atlantic salmon fed fry were stocked into eight streams in North West of England at densities ranging from 1 to 4 m⁻² over a period of up to three years to evaluate survival to the end of the first and second growing periods. Survival to the end of the first growing period (mean duration 108 days) was found to vary between 7.8 and 41.3 percent with a mean of 22 percent and CV of 0.44. Survival from the end of the first growing period to the end of the second growing period (mean duration 384 days) ranged from 19.9 to 34.1 percent with a mean of 26.3 percent and a CV of 0.21. Survival was found to be positively related to resident 0+ trout density ($P < 0.05$) and negatively related to altitude ($P < 0.05$). A comparison with published survival data from other studies in relation to stocking densities showed a negative relationship between fry survival and stocking density ($P < 0.05$).

Hatchery reared roach (*Rutilus rutilus*), chub (*Leuciscus cephalus*) and dace (*Leuciscus leuciscus*) were stocked into four rivers in order to determine the optimal age and season which would maximize survival over a 6-month post-stocking period. Post-stocking persistence within the stocked reaches was generally low; the highest level of persistence was estimated at only 33.8 percent. However, most of the estimates of persistence were considerably lower and (in practical terms) approached zero in several instances. The analysis indicated that river-specific factors are important in controlling the success of stocking exercises.

The survival estimates derived from these two studies are compared with other published estimates of survival. The development of stocking strategies, which specifically aim to optimize benefits to the environment, is discussed.

Keywords: Stocking; *Salmo salar*; *Rutilus rutilus*; *Leuciscus cephalus*; *Leuciscus leuciscus*

EIFAC/XXII/2002/Symp. E 16

**Fish habitat is everyone's business.
Canada's Fish Habitat Management Program**

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The mandate of Canada's Fish Habitat Management Program is to protect and conserve fish habitat in support of Canada's coastal and inland fisheries resources and to conduct environmental assessments prior to the Department of Fisheries and Oceans making regulatory decisions under the Fisheries Act.

The program objective of a net gain of habitat is achieved by a wide variety of actions that protect fish habitat yet still allow works and undertakings to take place in and around water. Some of the core activities of the program include detailed review of works and proposals for adherence to the requirements of the *Fisheries Act*, approvals and permits, community outreach activities, the generation of mitigation guidelines and fact sheets for the protection of fish habitat as well as enforcement activities for compliance with legislation and policies.

This paper presents an overview of the Canadian Fish Habitat Management Program and details many of the habitat managers' tools used in protecting the resource.

Keywords: Fish habitat management; Conservation and protection; Canada

EIFAC/XXII/2002/Symp. E 18

**Managed flooding as a tool for supporting natural fish reproduction
in man-made lentic waterbodies**

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Fish were studied in two different types of borrow pits in the flood plain of the river Dyje (Danube basin) in 2001. All six man-made borrow pits investigated had uniform habitats without shelters and with limited spawning and nursery areas. Spawning and nursery conditions in three of the borrow pits were improved by managed flooding during spring and summer. The other three borrow pits were marginally flooded for a short period or not flooded. Adult (≥ 1 year) fish were surveyed by beach seining. Since May, 0+ fish distribution was monitored monthly by electrofishing and with fry beach seine nets. We found that the species diversity of adult fish did not differ significantly between flooded and non-flooded borrow pits, whilst the species composition and fish density did. In 0+ fish assemblages we found considerable differences in species diversity, species composition and density. Seasonal decline in 0+ fish density varied between borrow pit types.

Keywords: Juvenile fish; Flood plain; Borrow pits; Habitat improvement

EIFAC/XXII/2002/Symp. E 19

The importance of planning in the rehabilitation of freshwater fisheries

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The maintenance and development of freshwater fisheries is based on an understanding of the many biotic and abiotic factors influencing the fish population dynamics. This information has been used to derive models on the most suitable habitats for different fish species and predict carrying capacities of the water bodies concerned. They are also used to determine the impact of various anthropogenic activities on the fish stocks and the possible outcome of enhancement and rehabilitation activities. Unfortunately, the models tend to be based on instream characteristics such as flow, depth, substrate and cover. It is well known that features associated with land-water ecotones, such as bankside biota, adjacent land use and modification of channel morphology, all affect fish population dynamics. This paper examines the role of riparian characteristics in maintenance of fish populations and the characteristics, which should be considered in parallel with instream enhancement methods to manage the fish stocks from a more holistic perspective. Recommendations for development of management tools are discussed.

Keywords: Rehabilitation; Fishery management; Ecosystem health; Integrated management

*EIFAC/XXII/2002/Symp. E 20***Effects of fisheries management on fish communities of Lake Peipsi-Pihkva**Toomas Saat¹, Väino Vaino¹, Evgeni Afanasjev², Nina Koncevaya²¹Estonian Marine Institute, University of Tartu, 18b Viljandi Road, EE-11216 Tallinn, Estonia²Pskov Branch of GosNIORH, Pskov, Russian Federation

Lake Peipsi-Pihkva, one of the largest lakes in Europe, is a shallow eutrophic waterbody shared by Estonia and the Russian Federation, characterized by high fish productivity. The fish resources are heavily exploited. In recent decades, stocks of some commercial species have substantially declined (vendace, smelt, perch), while stocks of some other species have increased (pikeperch, bream). There have been remarkable changes in population structure of commercial species, related both to the changes in the environment and to fishing. Effects of different fisheries management strategies and measures on fish communities are analysed. The most remarkable changes are related to (1) the ban to use small mesh-size active gear in the 1970s and (2) the expansion of gill net fishery in the early 1990s.

Keywords: Fisheries management; Lake Peipsi-Pihkva; Fish communities

*EIFAC/XXII/2002/Symp. E 22***The benefit for the environment of the different crayfish management strategies in Finland**Jorma Kirjavainen¹ and Matti Sipponen²¹Employment and Economic Development Centre for Häme, Raatihuoneenkatu 11, FIN-13100 Hämeenlinna, Finland²Employment and Economic Development Centre for Central Finland, P.O. Box 44, FIN-40101 Jyväskylä, Finland

In Finland, the nation-wide strategy for crayfish management in inland waters was renewed in 2000. Its main objective is to maintain and increase the stocks of indigenous noble crayfish (*Astacus astacus*). As in southern Finland many watercourses are being chronically infected by crayfish plague, the strategy there attempts to restore the productivity of crayfish stocks by introducing plague resistant signal crayfish (*Pacifastacus leniusculus*).

Crayfish is the largest mobile macroinvertebrate in Finnish freshwater ecosystems playing an important role in the food web. In addition to the great ecological value it has also an economic value for recreational and commercial fisheries. So far, neither introduction of signal crayfish nor restocking of noble crayfish has shown any negative impact on the ecosystem.

Häme and Central Finland are two neighbouring counties adhering to different strategies. In Häme the results of noble crayfish stockings have been poor compared to the introduction of signal crayfish. Crayfish catches have increased rapidly, resulting in some new jobs for commercial crayfishermen. In Central Finland, signal crayfish stockings are forbidden and stocking with noble crayfish has been intensive. One goal is to maintain a gene pool resource of this species.

Keywords: Crayfish management; Signal crayfish; Noble crayfish; Management policy

*EIFAC/XXII/2002/Symp. E 24***Contribution of native and non-native species to fish communities in French reservoirs**

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Previous large-scale studies have shown that only 20 percent of the variability in fish community structure in French lakes could be explained by the sites characteristics. Furthermore, no relationship could be found between species relative abundance and stocking effort. Therefore, introductions are likely to be responsible for a great part of the observed communities. The objective of this study is to assess the importance of species introductions in French natural and man-made lakes. 30 reservoirs and 20 natural lakes were sampled to obtain species presence/absence data. The relationship between exotic and native richness was studied. Geomorphological variables are used to comparatively explain the patterns of richness for native and non-native species. Species reproductive and trophic traits are used to investigate potential niche overlap between native and

introduced species. The results are discussed taking into account our knowledge of the fisheries management practices.

Keywords: Lake; Reservoir; Fish communities; Species introductions

EIFAC/XXII/2002/Symp. E 25

**Management of fish communities and its impact on the lower trophic levels
in shallow ecosystems in Hungary**

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Increased nutrient loading has resulted in changes in trophic structure and significant alterations have occurred at the top of the food web in Hungarian natural waters. Long-term (1993-2000) fish manipulation experiments of different scales have proven the expectations that phytoplankton biomass increases linearly with the biomass of cyprinid fish and that this process is reversible. To influence eutrophication processes, reduction of external nutrient load and controlling trophic relationships were the most effective tools in small ponds and in a large shallow lake (Lake Balaton) as well. In shallow waters dominated by cyprinid fish, bottom-up forces are more important than top-down effects due to the impact of internal nutrient load. Maintenance of water quality seems to be possible by high predation pressure of fish on a wide range of different species and age classes of cyprinids and by stocking of multispecies communities of piscivores (min. 25 percent).

Keywords: Eutrophication control; Cyprinid fish manipulation

EIFAC/XXII/2002/Symp. E 28

Institutional changes and relationship between fisheries and conservation of the Saimaa ringed seal

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Institutional changes in Finnish fisheries governance have been connected to the changes in the society and in the evolution of stakeholder groups. Private water ownership has been an important institution, which has determined the access to the fishing waters and the management rights of the landowners in rural areas. During the last decades, new more urbanized groups of water owners and users have been shaped. Similarly governance of fishing waters has faced many needs which further mostly public interests in addition to the interests of local owners. These new interests and values are commonly emphasized by recreation and nature conservation. However the rationality of maximising the fish yield is still strongly stressed in several levels of the management regime. At the same time new organizations have been formed for the central and regional levels of governance.

In Finland the role of environmental policy has increased since the establishing of the Ministry of Environment in 1983. Usually the environmental and fisheries governance have acted separately, but the conservation of the Saimaa ringed seal is an example where the orientations of these two institutions moved closer. In this paper we study institutional changes in the case of the Saimaa ringed seal conservation, which has restricted fishing operations in large lake areas. We examine e.g. the environmental entitlements and knowledge used by the stakeholder institutions.

Keywords: Fisheries governance; Conservation; Lake Pihlajavesi; Saimaa ringed seal

EIFAC/XXII/2002/Symp. E 29

**Transboundary sturgeon intercept fisheries of the Lower Danube River system:
Need for a new management strategy to rebuild stocks and maintain fish species biodiversity**

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The actual conservation strategy based only on regulating escapement (closed seasons and areas, fish landing size and gear regulation), applied differently in each country may be responsible for the collapse of the fishery and species extinction. Since the beginning of the 20th century annual Romanian sturgeon catches have decreased 100 times from 1000 to 10 tonnes. Four species of sturgeon from the Lower Danube River system and the Western Black Sea are in trouble: (1) great sturgeon (*Huso huso*), (2) Russian sturgeon (*Acipenser gueldenstaedtii*), (3) stellate sturgeon (*Acipenser stellatus*), and (4) sterlet (*Acipenser ruthenus*). Other two species are almost extinct: Atlantic sturgeon (*Acipenser sturio*) and spiny sturgeon (*Acipenser nudiiventris*). Despite the "collapse" of sturgeon fishery reflected in official statistics, catch estimates in 1997/98 using the Rapid Rural Appraisal method confirmed that a major shared sturgeon intercept fishery still existed, yielding total catches between 300-400 t/year (47 percent Romania, 39 percent Ukraine, 12 percent Bulgaria and 2 percent Yugoslavia), but facing great difficulties due to habitat destruction, over-exploitation and pollution. However, the actual sturgeon fishery is based on fishing effort that is far in excess of historical levels (2-5 fold, and 20 times for some fishing zones). Fishing capacity has been increasing since 1990 without any entry limitation regulation, and in 1998 reached 2 500 fishing units (2 500 open-deck boats and 5 000 fishermen). To protect sturgeon species, a new conservation management strategy at regional level is needed, based on input and output control measures. The necessary steps of a new management strategy are: limiting entry to the fishery, decreasing actual fishing effort, and catch quota control. In addition, regulations are needed to protect sensitive spawning and nursery areas, and to ensure escapement of parental stock to spawning areas. Finally, monitoring, stock assessment and also enforcement tools have to be developed and implemented in order to support a sound conservation management strategy.

Keywords: Sturgeon fisheries; Management; Conservation; Danube river; Romania

EIFAC/XXII/2002/Symp. E 30

**Fisheries management involvement
in the application of the new European directive on water policy**

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The European Water Framework Directive (WFD) 2000/60/CE of 23 October 2000 provides the basis for a new policy on Community action in the field of water. Considering aquatic ecosystems in a broad sense (with adjacent wetlands and terrestrial environments), it aims to preserve and improve their ecological status.

The quality of an aquatic environment can be assessed by rating its ability to maintain sustainably a population of an indicator fish species. This approach was adopted to set up fisheries management plans but it appears that it can even more largely answer WFD demands.

The entire national hydrologic landscape of a country (all inland waterbodies) is divided into units, which are defined according to the needs of an indicator species population to maintain itself. The status of the environment is assessed according to its ability to sustain the whole life cycle of the indicator species: it is « suitable » when the entire life cycle takes place in natural conditions prescribed by the environmental characteristics, it is « disturbed » when at least one phase of the cycle is not carried out optimally, and it is « damaged » when at least one phase cannot be completed successfully. The disturbance level is quantified measuring the difference between the potential population level (corresponding to a suitable status) and the observed level, influenced by human disturbance listed in the context.

It clearly appears that the majority of the French aquatic environments are disturbed. This shows the existence of impacts of human activities which are significant and which can be found all over the territory. Zones of suitable status are well represented in the most upstream parts of the basins (mainly salmonid zones), while the degraded habitats are found further downstream (intermediate or cyprinid zones) because of the accumulative effects of point-source or non-point pollution that are stronger in the lower river sections.

Taking into account, in an exhaustive way, the totality of the waterbodies and all types of disturbances (physico-chemical and hydromorphological), we have performed a quantitative approach of impacts at the scale of functional entities. This gives us the opportunity to propose to managers action priorities that are more adapted to problems' hierarchy.

In this way our approach is compatible with the demand exerted by the new European directive.

Keywords: European Water Framework Directive; Fisheries management; Fish ecological indicator

EIFAC/XXII/2002/Symp. E 31

**The IMEW project:
Integrating inland fisheries with other aspects of wetland management -
Poachers and predators in the Nemunas Delta**

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The Integrated Management of European Wetlands (IMEW) Project addresses biodiversity maintenance within wetland areas, with particular focus on accommodating socio-economic development. Interdisciplinary teams in Finland, Greece, Lithuania and Romania, are looking at the benefits and problems of fishing at the local level, as well as public understanding, institutional dynamics and tourism as they relate to the issue of how to maintain and develop wetland areas. The impact of fisheries on the environment is great, and this presentation addresses the conflict between fisheries and predatory birds, the latter of which are often the focus of conservation movements. Unique aspects of this research are the cross-cultural analysis of the data and raising public awareness by using participatory research techniques in the field. An important outcome is to develop management programmes for the different areas, demonstrating how various local and international agencies can co-operate in conservation and sustainable use.

Keywords: Biodiversity; Conservation; Sustainability; Local knowledge

EIFAC/XXII/2002/Symp. E 32

**A constituency perspective on maintaining
biodiversity and ecosystems-based fishery management**

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Fishery management is both a technical and political process; it does not exist separate from societal wants and needs. Various constituencies and their wants, needs, and political power often shape fishery management throughout the world. An as-yet-undocumented worldwide movement of fishery and habitat resources has occurred; some by accident and some with strong constituency support. Strong constituency support is also imperative if managers are to act to reverse and remedy these situations. Fishery managers may be well informed on the need to maintain biodiversity and even on particular means for doing so but if current stakeholders are not inclined to support proposed efforts, little will be accomplished. This is particularly the case where certain groups of stakeholders pay the vast majority of fishery management costs. Anglers, for example, in certain jurisdictions may prefer catching non-native fish instead of native species and reflect little appreciation for the need for preserving local biodiversity. Some may actually oppose efforts to "bring back the natives". This essay will highlight constituency support as both a problem and as an essential part of the solution for dealing with this issue. In addition to some historical background, cases and examples of efforts in Europe and the U.S. where fisheries management has sought to maintain freshwater biodiversity or put the "genie back in the bottle" will be reviewed. Practical constituency-based management measures for dealing with these matters will be identified and discussed.

Keywords: Fisheries management; Political process; Constituencies; Conflicts

*EIFAC/XXII/2002/Symp. E 34***Conservation of biodiversity of sturgeon under conditions of the flow regulation of rivers:
Stock enhancement and living gene bank**

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The most effective sturgeon culture in the Russian Federation is in the region of the Kuban River. From 1996 to 2001 five sturgeon hatcheries released 26-28 million juveniles annually of Russian and stellate sturgeons. As a result of the flow regulation, natural spawning is not observed in this river.

The river flow regulation and simplified strategy of sturgeon stocking aimed only at large-scale release of juveniles, led to a decrease of complex heterogeneity of the sturgeon population. Therefore, a new concept of sturgeon culture with the primary goal of sturgeon biodiversity restoration is proposed.

Damming of rivers and a long-term artificial selection of only highly mature early spring migrants for hatcheries resulted in an adaptive sturgeon response of the highest functional maturity of all Russian and stellate sturgeon breeders and a shortage of mass spawning run.

The traditional technology of artificial reproduction is non-effective under modern ecological conditions. The use of ecological and hormonal methods to control seasonal propagation of stellate sturgeon, Russian sturgeon, beluga and sterlet makes it possible to stagger the sexual cycle of breeders from the various biological groups for early (5 months) or later (6 months) spawning. Use of these methods preserves the natural heterogeneity of sturgeon populations maintained through stocking.

A federal Living Gene Bank for the conservation of sturgeon biodiversity was formed in Krasnodar, containing over 8 000 sub-adults of 7 sturgeon species.

A new scheme of juvenile release of various sizes in different suitable conditions will also promote biodiversity of artificial populations.

Keywords: Sturgeon; Biodiversity; Reproduction; Russian Federation

*EIFAC/XXII/2002/Symp. E 35***Can management of freshwater fish populations be used to protect and enhance the conservation status of a rare fish-eating bird, the bittern (*Botaurus stellaris* (L.)), in the UK?**

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The bittern (*Botaurus stellaris* (L.)) is a red data list species with currently only around 20 breeding males restricted to a few wet reedbeds in the UK. The bittern, although catholic in diet, is mainly piscivorous. Eels (*Anguilla anguilla* (L.)) and rudd (*Scardinius erythrophthalmus* (L.)) are their main prey species. The EU species action plan for the bittern targeted degradation of the key wet reedbed habitat and food availability as the two main threats and limiting factors to the bitterns' conservation status. To date most conservation work has focused on the rehabilitation and creation of suitable wetland reedbed habitat with little or no consideration of the available or required food base. The importance of fish in the bitterns' diet make it imperative that the ecology of fish in wetlands is understood to enable habitat and fish population management to be beneficial to the conservation of bitterns in wetlands. Research was undertaken at two key breeding sites in the UK to assess the impact of habitat management on the dynamics of resident fish populations and their availability to bitterns. This paper assesses the application of fish population management as a key component to the suite of tools available to enhance the conservation status of bitterns.

Keywords: Rehabilitation; Bitterns; Reedbeds; Conservation; Water level management

EIFAC/XXII/2002/Symp. E 36

Analysis of the role of freshwater fish conservation in managing the environment

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Fresh waters have suffered the most intense intervention of all ecosystems over the past 100 years and many fish species are now extinct, rare or endangered and many species are now protected by active management of the environment as well as more traditional methods of conservation management, e.g. regulation of exploitation, nature reserves, captive breeding programmes. This paper uses case studies from Europe and Africa to show the value of fisheries conservation activities in improving the aquatic environment and protecting catchments from further degradation. The paper concludes that until conservation management includes major short-term economic incentives and responsibility is devolved to the people, it will be overridden by the market tendencies of the modern consumer society.

Keywords: Conservation management; Economic incentives; Habitat degradation; Inland fish

EIFAC/XXII/2002/Symp. P 01

Experimental evaluation of topmouth gudgeon (*Pseudorasbora parva*) grazing on water snails

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Topmouth gudgeon is an alien fish species rapidly colonising various waterbodies in Europe. In overpopulated waters they may cause considerable changes in the ecosystem. Besides small water invertebrates, topmouth gudgeon are reported to feed also on water snails, as they possess a relatively large mouth and well-ossified jaws with strong bundles of collagen fibres in the lips. Topmouth gudgeon do not consume the whole snails when they are bigger than their mouth gap, but they pull the soft part of the snail out of the shell. Their capability to provide any noticeable grazing pressure upon water snails was evaluated in a laboratory experiment with *Planorbarius* prey. Topmouth gudgeon (1.4 - 3.0 g) are capable to consume up to 150 mg of snails daily, which is four times more than other cyprinids (nase, *Chondrostoma nasus* and grass carp, *Ctenopharyngodon idella*) of the same size class.

Keywords: *Pseudorasbora parva*; Snail control; Food biology; *Planorbarius*

EIFAC/XXII/2002/Symp. P 02

Regional variations in Swedish patterns of recreational fisheries

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Interest in recreational fishing is widespread in Sweden. About 35 percent of adult Swedes fish for recreation. Recreational fishery can be seen as one expression of the urbanized society's need for contact with nature and outdoor recreation. There are great variations within the whole spectrum of recreational fishery. One important dimension is the distinction between the different groups of fishing tourists and local fishers. In the case of Sweden different regional patterns are evident concerning participation, attitudes towards the use of national resources and willingness to pay for the access to recreational fishing. The paper is mainly based on a separate analysis of the Swedish data from the Nordic recreational fisheries survey material. A comparison is made with the information derived from the official Swedish survey on recreational fisheries.

Keywords: Recreational fishing; Sweden; Regional pattern; Fishing tourists

EIFAC/XXII/2002/Symp. P 04**A comparative study on determining fish number and biomass in lakes:
Five methods compared with the true answer**

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Lake Hanebjerg on the Gissel field Estate is a 2.15 ha drainable carp pond. Five methods were used to determine the number and biomass of fish: mark-recapture, PASE electrofishing, multi-mesh gill nets, hoop-net, and 25-m² dropnet. After the assessments of the fish population, the lake was drained and all fish were counted and weighed.

The draining of the pond revealed a fish population comprising the species roach, perch, pike, carp, eel, bream and tench. Fish density was 8.3 fish per m² and biomass was 62 g per m². Roach was the dominating species (89 percent by number, 46 percent by weight) followed by perch and pike. 149 large (40-71 cm) carps stocked five years earlier constituted 35 percent of the biomass.

All five methods turned out to be able to assess some, but not all, parts of the fish community with varied accuracy. None of the methods was able to detect the presence of carp.

Keywords: Population estimate; five methods; Total drawdown; Comparison

EIFAC/XXII/2002/Symp. P 06**Morphological and ecological peculiarities of sturgeons
reared under control of seasonal propagation of breeders**

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The artificial maintenance of sturgeon populations in the Sea of Azov basin requires complex ecological-morphological monitoring of juveniles reared at the hatcheries. The monitoring programme includes the estimation of body length and weight variation, physiological-biochemical indices, teratological analysis, thermal stability, resistance, oxygen deficiency resistance and melanophore adaptive response ("background") as a criterion of their physiological fitness.

The teratologic analysis of fish development obtained with up to 90 days delayed completion of the reproduction cycle of breeders, showed no notable differences in frequency of the typical morphological anomalies, compared fry obtained with conventional biotechniques. The most frequent defects are observed in pectoral fins (up to 20 percent) and olfactory organs (up to 10 percent).

Fingerlings testing showed the adequate and timely adaptive reaction of melanophores towards dark and light background.

The experiment illustrated early euryhalinity, thermal stability, oxyresistance of sturgeon fingerlings under controlled seasonality in their reproduction. This could be representative of adaptive abilities to survive under natural conditions.

Keywords: Fingerlings; Sturgeon; Reproduction; Russian Federation

EIFAC/XXII/2002/Symp. P 07**Monitoring of European eel (*Anguilla anguilla*, L.) stock in Greece**

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As there is an increasing demand for glasseels for the eel farming industry, and there is also concern over the depletion of eel stock is raising everywhere in Europe. Therefore, studies were carried out in Greece to monitor natural eel stocks.

Our results indicate that glass eels enter inland waters of Western Greece between October and mid-April. Massive arrivals were observed during December and January. The main factor influencing glass eel ascendance seems to be freshwater temperature.

Concerning adult eels, fishing data indicate a dramatic drop of the natural stock during the last years. This drop is equally noticed both in the Ionian and the Aegean coast of Greece.

A regular monitoring system is required to study the population parameters of the natural eel stock and to impose actions to protect this species (re-stocking, fishing regulations and biotope protection). Especially for glasseel, it is suggested to develop a monitoring network with better spatial repartition.

Keywords: *Anguilla anguilla*; Fisheries; Greece; Glasseel

EIFAC/XXII/2002/Symp. P 08

New fisheries management approach for the Bütgenbach and Robertville reservoirs (Wallonie, Belgium)

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Following the scientific studies of the two lakes carried out for several years by the Universities of Liège and Namur, a new policy for fisheries management has been enforced.

Based on the very different ecological and biological characteristics of the two waterbodies, it was necessary to radically modify their management to transform the Bütgenbach reservoir into a predator-dominated status (pike, pikeperch, ...) and the Robertville reservoir into a salmonid-dominated status (brown trout, coregonids, ...). The poster describes the trophic-dependent introduction of *Coregonus lavaretus* into the Robertville reservoir within the framework of the new policy.

Keywords: Trophic level; Coregonids; Artificial lake; Reservoir; Fisheries management

EIFAC/XXII/2002/Symp. P 09

Restoration of the River Medlock

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The River Medlock drains the major urban conurbation of Manchester and Oldham and until the early 1990s suffered from severe industrial and domestic pollution. The improvement after 1990 has been due in part to improvements in the combined sewer outflow system involving the construction of large sewage interceptor storage tanks. Electric fishing surveys carried out in 1993 found only stickleback (*Gasterosteus aculeatus*) and a few roach (*Rutilus rutilus*) fry (age 0+), suggesting that the water quality was no longer preventing the development of a fish population. However, in the absence of an indigenous fish fauna natural recolonization would be severely restricted. Hence, between 1993 to 1999 a total of 3 600 minnow (*Phoxinus phoxinus*), 35 000 chub (*Leuciscus cephalus*), 17 000 dace (*Leuciscus leuciscus*) and 4 000 roach (*Rutilus rutilus*) were stocked at a number of sites along the course of the river.

Fifteen sites were periodically surveyed between 1995 and 2000, in order to assess the stocking. Chub, in particular, were abundant at two sites but absent from others. This was thought to be due to unsuitable habitat. Relatively few dace were recorded. The reason for this remains uncertain. The findings of this study are discussed in relation to the restoration of other urban rivers in the north west of England.

Keywords: Urban recovering; Stocking; Monitoring

*EIFAC/XXII/2002/Symp. P 10***The combined use of acoustic tracking and echosounding to investigate the spatial distribution of bream (*Abramis brama*) in the River Trent, England.**Jim Lyons^{1,2} and Martyn C. Lucas²¹Environment Agency, Midlands Region, Scarrington Road, West Bridgford, Nottingham NG2 5FA, United Kingdom²University of Durham, School of Biological and Biomedical Sciences, South Road, Durham DH1 3LE, United Kingdom

A better understanding of the spatial behaviour and distribution of fishes in modified, lowland rivers is necessary for ecosystem restoration and fisheries enhancement in these systems. Integrated approaches to measuring patterns of space use by key fish species are needed. Telemetry of tagged fishes is a preferred method of measuring habitat use and movement of fishes. However, the small sample sizes achieved are often criticized. Mobile horizontal beaming echosounding is increasingly used for determining fish abundance in large rivers and can be used to do so at a sample size approaching that of the population. We seek to combine both approaches, firstly with respect to bream *Abramis brama* in the River Trent, England.

Fieldwork was carried out on a 7.6-km reach of the lower River Trent, England. This section is mostly 80-m wide and 3-m deep and is bounded by two navigation weirs. Nine adult bream were acoustically tagged and tracked in summer 2000, in sessions stratified into 6-h periods. Fish exhibited clear movements between a daytime resting area to which the whole group homed daily, followed by nighttime excursions, presumably for foraging, when the group split up. Horizontal-beaming mobile echosounding surveys were carried out at night on three occasions and the targets were counted and fish size estimated, assuming perpendicular insonification. Distribution of tagged bream locations and fish targets > -30 dB (mostly adult bream in this stretch) shows concordance, suggesting that in this reach, in summer, bream can be identified from echosounding surveys. A similar analysis for all fish, including small fish targets (> -55 dB), gave a significant negative rank correlation, suggesting that adult bream use space differently to small fish. To date, direct video observation and fish capture in the main channel at night has not been possible. Further testing of the utility of combining these approaches is necessary, but early results are promising. In the future further use of telemetry and echosounding may enable better interpretation of space use by fishes than either approach alone. The imminent advent of coded acoustic tags that can be interrogated during echosounding surveys would enable direct overlay of known fish identities on echosounding traces.

Keywords: *Abramis brama*; Habitat use; Echosounding; Acoustic telemetry

*EIFAC/XXII/2002/Symp. P 11***Development of rearing techniques and integration with stocking strategies for compensation of habitat loss in rivers**

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Generally observed decrease of fish stocks during the last two decades drew attention of the scientists to analysing the status of riverine fisheries in Poland. Research carried out show loss of biomass and species richness, especially of migratory species. To compensate this loss, two main directions of action were developed: elaboration of biotechnology of rearing and reproduction of endangered fish species and stocking programmes. In case of stocking, often the main goal of stock replenishment cannot be achieved without understanding the dynamics of river hydraulics and ecological processes. As lack of scientific background information prevails, there is need for optimizing stocking programmes according to different rearing regimes, river types and their trophic condition.

Keywords: Stocking; Pond reared fish

EIFAC/XXII/2002/Symp. P 12

**Effect of long-term basin processes on fish community dynamics
in lowland and upland river system**

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Changes in biodiversity, biomass and abundance of fish communities during a 20-year period were studied on two small rivers of Central Poland: the upland Lubrzanka River, and the lowland Grabia River.

The rivers differ in terms of geomorphology of the catchment and river valley, as the upland river flows through not-permeable calcareous rocks and heavy clays, and its valley has a V-shaped profile, while the lowland river crosses areas built mostly with sands and its valley is predominantly U-shaped, enhancing infiltration processes. It is suggested that different processes affect water and habitat quality in the analyzed riverine systems – in case the Lubrzanka these are erosion and surface runoff, and the Grabia may be rather impacted by large urban areas situated along the river course.

Both rivers also differ in strength of abiotic regulation, especially related to discharge, temperature and pH variance. On the basis of these factors, different fish communities evolved, with divergent life strategies.

The aim of the study was to identify stress factors for each of the riverine systems, classifying them according to their impact on fish populations, and, in consequence, describe the mechanisms that support fish biomass and diversity in highly variable and in stable river ecosystems. The long-term target of the study is to elaborate methods for successful identification and preservation of the sections of the rivers crucial for fish recruitment and optimization of fish habitats in areas exposed to serious anthropogenic stress.

Keywords: Long-term changes; River basin; Aerial photography; Fish communities

EIFAC/XXII/2002/Symp. P 13

Formation of fish stocks in two different types of water-supply reservoirs

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Two types of reservoirs were investigated, i.e. stratified reservoirs with the shoreline following the river valley and with an inflowing river (valley reservoirs); and non-stratified bankside reservoirs with a dam built around the circumference of the reservoir, which is filled by pumping. In 1998 and 2000, the entire water volume of the reservoirs was scrutinized by using an acoustic Simrad EY 500 split-beam echosounder and by applying direct capture methods (seining, multimesh gillnets, trawl). The reservoirs had similar surface areas of 100-300 ha, volumes of 10-50 million m³, average depths of 10-20 m, similar retention times, trophic levels and fish species compositions. The volume of each reservoir was divided into three pelagic habitats (strata) ranging from 0 to 4 m, from 4 to 10 m, and > 10 m, as well as into a maximum of eight near-bottom habitats (near-bottom sectors) ranging from the littoral to the deepest layer which was defined as the volume 1.5 m above the bottom. Each group of reservoirs showed a distinct vertical gradient of fish distribution as well as a difference between inshore and offshore regions. In the bankside reservoirs fish were present in all habitats, with significantly different fish stocks in individual layers. In thermally stratified valley reservoirs fish were present almost exclusively in the top layer between 0 and 10 m depth.

Deeper water of the non-stratified bankside reservoirs contained many 0+ fish and higher fish abundance and biomass than shallow water. It was likely that fish could reach the maximum depth because of favourable dissolved oxygen concentrations, resulting from artificial destratification using aeration. Fish species composition, abundance and biomass in stratified reservoirs showed a gradient from the tributary to the dam. In the valley reservoirs, the fish composition and fish behaviour resembled those in an eutrophic lake, while bankside reservoirs contained non-natural fish stocks with a very different behaviour and high predation and turnover rate. In valley reservoirs, the species succession led to cyprinid dominance while in bankside reservoirs perciform fish prevailed, because the shortage of spawning substrate controlled cyprinid expansion.

Keywords: Stratified valley reservoir; Non-stratified bankside reservoir; Abundance and biomass gradient; Fish species composition

*EIFAC/XXII/2002/Symp. P 14***Estimating the fish yield potential of north east German lakes
by using the Phosphorus – Primary Production – Fish Yield concept (P-PP-F)**Roland Lemcke¹ and Uwe Brämick²¹Agency of Agriculture and Fisheries Mecklenburg-Vorpommern, Institute of Fisheries, An der Jägerbäk 2, D-18069 Rostock, Germany²Institute of Inland Fisheries Potsdam-Sacrow, Jägerhof, 14476 Gross Glienicke, Germany

In the last five years, the fish yield potential of about 500 lakes in north east Germany was assessed on the basis of total phosphorus concentration at spring turnover. The calculated yield potentials ranged from 15 to about 80 kg/ha and year for different lake categories. Highest yield potentials were predicted for polymictic hypertrophic lakes.

The estimated fish yield potential is scheduled to become the basis for a new system of appointing rental values of the lake fishing rights. Up to now the values are referring exclusively to lake area, without taking into account the differences between lakes.

Using the “Phosphorus – Primary Production – Fish Yield” (P-PP-F) concept of Knösche and Barthelmes in generally, we adapted the procedure to the specific conditions of lakes in the area under investigation. To assess the yield potential of our lakes, we are now using equations resulting from yield statistics of local fishermen between 1970 – 1990. This period is characterized by a comparable fishing pressure on all parts of the fish communities including species of poor market value like bream, roach, rudd etc.

To evaluate the quality of the estimation model, calculated yield potentials are compared to yield statistics, taking into account changes in fishing effort over the last 10 years.

Keywords: Fish yield potential; Lakes; Estimation procedure

*EIFAC/XXII/2002/Symp. P 16***Spawning habitat requirements of riverine European grayling**

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Information on the habitat preferences of a species is needed to evaluate the environmental consequences of water and land use practices. In this study, the spawning habitat requirements of grayling in a medium-sized boreal river were investigated. The preferred ranges for dominant substratum size, water depth, mean velocity, bottom velocity and percent instream vegetation cover at egg burial sites were 16-32 mm, 40-110 cm, 40-90 cm s⁻¹, 30-60 cm s⁻¹, and <10 percent, respectively. Velocity and dominant substratum size were the most important variables separating the nests from the available habitat whereas the role of depth in the spawning site selection appeared insignificant. As the results were consistent with previous findings on the spawning habitat of grayling, suggestions for general preference curves applicable to habitat-hydraulic modelling were produced for further evaluation.

Keywords: Thymallidae; Habitat preference curves; Kick-sampling

*EIFAC/XXII/2002/Symp. P 17***Freshwater angling in Portugal: A first countrywide characterization**João M. Oliveira¹, M. Teresa Ferreira¹ and Jorge Bochechas²¹Department of Forestry, Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal²Fisheries and Game Services, Direcção Geral das Florestas, Avenida 5 Outubro n°52- 6° Drt, 1050 Lisboa, Portugal

There are currently more than 300 000 anglers in Portugal (about 3 percent of the total population). Over one year a nation-wide angling census has been done, based on a written inquiry collected by the 7 regional forestry administrations. The average Portuguese anglers are male (97.5 percent, middle-aged (30-50 years, 48.2 percent), have an average level of education (4-12 years, 72.5 percent and are mostly employees (65.8 percent). Angling is practised alone and often (between 15 and 60 days per year). A total of 46 percent of the anglers do not travel far for angling purposes (<50km), and a moderate amount of money is spent on fishing equipment (less than 500 Euro per year for 82.6 percent). Preferred angling species are brown trout *Salmo trutta* in mountainous areas, black bass *Micropterus salmoides*, common carp *Cyprinus carpio* and pike *Esox lucius* in reservoirs, and these plus nase *Chondrostoma* spp.

in large rivers. The anglers reported a general decrease of trout and black bass stocks whereas stocks of Iberian barbel, nase and chub *Leuciscus* spp. remained stable, while carp and pumpkinseed *Lepomis gibbosus* stocks were increasing.

Keywords: Fisheries; Fish; Socio-profile; Preferred species

EIFAC/XXII/2002/Symp. P 18

Assessment of minimal flows required for spawning activities of sea lamprey *Petromyzon marinus* using the wetted usable area

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The sea lamprey, *Petromyzon marinus*, is still frequently encountered in Portuguese large rivers, including the Tagus (about 200 km from the mouth to the first impoundment). Its populations needs conservation enforcement, including the maintenance of their spawning grounds. A thorough mesohabitat mapping on the main river allowed the identification of areas still used for spawning, considering channel structure, *in situ* observations of lamprey nests and inquiries with the fishermen. The four most important spawning reaches were subject to complete topographic mapping of the river bottom. For each reach, a flow duration curve was calculated (range of flows: 0 to 50 m³/sec). The wetted perimeter was determined for each topographic section and an a-dimensional total wetted area calculated for each spawning reach (total area: about 200 000 m²). Considering a threshold of 0.3 m/s for minimum water velocity in each topographic section, a wetted usable spawning area was then determined, and its variation with flow simulated. The usable area varied from 45-85 percent of the initial wetted area, and increased with flows between 10 and 20 m³/sec with a small gain with higher flow values. This range of flows should be considered as the minimal flow requirement for the protection of lamprey spawning grounds in the regulated Tagus River.

Keywords: Wetted perimeter; Usable area; flow requirements; Petromyzonidae

EIFAC/XXII/2002/Symp. P 19

Fish parasites as a biotic factor affecting fish reproductive success in man-made lentic waterbodies

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Fish parasites were studied in flooded and non-flooded borrow pits in the flood plain of the River Dyje (Danube basin) in 2001. The reproductive success of fish was affected also by the larval stages (metacercariae) of the trematode *Posthodiplostomum cuticola*, which causes black spot disease. Managed flooding improved spawning and nursery conditions, however, it also increased the abundance of intermediate and definitive hosts. Abundance of aquatic snails, Planorbidae, the first intermediate host, and frequency of visits of piscivorous birds, especially Ciconiiformes, the definitive host, were significantly higher in flooded than in non-flooded borrow pits, thereby parasite transmission increased. Consequently, intensity of infection of fish (the second intermediate host) was higher in flooded borrow pits. Thus, managed flooding enhanced spawning and nursery habitats for fish but also supported higher intensity of infection of *P. cuticola* metacercariae on 0+ juvenile fish which had a significant effect on fish development.

Keywords: Metazoan parasite; Juvenile fish; Borrow pits; Flood plain

*EIFAC/XXII/2002/Symp. P 20***Status of inland water resources in Greece**Ioannis Paschos¹, Iphigenia Kagalou¹, Alkis Oikonomou², Antonis Kokkinakis³ and Panos S. Economidis⁴¹Department of Aquaculture and Fisheries, T.E.I. of Epirus, GR 46100 Igoumenitsa, Greece²National Centre for Marine Research, Hellinikon, Athens, Greece³Institute of Fisheries Research, Kavala, Greece⁴Dept Biology, Aristotelion University of Thessaloniki, GR-540 06 Thessaloniki, Greece

The present study was carried out on behalf of the Directorate of Aquaculture, Greek Agricultural Ministry, under the PESCO programme. This study incorporates assessment, conclusions and proposals for the management of inland waters of 20 prefectures for 43 lakes, 63 rivers and 121 springs. An analysis of geomorphological, environmental and biological data is included. We present the status of fisheries, relevant literature and threatened species for each region, lake, river and spring. Appropriate proposals for the management of inland water resources are made. Special software was developed for the presentation of the results of this study.

Keywords: Greece; Lakes; Rivers; Springs*EIFAC/XXII/2002/Symp. P 21***A numerical indicator as a decision tool in the commercial fishing management**

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In the last few years, commercial fishing in Portugal has been subjected to new management measures. The most significant of these measures is the creation of "Commercial Fishing Zones" where net fishing is subject to specific regulations (e.g. fishing permits quotas, daily catching limits, closed seasons and characterization of authorized fishing traps and methods).

The main goal of this study is the creation of "Commercial Fishing Zones" in Tagus River. So that an accurate definition of the number of zones, boundaries and specific regulations is implemented, it is necessary to achieve a broad knowledge of the fishermen and commercial fishing activity developed in the selected river area.

In order to better understand the importance of commercial fishing in the selected area, a decision tool was built. A numerical indicator based on five characteristics – fisherman age, fishing frequency, catch, earnings and level of importance of the activity – was established.

Keywords: Commercial fishing; Fisheries management; Tagus River; Portugal*EIFAC/XXII/2002/Symp. P 22***Fish sampling by the Artificial Vegetation Module (AVM) system**Christian Skov¹, Lene Jacobsen¹, Søren Berg¹, Erik Jeppesen², Martin Søndergaard² and Torben Lauridsen²¹Danish Institute for Fisheries Research, Dept. of Inland Fisheries, Vejløvej 39, DK-8600 Silkeborg, Denmark²National Environmental Research Institute, Dept. of Freshwater Ecology, Vejløvej 25, DK-8600 Silkeborg, Denmark

Fish in the littoral zone of lakes were sampled using a variety of methods. For sampling fish in brackish waters, the Artificial Vegetation Module system was developed, and the system is now introduced as a new method for most lentic waters. The AVM-system allows the researcher to design and build an experimental study area and monitor the exact distribution of fish between different habitat types. Each module consists of a steel frame with artificial vegetation and equipped with a popnet, which can totally enclose the module. Sampling is easily performed by releasing the popnet capturing the fish inside. The module is then lifted out of the water, and the net is emptied into a container, thus giving a snapshot of the fish composition in the exact habitat type. We have used the AVM-system for three years in pond-, enclosure- and full-scale lake experiments.

Keywords: Fish sampling; Artificial vegetation; Habitat complexity; Flexible study-design

EIFAC/XXII/2002/Symp. P 23

**Migrations of bream *Abramis brama* L. in Lake Peipsi basin:
New management approach needed**

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The bulk of the Estonian inland fisheries catches originate from Lake Peipsi and Lake Võrtsjärv, connected by the Emajõgi River. The fish stocks of these lakes have traditionally been treated separately. The tagging of bream, one of the most important commercial species, revealed the existence of an abundant population spawning in the upper course of Emajõgi River (up to 95 km from Lake Peipsi) and migrating into both, Lake Peipsi and Lake Võrtsjärv for feeding and wintering. The catches of that population have increased in Emajõgi River tenfold in the 1990s compared to the earlier decades. As the abundance of bream spawning in the lakes has decreased, in recent years the river stock has largely contributed to the bream catches in both lakes. The data discussed in the poster demonstrate the need for a new management approach for the joint stock of the lakes.

Keywords: Bream; Management; Migration; Tagging

EIFAC/XXII/2002/Symp. P 24

**Habitat selection and food preferences of native and stocked trout
(*Salmo trutta* L.) in low productive streams**

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Supplemental stocking of brown trout (*Salmo trutta* L.) is still a regularly used strategy to attempt to improve the fisheries in the upland streams of North and Central Portugal, characterized by low nutrient concentrations. The aim of this study undertaken in two rivers, was to assess intra-specific effects of stocking with hatchery-reared trouts of age 1+. Using multivariate procedures we concluded that competition for the limited food resources may occur between stocked individuals and the wild ones of the younger age classes (generally 0+), as these groups exhibited a higher overlap of food preference. Regular electrofishing surveys showed that the introduced fishes displayed small-scale displacements, but snorkelers did not observe obvious agonistic behavioural interactions. This is probably because of distinct microhabitat selection between domestic and wild fishes, related mainly to current and substrate type, as was displayed by polynomial preference curves.

Keywords: Stocking; Trout; Habitat; Diet

EIFAC/XXII/2002/Symp. P 25

**The introduction of the fish from the Danube area into the
Mediterranean Vransko lake, Croatia**

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The Vransko Lake is a fresh-water lake in southern Croatia, only one kilometre away from the Adriatic Sea. This is an oligotrophic lake with mild climate. At first the only fish species that inhabited the lake was eel (*Anguilla anguilla*) from the underwater karsts caves. After 1895, when an artificial channel was dug, marine euryhaline fish species sporadically migrated to the lake. In the late forties common carp (*Cyprinus carpio*) from northern Croatia was introduced. Up to the mid-fifties, mostly accidentally, several other fresh-water species were also introduced.

During more than 50 years of existence in the Vransko lake, common carp adapted well to its conditions and developed into its wild, elongated and scaled form. The original goal of introducing common carp for commercial fisheries was never reached. Nevertheless, carp angling nowadays attracts many tourists who visit the Adriatic coast or camp by the lake.

Keywords: Introduction; Common carp; Mediterranean; Croatia

*EIFAC/XXII/2002/Symp. P 26***Gill net fishing on Lake Peipsi and selection of mesh size limits for fishery**

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The importance of gill-net fishing on Lake Peipsi-Pihkva started to grow in the beginning of the 1990s, due to the increasing stocks of pikeperch, now this species provides highest revenues in commercial gill net fishery. However, the share of gill nets in the total catch is highest in the case of whitefish, followed by bream, pike, burbot and pikeperch. In subsistence gill-net fishing carried out by local inhabitants, the most important species are roach and perch. The study discusses a strategy of selection of mesh size limits for gill nets during recent years.

Keywords: Gill-net fishery; Mesh size limits; Lake Peipsi; Catch composition

*EIFAC/XXII/2002/Symp. P 27***Pikeperch fishery in Lake Peipsi-Pihkva**

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The study focuses on pikeperch fishery, providing highest revenues in the lake system. From the 1930s onward, the pikeperch population was suppressed by use of small mesh-sized active gear. After fisheries rearrangements at the end of the 1970s, however, its abundance has significantly increased, facilitated also by favourable environmental conditions during the last decades. Several strong year classes in the 1980s and the 1990s have formed a basis for continuous increase of the commercial catches, reaching nearly 1300 t in 2000. Due to the high level of exploitation in recent years the population consists mainly of few strong young year-classes. Therefore the Danish seining, the most important fishing technique used, has caused year by year an increasing share of by-catch of undersized specimens. Increasing of mesh-size in seining would, however, substantially lower catches of perch, the second most important commercial species. Several harvesting patterns, such as more intensive use of gill nets in the future will be discussed in order to find a strategy to maximize economic rent of exploitation of the fish resources of the lake system.

Keywords: Sander lucioperca; Year-class strength; Mortality

*EIFAC/XXII/2002/Symp. P 28***Inland fisheries of Turkey and some environmental problems of Uzungöl Lake**Bülent Verep¹ and Ertug Düzgüneş²¹Karadeniz Technical University, Rize Faculty of Fisheries, 53600 İyidere-Rize, Turkey²Karadeniz Technical University, Sümene Faculty of Marine Sciences, 61530 Çamburnu, Sümene-Trabzon, Turkey

Turkey is very rich in terms of inland water. Turkish inland waters consist of 36 rivers (combined length 178 000 km), 200 lakes (9 000 km²) and 1 142 small lakes and impoundments (combined area 157 km²). The total water surface of Turkey is approximately 10 000 km² (1 percent of the country). Uzungöl Lake is a small lake on the northeast of Turkey. It faces serious pollution problems due to fish farms and sedimentation. As a result, the lake has been covered with water plants and its depth and volume decreased significantly. For example, its maximum depth is now reduced to 5.87 m from 20 m thirty years ago.

In this study, general information on Turkish inland waters, fisheries and properties, and specific problems of Uzungöl lake are presented.

Keywords: Inland Water; Freshwater fish; Fisheries; Uzungöl

*EIFAC/XXII/2002/Symp. P 29***Modelling fish communities using the River Habitat Survey**

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A successful pilot study has been undertaken by the River Habitat Survey (RHS) Lead Region using RHS data and Fisheries data from Midlands Region Environment Agency to develop a modelling tool which predicts fish communities based on observed habitat data. It will also predict which fish communities should be present if all habitats were natural. Habitat suitability for different communities is assessed by examining the physical impacts of river engineering, and the presence of positive and negative habitat features. The results have been shown to be statistically robust and a range of applications is developing for the tools. Further work is ongoing to apply the modelling methods developed in this pilot to fish communities nationally and to build other modelling tools for other species / communities, particularly those included in the Habitats Directive.

Keywords: Fish Communities; River habitats; Modelling

*EIFAC/XXII/2002/Symp. P 30***The fish fauna of mountain streams in the Chiri and Seorak National Parks, S. Korea**

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The fish fauna of mountain streams in the Chiri (440 km²) and Seorak National Park areas (373 km²) of S. Korea was investigated from 1998 to 2001. Mt. Seorak is biogeographically in the West and East-north sub-districts, and Mt. Chiri belongs to the South sub-district of Korean peninsula. At Mt. Chiri, 3 422 fish individuals, classified into 30 species and 12 families were collected. At Mt. Seorak, 2 557 fish were collected and classified into 17 families and 42 species (total freshwater fish in South Korea (99 373 km²): 39 families, 202 species; 14 national parks in S. Korea (2 994 km²): 29 families, 102 species). *Zacco temminckii* (RA 47.9 percent) was dominant at both parks. The proportion of Korean endemic species in both parks (20 species, 33.3 percent) was higher than the average of Korean rivers (25.9 percent). Even though the total number of species and endemic species of streams in 14 Korean national parks are not clearly proportional to the area of a particular park, larger parks tend to have higher fish diversity. We conclude that Korean national park areas are very important for fish diversity and conservation, especially for the Korean endemic and endangered species.

Keywords: Mountain streams; National Park; Korean endemic species; *Zacco temminckii*

*EIFAC/XXII/2002/Symp. P 31***The influence of fisheries management on the design and execution of a flood alleviation scheme on Glossop Brook (a native brown trout fishery)**

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Glossop Brook is situated on the edge of Peak District National Park in Derbyshire. Flooding of Glossop Brook was found to occur approximately once every four years, causing considerable damage to the town and local economy. Flood alleviation works were undertaken during 1995 and 1996 with the aim of reducing the occurrence of flooding to approximately once every fifty years.

Historically, the needs of resident fish populations and the aquatic ecology in general were given little consideration when major riverine engineering projects were deemed necessary. The subsequent decline of fish populations following such projects has led to a process of negotiations between fisheries managers and engineers during the planning process. Mitigation measures involving the redesign of hard engineering features have been developed in order to provide a more sympathetic environment for fish whilst still maintaining the integrity of the design.

Glossop Brook supported a healthy and self-sustaining population of brown trout (*Salmo trutta*) with growth rates typical for the north of England. It was therefore considered imperative to take measures to protect the long-term viability of the fishery by incorporating enhanced habitat features in the final design.

In order to ascertain the success of this fisheries management intervention a programme of pre and post project construction monitoring was undertaken using electric fishing and a habitat model (Habscore). A control reach was incorporated into the monitoring programme against which results could be evaluated. Data from pre-construction surveys were used to mitigate the impact of further phases of the scheme.

The results from this study are discussed in relation to the conflict between fisheries and the protection of lives and property that exists in a heavily urbanized environment. Examples of how the planning process can be used for the benefit of the aquatic environment are also included.

Keywords: Salmo trutta; Flood protection; River engineering; Mitigation

EIFAC/XXII/2002/Symp. P 32

Protection of endangered Salmonid species in Bosnia and Herzegovina

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Pre and post-war research into autochthonous salmonid species in Bosnia and Herzegovina indicate that they are endangered. Brood stock material collections in fish farms are devastated and used up. This particularly pertains to brown trout, Adriatic trout, Neretva trout and Danube trout.

Two years ago we initiated a project in several fish farms aimed at protection of autochthonous salmonid species, collection of brood stock, production of fingerlings and stocking. Since few natural isolates with no genetic influx caused by stocking exist in Bosnia and Herzegovina, our results show that the project can be successfully completed only by Cupertino of all the fish farms in Bosnia and Herzegovina. We have stressed conservation of salmonid species, particularly in Neretva River. Along with the production of fingerlings we started DNA analysis of several populations.

Keywords: Endangered species; Adriatic trout; Fingerling production; Neretva River

The Symposium on Inland Fisheries Management and the Aquatic Environment: The effects of fisheries management on freshwater ecosystems was held in Windermere, United Kingdom, from 12 to 15 June 2002, in concomitance with the Twenty-second Session of the European Inland Fisheries Advisory Commission (EIFAC). One hundred and fourteen participants from 27 countries attended the Symposium; 29 experience papers and 29 posters were presented. The Symposium considered biological, environmental, social and economic impacts of fisheries management of lakes and rivers. Fisheries management has produced clear benefits to the ecosystem and to stakeholders over and above benefits to the fishery itself. It highlighted that traditional fisheries management is not always implemented successfully in European inland fisheries. At the same time, the trend away from traditional management of fisheries resources towards integrated management of the ecosystem emphasizes the need to develop new participatory approaches.

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