THE ASSESSMENT, MONITORING AND MANAGEMENT OF THE CARPATHIAN RIVERS FISH DIVERSITY

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ABSTRACT: The interest for this type of scientific studies was raised by the increasing concerns considering the trend of the marked diminishing of the aquatic ecosystems as complex resources worldwide. Based on some characteristic Carpathian rivers (Cibin, Târnava Mare, Târnava Mică, Târnava and Vişeu) habitats and fish fauna, this paper propose some methods which can be used, in different optimum combination sets, to offer comparable results for complex ichtiological studies, of the Carpathian specific rivers, through assessing species or/and this species habitats for measurable conservative and economic goals. The approach used for these river basins assessment, monitoring and management can be used as a model approach for any other Carpathian watersheds, both of economic and/or conservative interest. This approach should be based on extensive and intensive biological and ecological data, obtained and monitorised in the field at least along a three-five (better more) years period.

1. INTRODUCTION

The interest for this specific category of scientific studies was raised from the leading concerns considering the trend of interrupted and pronounced quantitatively and qualitatively diminishing of the aquatic ecosystems as complex and very valuable resources worldwide (Kalinin and Bykov, 1970; Sokolov, 1977; Aldwell, 1977; Arnell, 2004; Lundqvist, 2009). In spite of the relatively low/medium human access in the mountainous zones, these areas become lately a more and more attractive target for socio-economic objectives and the Carpathian Mountains basin is not an exception (Dankó L., 1993; Costea, 2008; Curtean-Bănăduc et al., 2008; Sandu et al., 2008; Hajdu and Füleky, 2008; Reif, et al., 2009; Bănăduc, 2010).

In any period of the human civilisation evolution and in almost all geographic regions (excepting Antarctica), the streams and rivers were very important resources, but were used by people with various interests, methods and also associated effects.

From the human economic perspective, the lotic ecosystems and the ecosystems which depend on these offer many distinct resources (water, minerals, biological resources, etc.) and also services (absorption and recycling of human activities wastes through natural processes, recreational services, etc.) (Minca and Petz, 2008; Radu, 2009). For the sustainable management of the hydrographical basins, few main steps are necessary to be adapted to each area/basin of interest like: assessment of their capacity for support and self-regulation, monitoring to have a permanent updated image of the ecological status and the potential threats, modelling to support different scenarios of actions, and prognosis. All of this should be adapted and integrated for river basins optimum management plans.

All of these important elements, through the fish fauna conservation, protection and economic exploitation perspective, based on some Carpathian characteristic rivers data, were approached here, and specific proposals were bring out.

2. FISH DIVERSITY ASSESSMENT

Historically, the human society activities have had important destructive impact on fish species associations and communities from small streams to large rivers, ponds, lakes, seas and oceans. The present is not different, the main disadvantageous direct or/and indirect effects on fresh water ecosystems are mainly due to the habitats chemical and physical alterations (Petts, 2001; Dudgeon, 1992, 1995; Iannuzzi and Ludwig, 2004; Das and Chakrebarty, 2007; Marković et al., 2007; Liogchii, 2008; Kutzenberger, 2008; Yacoub, 2011; Tockner et al., 2009; Yildiz et al., 2010).

The fish community diversity assessment is a successful tool which is used for the aquatic habitats ecological assessment all over the world (Fausch et al., 1990; Edds, 1993; Harrison and Whitfield, 1995; Schiemer, 2000; Aparicio et al., 2000; Magalhaes et al., 2002; Pont et al., 2007; Vassilev and Botev, 2008; Kadye et al., 2008). To obtain more precise specific results, these assessments can/should differ from one biogeographical area to another, also from one type of human society to another, among one goal to another, etc. The transferability of some methods from one ecoregion to another without appreciable adaptations is restricted.

Assessing fish communities diversity causes and effects requires an adaptative scale approach (Friesel et al., 1986; Habersack, 1998; Levin, 1992; Naiman et al., 1992). The river/basin approach is one of the most appropriate one in this respect.

For the Romanian Carpathian rivers of I and II orders there is a solid scientific base in this respect, actually the majority of these rivers were studied starting with Antipa (1909), Bănărescu (1964, 1969) and others important ichtyologist generations. Along over this more than a Century, the fish diversity assessment studies were variable in terms of methods, the results of these studies starting with data which underlined only the type of habitats, qualitative information regarding the collected fish and only lately some quantitative information regarding the sampled fish, the last approach which can allow an ecological perspective on the fish populations, associations, communities and their habitats.

Based on some characteristic Carpathian rivers (Cibin River, Târnava Mare River, Târnava Mică River, Târnava River, Vişeu River) habitats and fish fauna (Bănăduc, 1999, 2000, 2005, 2006, 2008, 2010), this paper propose some methods which can be used, in different flexible combination sets, to offer comparable results for complex ichtiological analyses, of the Carpathian specific lotic ecosystems, through assessing species or/and their habitats for measurable conservative and economic objectives.

Using fish as bio-indicators for the habitats assessment is a relatively common practice, but the obtained results can be valuable only in the following circumstances: using non-destructive sampling techniques, the samplings should include all the present fish species, to be aware about the human impact types and pressure presence and potential as threats, to catch not only the short-lived fish species but also the long-lived species, to understand the fish species mobility, knowing the fish spatial and temporal biological and ecological needs, to be aware about the natural biotic and abiotic conditions variability in space and time, etc.

When choosing a method or a combination of methods for the fish assessment, we have to take care about the following important issues: an optimum coverage of the spatial distribution of the fish species in the area of interest (all habitats and microhabitats categories for all the fish species and all their life cycles); appropriate/adapted for each local conditions sampling techniques and methods, optimum recording of the primary data; optimum timing of the fish assessment to ensure the fact that the results highlight the ecologic status of the fish populations in the context of the natural or seminatural cycles and of the human activities impact presence; registering proper environmental data to can find final explanations for different situations on the field.

The sampling techniques and methods should be preferably used together, in different combinations which finally offer a solid image of the reality based on which future needed monitoring systems and management plans will be created. The electric fishing (single or/and multiple catch; generator driven or back-pack with single or multiple anodes) offer a good picture concerning the distribution and also the abundance of some fish species along many years, and as a consequence the identification of the negative human impact effects. The electric fishing inefficiency/partially efficiency in the cases of large rivers, of big/very big fish species/individuals, of the water with low content in salts and minerals, of the water column depth, of the substratum characteristics, etc., should be avoided by using other categories of fishing (with net active tools and traps, angling, direct observations, etc.). For complementary qualitative information cheeking the fishermen captures and cheeking the dead fish corps where there are available, can be also taken in consideration. The fishing should be done in time/effort unit or river sector/length unit.

The direct observations can be performed in the periods when the river water is clear, in bypass reaches, in spawning habitats, near the hydro-power stations intakes, etc.

The fishing activity costs can be reduced if the sampling sites selection (localisation and number) is based on old information about distribution and on the natural and/or human induced characteristics of the fish habitats. Of course the surprises can appear in such cases in the circumstances in which no historical reliable data exist in this cases we should make an extensive sampling programme.

Beyond the relatively numerous assessment approaches existing today, we will highlight here some elements which we consider as appropriate for the Carpathian watersheds ichtyofauna habitats assessment. The selection of satisfactory approach takes place normally based on biologic and ecologic considerations, social and economic considerations, methodological limitations, time limitations and also financial constraints.

The more or less old maps and historical data can provide utilizable abiotic data and information (mineralogical, geological, geomorphologic, hydrological, geographical, pedological, climatological, etc.) to discover and characterise past undisturbed/relatively undisturbed conditions at the river scale, for needed up to date comparative analyses.

With certain major economic value, fish are one of the few groups of freshwater organisms for which substantial historical information and data are acquirable. Historic fish captures, fish sales, fish markets and even biological data on the distribution of species are disposable back to many centuries ago. In general all these information are based mainly on some commercial fish species.

The historical human impact data on fish and fish habitats can be sometimes discovered, in respect of: fishing, overfishing, river beds regulations, construction of dams, land cover alterations, riverine corridors alterations, etc.

The fish species diversity criteria approach can demonstrate the indigenous versus non-indigenous fish fauna appearing in a distinct category of Carpathian rivers in natural, seminatural or anthropogenic impacted river sectors.

The sef-sustainable versus not self-sustainable populations of indigenous fish species, can reflect elements of habitat quality, connectivity, reproduction and genetic variability.

The species composition criteria depend on the possible anticipation of definite fish communities in a river sector, communities which contain or not some key-species, flag species and other associated species to them. The fish species composition has various situations and dynamic in natural, seminatural or anthropogenic impacted lotic ecosystems sectors.

The guild composition approach is based on the fact that different guilds take over different functions within lotic ecosystems. Each guild show analogous strategies of resource discovery and use, and have created similar organisms in respect of their habitat and microhabitats preferences, reproduction, migration, colonisation, recolonisation, sheltering, feeding, etc.

The population size analyze, based on quantitative or at least semi-quantitative measures of density and/or biomass per surface units/subunits or per river sections length reveal the ecological status of the fish associations, and also of their habitats and ecosystems.

The decisive role of reproduction, make the fish population age structure and sex structure approach, a needed tool for the reproduction and the recruitment success or insuccess analyse.

For the fish associations assessment the most coherent approach is to use comparable field data of reference river sections along the studied lotic system. Actual field data are often missing for the Carpathian rivers; this induce a switch to upstream or/and downstream sections, but indispensable in the same ichthyologic zone (Bănărescu, 1964) of the studied river. If the needed reference sites are not present or accessible for sampling in the studied river, an alternative solution is to switch to other similar rivers within the same ecoregion, also in the same ichtyolgic zone. The Carpathians areas fortunately still have such river sectors or even rivers which can be used as reference rivers or river sectors.

Each of the above mentioned approaches are characterised by advantages and disadvantages, their applications should be done in appropriate integrated sets of approaches, special selected to can work together for one or other of the Carpathian different categories of rivers.

One of the largely accepted integrated approach in this respect is that one based on the biotic integrity using fish communities (Karr, 1981; Leonard and Orth, 1986; Fausch and Schrader, 1987; Lyons, Wang and Simonson, 1996; Hughes and Oberdorf, 1998; Goldstein and Simon, 1998; Smathers et al., 1998; Miller et al., 1988; Bramblett and Fausch, 1991; Oberdorff et al., 2002; Sostoa et al., 2003; Bozzetti and Schulz, 2004; Pont et al., 2007; Petesse et al., 2007; Casatti et al., 2009). It is demonstrable the fact that particular adaptations are necessary for each studied river in different regions. Such a specific adaptation of an integrity biotic index for the Carpathians area basins/rivers was proposed by Bănăduc and Curtean-Bănăduc (2002) and its main elements are shortly presented below.

The combination of metrics for this index was created to expose insights of assemblage, community, population, and ecosystem perspectives, and to suit local and/or regional patterns in fish ecology.

Every selected metric value should to be compared with the value estimated from similar/comparable sites/sectors with smaller, minimal or no human impact.

In general it can be considered that as this adapted/flexible biotic integrity index values decreases, the habitat and lotic ecosystems (as sources of services and resources) quality decrease too.

The Carpathian Fish – Integrity Biotic Index score represent a nine-metrics sum and can be interpreted using the following intervals for comparation: (45-43 – excellent) this maximum score attest an excellent, comparable to pristine conditions, exceptional assemblage of species; (42-36 – very good) this second score certify a decreased species richness, intolerant species in particular, sensitive species present; (35-31 – good) this score describes fair intolerant and sensitive species absent, skewed trophic structure; (30-24 – fair) a score which reflect some expected species absent or rare, omnivores and tolerant species dominant; (23-17 – fairly poor) this score shows few species and individuals present, tolerant species dominant; (16-10 – poor) this score reveal very few species and individuals present, tolerant species dominant; (9-1 – very poor) this minimum possible score reflects extreme few species and individuals present, tolerant species dominant, or no fish individuals present.

The selected fish assemblage metrics in this respect are the following: species richness and species composition (total number of fish species; proportion of benthic fish species; proportion of water column species; proportion of individuals of intolerant species; proportion of individuals of typically tolerant species), trophic composition (proportion of individuals as omnivores feeders; proportion of individuals as insectivores feeders) and fish abundance and condition (number of individuals in sample; introduced species - on zoogeographic basis). Ratings of 5, 3 and 1 are assigned to each metric according to weather its assessed value approximates, deviates from the value expected at a comparable site that is relatively undisturbed.

The Carpathian Fish - Index of Biotic Integrity scores results are generally overlapping on the other much more resources consuming assessment methods. This index significant metrics respond to river natural, seminatural and/or anthropogenic variations/disturbances in a predictable manner, match lotic ecosystem quality correctly revealing an important correlation with the local habitats and microhabitats degradation, are generally spatially and temporally stable, and showed significant correlation with independent measures of water quality. Although the overall classifying success of this index is similar to that of its significant metrics, the index is superior to the metrics. This is because it represents a compromise measure, balancing the tendencies of the metrics overestimate or underestimate the habitat quality.

The high quality of the Carpathian Fish - Index of Biotic Integrity, as an indicator of fish assemblage and habitat quality, rely on the: possibility to explain the features of the fish assemblage in a particular Carpathian region; tracked medium-term and long-term modifications, is replicable across a wide suite of sampling sections; is evidently correlated with other indicators of the river water quality.

The Carpathian Fish – Index of Biotic Integrity is very efficient in discriminating over a large gradient of human activities negative effects: biotic assemblages changing due to flow alteration, dam discharges, toxic chemicals (accidental, episodic, intense, concentrate in sediments, etc); habitat disturbance, microhabitat disturbance, unnatural runoff, banks vegetation clearing, islands vegetation clearing, excess sediments or nutrients transport, channelization, de-snagging; and seem consistent in medium and long periods of time in differentiating human activities negative impacts.

The principal quality of the assessment made with this specific index is based on its capacity to interpret the main features of the fish assemblage in characteristic Carpathians area conditions.

Even if some of the fish species of the fish assemblages can change from one Carpathian area to another, if our approach of the relationship between ecosystem function and fish diversity have correct basis, the transferability of this specific index applicability, for other Carpathian rivers is correct. Some slightly technical adjustments made by ichthyologists with local/regional knowledge are possible needed.

The spatial assessment unit – the unit of a river sector of a lotic system where a specific method is used – has to highlight all the main spatial attributes which characterise a Carpathian specific river type. In these circumstances, the smallest unit should include all types of the permanent water bodies or related with them (main channel, secondary channel, floodplain, etc.) and habitats (pools, side arms, runs, oxbows, etc.).

The temporal assessment unit – the time unit when a specific method or a set of methods are applied – has to reflect all the temporal attributes characteristic for a Carpathian specific river type.

The fish diversity assessment is a mandatory first essential step in the cases when we have to create an integrated monitoring system for fish and/or related abiotic and/or biotic elements.

This approach is in the view of the European Union Water Framework Directive requirements to diagnose the ecological status of the aquatic ecosystems using fish as bioindicators.

3. FISH DIVERSITY MONITORING

The results of the fish diversity assessment should produce the first needed data base for creating a monitoring system for fish and/or related abiotic and/or biotic elements. Actually the assessment support the construction of a monitoring system, avoiding future redundancy in monitoring data and therefore reducing the involved time and costs.

Some of the advantages of using fish monitoring for the lotic ecosystems protection are: direct interest to the riverine settlements human population, the major visible component of aquatic biodiversity, total dependence on the aquatic environment, fish community reflect the ecological integrity, integrate the effects of different negative factors in time and space, reflect the ecologic status of the water body, sensibility to the point and non-point accidental and permanent pollution sources, not expensive, relatively easy to be catch and identified, include a range of species that represent a multitude of trophic levels, top positions in the food webs, good biological and ecological knowledge about the majority of the fish species, etc.

For proper managerial conclusions based on the monitoring data base, the data should include the followings: climate and meteorological conditions, stream description (hydro-geomorphological characteristics, perennial or ephemeral), watershed characteristics and description (geomorphologic characteristics, land use - orchards, forest, grassland, agriculture, settlements, industry, nonpoint source of pollution, point source of pollution, erosion), riparian vegetation (trees, shrubs, grasses, buffer stripes size and characteristics), in-stream features (length, width, surface, velocity, morphology, modified sectors, diversions, mineral exploitations, dams), aquatic vegetation (hydrophytes, semi aquatic grasses, algae), water quality (odour, colour, temperature, transparency, conductivity, dissolved oxygen, turbidity, pH, sulphate, nitrite, nitrate, phosphate), river bottom materials (boulders, cobbles, gravel, sand, silt, detritus, mud, marl), fish, etc. The fish diversity monitoring programmes should include variables that could be measured in short periods of time, as simply and accurate as is possible, not only by specialists but also by non-specialists based on a minimum initial training.

To refine the capacity of the monitoring programme to avoid redundancy and bigger then is necessary time and costs investments, an initial pilot monitoring programme should be create. Only after at lest one year cycle of monitoring we can be sure that are no redundant locations, periods and data, and can to adjust finally the monitoring programme.

Each specific physiographic, botanical and ichtyologic (Bănărescu, 1964) zone/subzone should be covered by sampling sections. The sampling sections should cover the main human impacted sections/subsections. No a priori good or bad site should be considered as monitoring sections. Each monitoring section should be approximately of minimum 100 m in length. The monitoring sections should be as variable as is possible, including where are accessible for example: main channels, side channels, backwaters, impounded zones, tributaries confluence, etc.

Full sets of samplings should be made during all the seasons.

The relative abundance is one of the most common variables which can be monitorized for all fish specimens regardless of size and weight or it can be monitorized separately for adults and juveniles.

The fish abundance is characterized as fish numbers collected on site, on species and on life stage categories.

The fish species richness, as a component of the overall diversity of the fish community, is referring to the total number of fish species taken in a sampling campaign or to a defined unit of effort.

Biomass will be characterized by biomass per each fish species and each fish life stage at each sampling site.

Density will be reported as numbers and/or biomass per kilometre per each fish species and fish species life stage.

The fish population structure is referring to the distribution of fish individuals of a single fish species among size or age categories, no smaller than 100 specimens.

The fishing methods should be select in the assessment period and should be ameliorate, in the monitoring period of an initial pilot programme. Excepting the fish individuals needed for gut analyse, toxicological analyse (heavy metals, organochlorines, etc.) fish tissue analyse and the individuals for parasitological fish tissue analyse, and the individuals with anomalies, all the captured individuals are released immediately after their identifying, measuring, weighing, enumerating and photography in their habitat. Among the individuals with anomalies only 1% will be preserved and the others will be released but their anomalies will be recorded (as: parasites, anatomical abnormality, morphological abnormality, multiple abnormalities, injuries, fungus, tumours, etc.). The general retained individuals should be as much as possible in minimum number/percentage for obvious conservative interest, and will be preserved in 5% formalin for further studies.

Active monitoring can be based on passively and/or actively transmitters of data.

The unsuccessful samplings attempts should be registered to can change the used methods sets.

The field fish sampling sheet should be adapted at the local conditions, in general will contain the following elements: geographical or/and administrative area name, field station number, location personal code, project code, sector code, subsector code, start date, start time, finish date, finish time, site type, stratum type, technique, method, gear, coordinates, fishing effort (time, distance, area), etc.

For good report writings, these are indicated to be done immediately after or in short time after the field activities. Properly completed data sheets are submitted to contractor on a certain time periods basis.

(Noss, 1990; Gutreuter, 1993; Angradi, 2006; Bănăduc, 2008; Oprean and Popa, 2010: West et al., 2008).

4. FISH DIVERSITY MANAGEMENT

The fish diversity continues to decline in the Carpathians Basin, in response to intense anthropogenic threatening elements. At the same time, natural resources and services management are obviously deficient to change this situation, new effective basin planning of priority strategy is still needed. However, despite the scientific data on planning for fish management, policy and strategic actions are many times compromised by lack of logic and of clarity in specific terms and proper expertise. As a consequence each basin in each eco-geographic area should have specific adapted management approaches.

The management plans should integrate the fish role for the local communities and widely accepted values as: food, passive recreation, active recreation, occupation, cultural benefits, educational benefits, genetic resources, biodiversity ethic, etc.

Fish does not stop at national boundaries, so the best way to protect, conserve and manage fish diversity is by close trans-boundary and international co-operation between all the countries within the Carpathian area: Serbia, Romania, Ukraine, Slovakia, Hungary, Czech Republic, Poland and Austria.

The river basin approach only can offer a proper management to fish and associated abiotic and biotic elements. In this respect the Carpathian basins of the European Union countries are managed since 2000 using the river basin approach in relation with the EU Water Framework Directive.

The management plans for each approached basin or sub-basin should include all the significant present or potential pressures as: organic pollution from urban and rural settlements wastewater, organic pollution from industry, organic pollution from agriculture, nutrient point source pollution, nutrient diffuse source pollution, hazardous wastes pollution, river and habitat continuity interruption, hydromorphological alterations, disconnection of adjacent wetlands/floodplains, hydrological alterations, sedimentation, invasive species. Here, should be included also: a description of the main pressures, an integrated overview on the monitoring networks, the modified water bodies inventory and characterisation, a social and economic analysis of the lotic systems resources and services, water quantity characterisation, climate change perspective, protected areas inventory and characterisation, etc.

At the base of the management decisions (in special regarding the partitioning of the lotic ecosystems resources and services) can stay mathematic models which allow the prognosis of the fish communities diversity (expressed through diversity indexes) in the conditions of the habitat characteristics variation, or mathematic models which reveal the variation of some parameters of fish populations in relation with the variation of the habitat characteristics.

Each basin, or each basin considered important should have a specific adapted management plan. In this respect, here will be presented some specific management elements for three considered Carpathian rivers (Cibin River, Târnava River and Vişeu River.

Cibin River

The Cibin lotic system (78 km length) watershed (2210 km^2) is situated in the center of the Romanian national territory (between 45°10' and 46°20' northern latitude and between 23°41' and 24°59' eastern longitude) in the south-west part of Transylvania Depression.

In this case the fish fauna was negatively impacted by human activities effects. Historically, important human impact presence on the Cibin River area started in 1200 – 1300 a.C. period (Niedermayer, 1979; Beşliu, 1998; Beşliu, 2001; Bănăduc-Curtean, 2002; Angela Curtean-Bănăduc, 2011), with minerals exploitation, river banks changes, tributaries deviations, wetlands drainages, sewage wastes and industrial pollutants discharges get started for more than seven centuries till the present moment. More specificaly, in the present, the local ichtiocenosis management actions should face the following main threatnings effects: river channalisation, marshes and floodplain drainages, cut of meanders, river banks reshaping and embanking, tributaries deviations, dams, water and sediments pollution and mineral resource exploitation.

There are few remedies proposed for the hydrotechnical works impact in relation with an optimum management of the fish fauna: land acquisition and wetlands areas ecologic rehabilitation; rehabilitation of river assimilative capacity; the dam lakes water should be use based on an equitable and balanced allocation among the watershed consumers, which must include not only the servitute discharge necessary for the downstream users, but the sanitation discharge too; revitalization of the best traditions for land protection and use; restoration, creation and enhancement of new wetlands; protect and restore sectors of typical local ecosystems; etc.

For the river and its triburaies water and sediments pollution impact minimisation, there are proposed also some important remedies like: increasing water consumption efficiency through general contor meters utilisation and reliable transport pipe systems; keeping inactive the hazardous waste sites; creation of a hazardous site evaluation unit, staffed by biologists and/or ecologists, which represents wildlife interests, involved in the process of identify and clean up inactive and active hazardous waste sites; developing a potential resource damage claim against the major polluters; the physical and chemical standards used to characterised and manage wastwater treatment must be addapted to protect the downstream environment in the below vicinity of the wastewater works; countermeasures against the annual several oil spills; the protected and semiprotected river sectors must be large and dense enough to allow the river self cleaning capacity to be active to face the human impact pressure; the healthy fish populations must be managed like a valuable biological capital whose interest is collected through reducing the expenses for water cleaning technologies; etc.

In oposition with the river bed mineral exploitation or overexploitation effects, a rational gravel mining activity should be based on the river bed exploitation quantities under the annually river bed regeneration rate and on the filtering of the the used industrial water for the sand and gravel washing.

The problems coming from the riverine land exploiation can be minimized or avoided based on some specific remedies: rational grazing on river banks; incentive policies for cultivation of multy-year cultures (forests, vineyards, orchards); rehabilitation of the riverine forest corridors, interdiction of the arable land extension in the minimum 5-15 m riverine corridors along the banks; prohibiting access to the upper parts of the catchment areas (limiting damage from the water erosion) so that spontaneous perennial vegetation could regenerate in best conditions; varying sylviculture and grazing activities; etc.

Totaly or partialy protected from human direct or indirect aggressions, the protected habitats are needed in the context of an optimum management of the ichtiocenosis. The larger a protected area the better it could fulfill its conservation and protection functions. In respect of protected areas the management should be a permissive one in the following directions: a properly conceived protection could be a useful aid to the direct and indirect economic development of the riverine setlements; perfect complementarity should exist, between local development and nature conservation.

Although there is a considerable number of damaging practices and activities affecting Cibin River resources and services, the potential for the recovery is substantial, in case of a proper ecological integrated management. (Curtean-Bănăduc and Bănăduc, 2001).

Vişeu River

The Vişeu River watershed (1606 km^2) is situated in the Maramureş Depression, in the north-west of Romania.

For this watershed fish fauna rehabilitation, protection and conservation, the basin management measures should minimize the impact of: waste waters, non-native fish species escaped from fish farms; hidrotechnical works, riverbed and river banks changing, illegal fishing, solid waste deposits, riverbed minerals overexploitations, increasing average water temperature, eutrophication, mining waste deposits (deposits with Cd, Cu and Zn content), transport of logs in the riverbeds, siltation, clear felling of mountain slopes, illegal sawdust depositation in the rivers and on river banks, etc.

The management of fish populations for increasing their number and biomass represent in fact species protection and conservation. There are some management elements which should be integrated in this basin management like: maintaining of the relatively high and constant water flow; forest water retention capacity should be encouraged by the appropriate forestry management in all the basin; no dam type hydro-technical works should be allowed to be built on the Vişeu River basin in the future; no important water captures should be allowed for hydro-technical works in the neighbouring watersheds; the water quality in the streams should be improved everywhere in the basin where it is a necessity, through (quantitative and qualitative) cleaning activities, canalisation of villages, sawdust management and avoidance of river bed alteration; stopping illegal fishing and forbidding legal fishing for the Danube salmon (*Hucho hucho*); the lower gorge sector of the Vişeu River, including the confluence area, should have a highly restricted protection regime not only for Danube salmon but for all the local fish species (as trophic resources) and for the trophic resources of benthic macroinvertebrates; the aquaculture of Danube Salmon and the artificial stocking and restocking of water bodies of interest should be initiated; significant decrease of physical and chemical pollution; no management actions for trout fishing in the upper lotic systems; no natural and/or semi-natural riverbed modifications; etc.

From the perspective of management objectives and measurements required, in the Vişeu River watershed two management zones can be revealed: 1. zones which should be managed for biodiversity conservation - Vaser Watershed, upper Ruscova watershed, upper Vişeu River, Vişeu River Gorge. In these areas the natural structure of the habitats and the fish communities, and the natural dynamic of the ecologic processes, are still existing. 2. Zones where the resources should be used in a sustainable way – zones in which resources and lotic ecosystems services can be used within the self-regulation and self-support limits of these ecologic systems. (Oprean et al., 2009)

Târnave rivers

The Târnava River basin (6157 km2) is placed in the central part of Romanian Carpathians arch, drain the Transylvanian Depression, respective its southern section the Târnavelor Plateau, and vary significant in climate, geology, relief, hydrology and anthropogenic impact.

For this watershed fish fauna diversity rehabilitation, protection and conservation, the basin management actions should minimize the impact of: hydrotechnical works (drainage works in the river's floodplain, marshes and secondary channels and tributaries deviations, embanking of some river sectors and some ponds and wetlands connected with the river drainage, cutting meanders, river banks reshaping and embankments, floodplain and marshes drainages and tributaries deviations, dams); river bed "cleaning"; water overabstraction; riverbed sediments overexploitation (the banks and river bed increased erosion, reshaping and elevation changings, the downstream excessive siltation and decrease of water quality); water pollution (hazardous wastes, sewage effluent, polluted tributaries; organic substances in different degrees of decomposition, chemical zootechnics disinfectants, phyto-sanitation products, suspensions, detergents, oil products, nitrites, nitrates, sodium chlorite products, organic solvents, synthethic resins, SO_2, SO_3, NO_2, CO, Cr, Pb, Zn, Cu, Cd); riverine lands wrong exploitation (arable lands coming near the rivers, destroyed riverine buffer areas), etc.

For the water and sediment pollution effects remediation, the following management directions/actions should be integrated in the Târnave rivers basins management plan: increasing water consumption efficiency through general contour meters utilization and a reliable transport pipe system; keeping inactive the hazardous waste sites; the creation of a hazardous waste site evaluation unit, staffed by biologists, which represents wildlife interests, involved in the process of identify and clean up inactive and active hazardous waste sites; developing a potential resource damage claim against the major polluters; countermeasures against the accidental oil spills; the protected and semi protected river sectors must be large and numerous enough to allow the existence of the river self cleaning capacity, as a long term cheapest alternative to the present one "polluted water pass away to the downstream effluent"; the healthy river biocoenosis must be managed like a biological capital whose interests is collected through reducing the expenses for water cleaning technologies; etc.

For the hydrotechnical works impact remediation the following management directions should be integrated in the Târnave rivers basins management plan: activities for the river assimilative capacity restoration, including land acquisition and wetlands areas restoration; the Zetea Dam management strategy must be based on the equitable allocation of water resource; revitalization of the best traditions for land protection and use (ecological systematization of riverbanks, protection of lands near the river channel); the impact of inevitable wetlands loss, as long as wetlands may legally be destroyed and in the conditions of the fall in annual precipitation in the last quarter of century, can be mitigated and compensated through restoration, creation, or enhancement of other wetlands; protect and restore sectors of typical local ecosystems.

For the river bed mineral overexploitation remediation, should be imposed a rational gravel mining activity, based on riverbed exploitation quantities under the annually riverbed regeneration rate and filtering the used industrial water for the minerals washing.

For the riverine land wrong land exploitation remediation, the following management directions should be integrated in the Târnave rivers basins management plan: determine of incentive policies for cultivation of multy-year cultures; rehabilitation of riverine forest corridor, with interdiction of the arable land extension in the minimum 5-20 m riverine corridor along the river banks; rotating rational sylviculture and grazing activities, having regard to seasonal conditions, especially on the river banks.

Past and present active response actions, carried out or planed do not or will not sufficiently remedy the injury to fish populations resources without further integrated specific actions. Although there is a considerable number of damaging practices and activities affecting Târnave rivers basin, the potential for the recovery of the fish diversity under qualitative and quantitative aspects is substantial, including many possibilities to recovery them, in case of proper management actions. (Curtean-Bănăduc and Bănăduc, 2005)

4. CONCLUSIONS

The approach used for these basins assessment, monitoring, modelling and management can be used as a model approach for any other Carpathian watersheds, both of economic and conservative interest.

This approach should be based on extensive and intensive biological and ecological data, obtained and monitorised at least along a three-five (better more) years period.

5. ACKNOWLEDGEMENTS

This work was cofinanced from the European Social Fund through Sectoral Operational Programme Human Resources Development 2007-2013, project number POSDRU/89/1.5/S/63258 "Postdoctoral school for zootechnical biodiversity and food biotechnology based on the eco-economy and the bio-economy required by eco-san-genesis"

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