BARBUS MERIDIONALIS RISSO, 1827 POPULATIONS SYSTEM SUPPORT FOR MANAGEMENT DECISIONS SIGHIŞOARA-TÂRNAVA MARE NATURA 2000 SITE – STUDY CASE –

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The ADONIS: CE tool was applied in ichthyology to design an adapted core management model for the Mediterranean barbel (*Barbus meridionalis* Risso, 1827) in the ROSCI0227 area. The model includes habitat characteristics, management aspects required to maintain good conservation status and other similar measures, and the known pressures and threats to the species. We present recommended management advice for *Barbus meridionalis* populations, which offer the possibility of obtaining a favourable conservation status for the species in the next decade. Implementation of this advice would also benefit other fish species of conservation interest who share the same habitat.

Key words: *Barbus meridionalis,* habitat needs, anthropogenic pressures and threats, protected area, management, Sighișoara – Târnava Mare, Romania.

INTRODUCTION

Following the loss of habitats and species from anthropogenic causes across the European Union, in the EU Habitats Directive was ratified by signatory countries, in order to preserve the species and habitats contained in Annex 2 of the Directive. A core part of this Directive was the establishment of the Natura 2000 network, which needs specific onsite management elements.

In Romania, a number of the sites included in the Natura 2000 network make specific reference to fish species, in particular the *Barbus meridionalis* a species of conservation interest. The Natura 2000 network sites were selected based on particular criteria, including: well preserved, constant and vigorous fish populations, appropriate geographical position, characteristic habitats, and low anthropogenic impact. As well as natural features, Natura 2000 also takes into account political and institutional features, including: institutional capacity building; expansion of protected areas; education and outreach to the general public about biodiversity conservation, and effective management of sites of conservation interest (Papp & Toth, 2007).

Barbus meridionalis is a species of Community interest under EU Habitats Directive. Its typical habitat is in the Mureş River, in this river basin was listed also the site ROSCI0227, located in central Romania. It is a short-living, freshwater and benthopelagic species, present in hilly and mountainous lotic systems. It can be found in lotic sectors with clear, fast flowing water and hard riverbeds. Its reproduction period is in spring-summer time. It eats benthic macroinvertebrates (Bănărescu, 1964; Bănărescu & Bănăduc, 2007).

In Romania, suitable habitat areas for *B. meridionalis* had become relatively diminished and fragmented in recent decades because of human impact (Bănăduc, unpublished data).

The ichthyofaunal composition in areas where *Barbus meridionalis* is found in the Sighişoara-Târnava Mare Natura 2000 site (ROSCI0227) reveals smaller and unbalanced (in terms of age classes) populations as a consequence of human impact. The distribution range of *B. meridionalis* populations and their relatively low abundance in the studied area indicate the cumulative effects of decreasing quality in the Târnava Basin lotic habitats (Curtean-Bănăduc *et al*., 2005; Bănăduc *et al*., 2016). This local trend reflects a worldwide tendency towards degradation of aquatic habitats (Gomoiu *et al*., 2009).

Without the implementation of habitat and species management plans, and careful assessments of existing populations and threats to those populations, this trend is likely to continue, both locally and globally, with negative effects on both protected and unprotected areas. In cases where the microhabitats and habitats are properly assessed, clear-cut management elements can be adjusted in a flexible way suitable for local particular habitats/species circumstances, which should make a difference.

Recently, the components of process modeling are increasingly being used to develop “large picture” understandings of particular structures and/or actions of diverse areas of expertise for conservation purposes. Essentially the tools used in such modeling are software products, which are typically used to develop and/or study models of business institutions, and to highlight data regarding the models. They have three principal functions: endorse the actual situation, evaluate the outcomes of potential alterations and recommend strategy and actions to modify the actual situation in a wanted way. Finally the main outputs are recommended diverse paths to create blueprints which suggest particularized management features (Hall & Harmon, 2005).

In this paper, we use this technique in a novel context, that of planning a habitat management plan for conservation of *Barbus meridionalis.*

The main aims of this research are: to highlight the actual status of *Barbus meridionalis* populations in the ROSCI0227 study area; to reveal the effects of human impacts, threats and pressures; and to offer guidance through recommended management elements for the improvement of this species populations ecological status based on a distinct management model, which takes into account the habitat needs of *Barbus meridionalis* and particular habitat indicators, as part of a core management system.

MATERIAL AND METHODS

The case study area, ROSCI0227 – Sighişoara-Târnava Mare Natura 2000 site is located in the central part of Romania, in Mureş, Sibiu and Braşov Romanian administrative units. Biogeographically it is located in the Continental European region (Latitude E 24°49'16", Longitude N 46°8'4", 85,815 ha, 315–829 m a.s.l.). The standard data form of this Natura 2000 site includes the following fish species present on the Habitats Directive (92/43/EEC) Annex 2: *Barbus meridionalis* (Natura 2000 code 1138), *Gobio kessleri/Romanogobio kesslerii* (code 2511), *Sabanejewia aurata* (code 1146), and *Gobio uranoscpus* (code 1122).

The lotic sections of the Sighişoara-Târnava Mare Natura 2000 site where *Barbus meridionalis* individuals were identified are presented in Fig. 1.

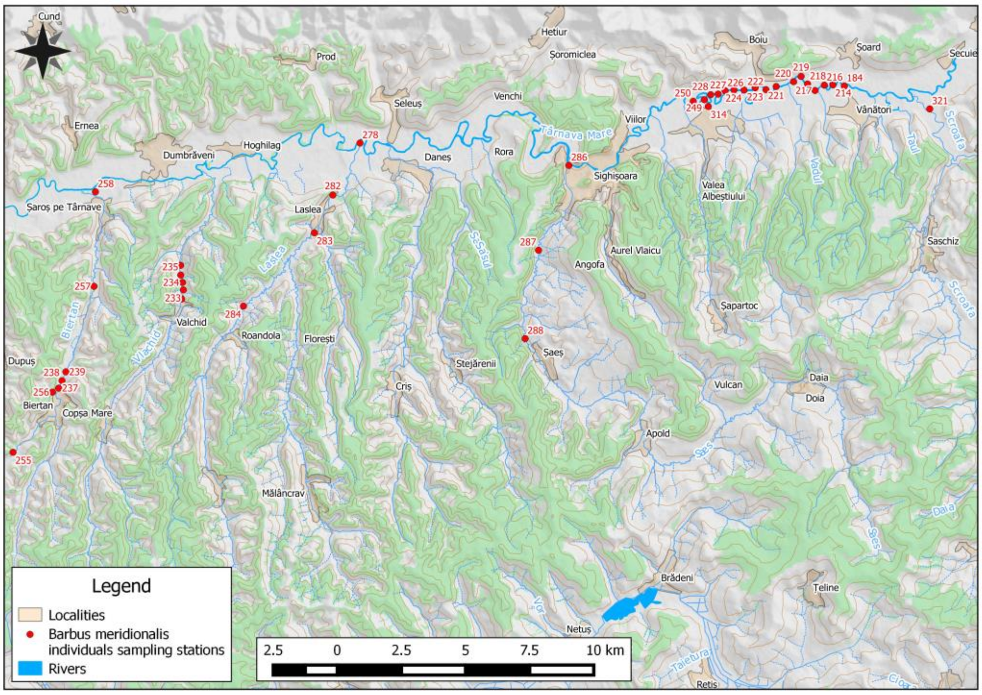

Fig. 1. *Barbus meridionalis* sampling stations on: Scroafa Stream (section 321); Şapartoc Stream (section 314); Şaeş Stream (sections 288, 287, and 286); Laslea Stream (sections 284, 283, 282 and 278); Biertan Stream (sections 258, 257, 256, 255, 239, 238 and 237); Târnava Mare River (sections 250, 249, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 214 and 184); Valchid Stream (sections 236, 235, 234, 233, and 232).

Sampling for *Barbus meridionalis* individuals was carried out between 2012–2014, using fishing nets. Captured individuals were identified on site and immediately released in the water. The fish populations ecological status was assessed in relation to the local anthropogenic impact, and specific pressures and threats to this fish species' habitat.

These researched fish populations ecological status was assessed based on particular created criteria as the followings: distribution range area, populations dimensions, equilibrated age classes, and the number/proportion of individuals of *Barbus meridionalis* in the studied fish communities. The researched species habitat necessities, pressures, and threats, were evaluated based on their presence or absence and *Barbus meridionalis* populations ecological status.

To identify key management features required for species survival and for good conservation status in the study area, the researchers made use of an adjusted model of management. Therefore, the researchers adapted the ADONIS: Community Edition (CE) software, created by the Business Object Consulting (BOC) Group. ADONIS: CE is free software provided by the BOC Group as an entry point to Business Process Management and to the more complex ADONIS software. ADONIS: CE uses Business Process Model and Notation (BPMN), a particular standardized modeling language which is suitable for visualization of processes.

RESULTS AND DISCUSSION

Barbus meridionalis populations ecological status assessment

Barbus meridionalis populations status on the Târnava Mare River vary from very good in the sections 250, 249, 223, 222, 220, 219, 218, 217, 216, 214, and 184, to good in section 221, to low in sectors 228, 227, 226, 225, and 224 (fig. 1) depending on the level of degradation of habitats. The quality of lotic habitats suitable for *B. meridionalis* on the Târnava Mare River is good or average. *B. meridionalis* population status on the Şapartoc Stream (in section 314) is low, due to an average/low habitat quality status. The studied fish species population status on Scroafa Stream (in section 321) is low, in a low habitat quality status. The status of *B. meridionalis* population in Şaeş Stream (sections 288, 287, and 286) is low and low is the habitat condition too. *B. meridionalis* population status on the Laslea Stream (sections 284, 283, 282, and 278) is low, similar with the habitat condition (low). The studied fish species population status on Biertan Stream (in section 321) vary among very good in 258 section, good in the 257 and 256 sections and low in the sections 255, 239, 238 and 237 is low, in a general average habitat quality status. The Valchid Stream studied population state varies between good (section 236) and low (sections 235, 234, 233 and 232) in the conditions of a general average habitat quality status in respect of *Barbus meridionalis* ecological needs.

Human pressures and threats

During this research in the Târnava Mare River, Şapartoc, Scroafa, Şaeş, Laslea, Biertan, and Valchid streams, relatively diverse pressures and threats on the *Barbus meridionalis* populations were found, including: sedimentation of aquatic habitats with silt due to poor agricultural practices, poorly implemented river channel alterations, riverine flooding from precipitation due to diminishing riparian vegetation; constant diffuse pollution; liquid and solid discharges; appearance and expansion of invasive and competitive fish species (i.e. *Pseudorasbora parva*); expansion of native but competitive fish species (*Gobio gobio*); lotic habitat fragmentation due to anthropogenic physical and/or chemical barriers (i.e. Copşa Mică, Mediaş); poaching; poor waste disposal near rivers and streams; river regularisation and straightening, and riverbed mineral overexploitation.

Specific needs

The studied species requires relatively cold and well-oxygenated water, with moderate-fast water speed; no cascades, rocky rather than sandy riverbeds, and can tolerate only moderate sediment suspension. Breeding habitats for *Barbus meridionalis* include high water velocity and moderate to well-oxygenated habitats with rocky substrata. Both the juveniles and adults are medium sensitive to organic pollution (Bănărescu & Bănăduc, 2007).

Specific habitat indicators

Based on *B. meridionalis* presence/absence and relative abundance in the studied lotic systems, indicators for this species habitat were proposed: water surface ratio with relatively high speed (66%), sandy riverbed substrata ratio (33%), pebbles substrata surface ratio (66%), riverine vegetation ratio (100%), and water clarity (50–100 cm).

Management measures

The natural morphodynamism of the inhabited lotic systems must be maintained.

Complex fish passages must be built to decrease the impact of the dams and remove semi-stagnant sectors in the sectors where there is mineral exploitation. Mineral exploitations should be forbidden for streams like Şapartoc, Scroafa, Şaeş, Laslea, Biertan, and Valchid. For the Târnava Mare River a minimum distance of 5 km between exploitation sites should be established, and the amount of extraction should not be greater than the natural self-restoration capacity.

Plants conservation, especially of shrubs and trees, in the riverine area is needed to reduce silt erosion and transport. Agricultural plants that do not need tillage are better to be used in this respect in the studied basins. Keeping riverine natural vegetation, with a minimum width of 50–100 m (Târnava Mare River) and 25–50 m (Şapartoc, Scroafa, Şaeş, Laslea, Biertan, and Valchid streams) on the banks is needed for their role as silt pitfalls.

Between April–July (reproduction period) it is advisable to ban fishing and also any human actions that can move the river substrata sediments.

An effective control system is needed to control poaching.

The illegal deposition of waste of any categories in lotic system areas have to be controlled and banned where possible.

There should be kept as low as possible the human impacts effects induced by organic and chemical pollution.

An yearly basic monitoring system, to include the fish fauna and organic pollution elements, is recommended.

Site adapted management model

The specific process for the selected site management model is based on activities (squares), decisions (triangles) and variables (circles) (Figs. 3 and 4). The principal objects used here to design the *B. meridionalis* specific management model for ROSCI0227 with ADONIS: CE are given below (Hall & Harmon, 2005).

A process in this management model is described as a series of steps and can be modeled relying on activities, decisions and sub-processes, documents attached to different activities and notes. The activities represent part of a process. The decisions are the main part of this process because for every decision, a probability for successful completion of activities can be selected (used in the analysis and the simulation). To each decision a probability condition can be assigned using variables and random generators . Models structured in sub-processes support better process organization and understanding.

In this paper we modeled the ecological requirements of *Barbus meridionalis*, including conditions which ensure favorable conservation status alongside critical requirements for habitat and management measures that can be taken to ensure species preservation. Fig. 2 shows the processes modeled, starting from the main process, namely *Barbus meridionalis* Sighişoara_Târnava Mare. The other processes revealed in the figure are part of the basic model, and were modeled as sub-processes. This management model was conceived as a sequence of sub-processes from the underlying process: *Barbus meridionalis* Sighişoara_Târnava Mare.

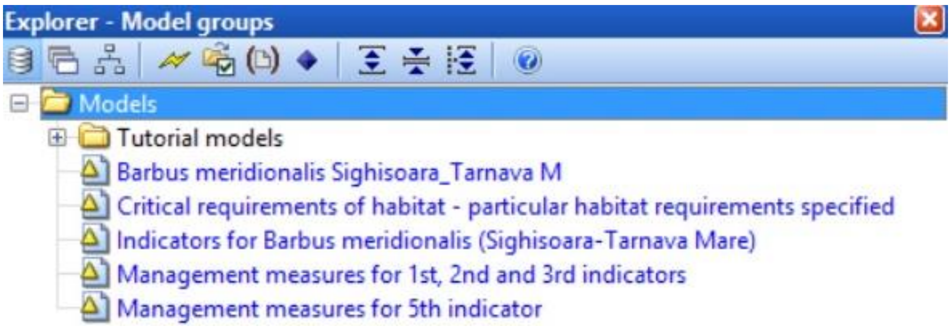

Fig. 2. Table of content for modeled processes.

The basic process is modeled using seven activities, a sub-process and a decision (Fig. 3). The process begins with two activities that present the scientific and common names of the species, continuing with sub-process Critical requirements for habitat (Fig. 4), and the decision whether or not species is in favorable conservation status. If it is – decision: “The conservation state is favorable?” Probability = 15% for YES branch – then the process continues with other characteristics of species structured in five activities chained (including other environmental requirements, reproduction, distribution in protected area, current pressures on species, threats) and the process ends. If the species does not fulfill conservation conditions – decision: “The conservation state is favorable?” Probability = 85% for NO branch – then the programme resumes sub-process Critical requirements for habitat until those conditions are met.

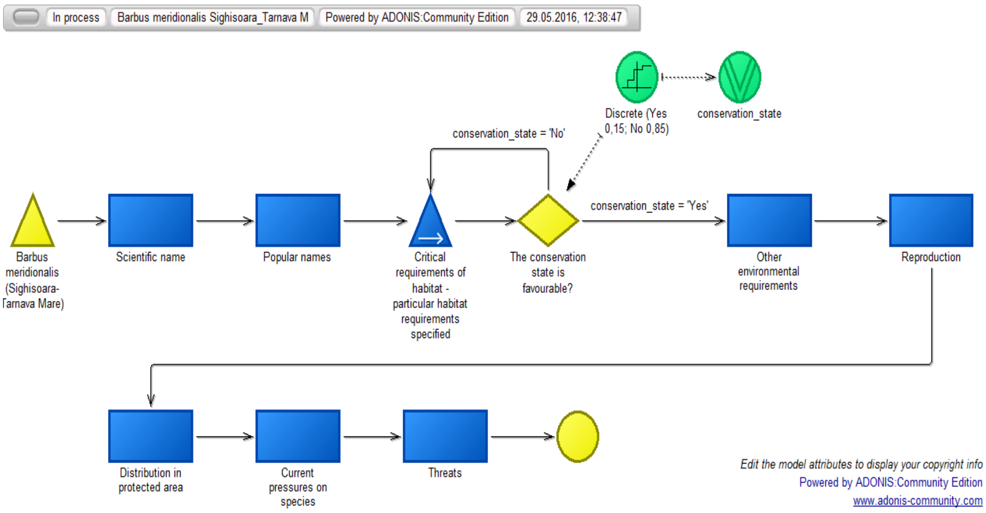

Fig. 3. *Barbus meridionalis* species – basic process.

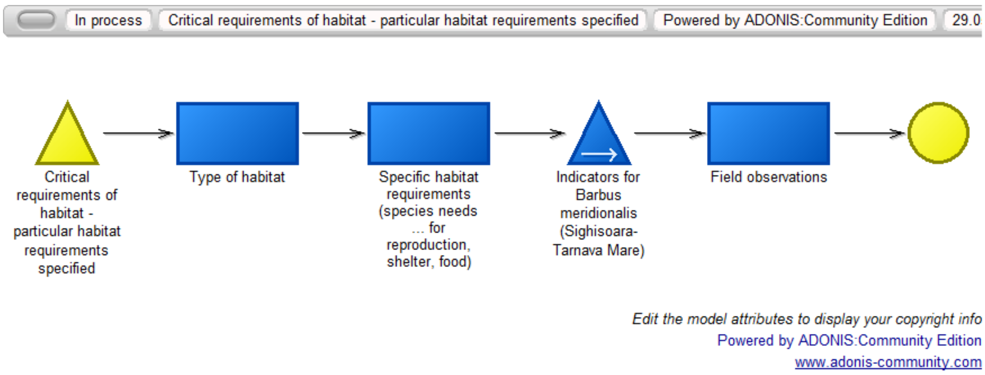

Fig. 4. Critical requirements
for *Barbus meridionalis* species – subprocess.

Next come the Critical requirements for habitat sub-process (Fig. 4) that shows the critical needs of the species and possible indicators measured on the ground. It was made using three activities – which describe type of habitat, specific habitat requirements (species needs for reproduction, shelter, food) and different field observations – and one sub-process (Fig. 5) which restricts species possible indicators and the percentage in which they are found.

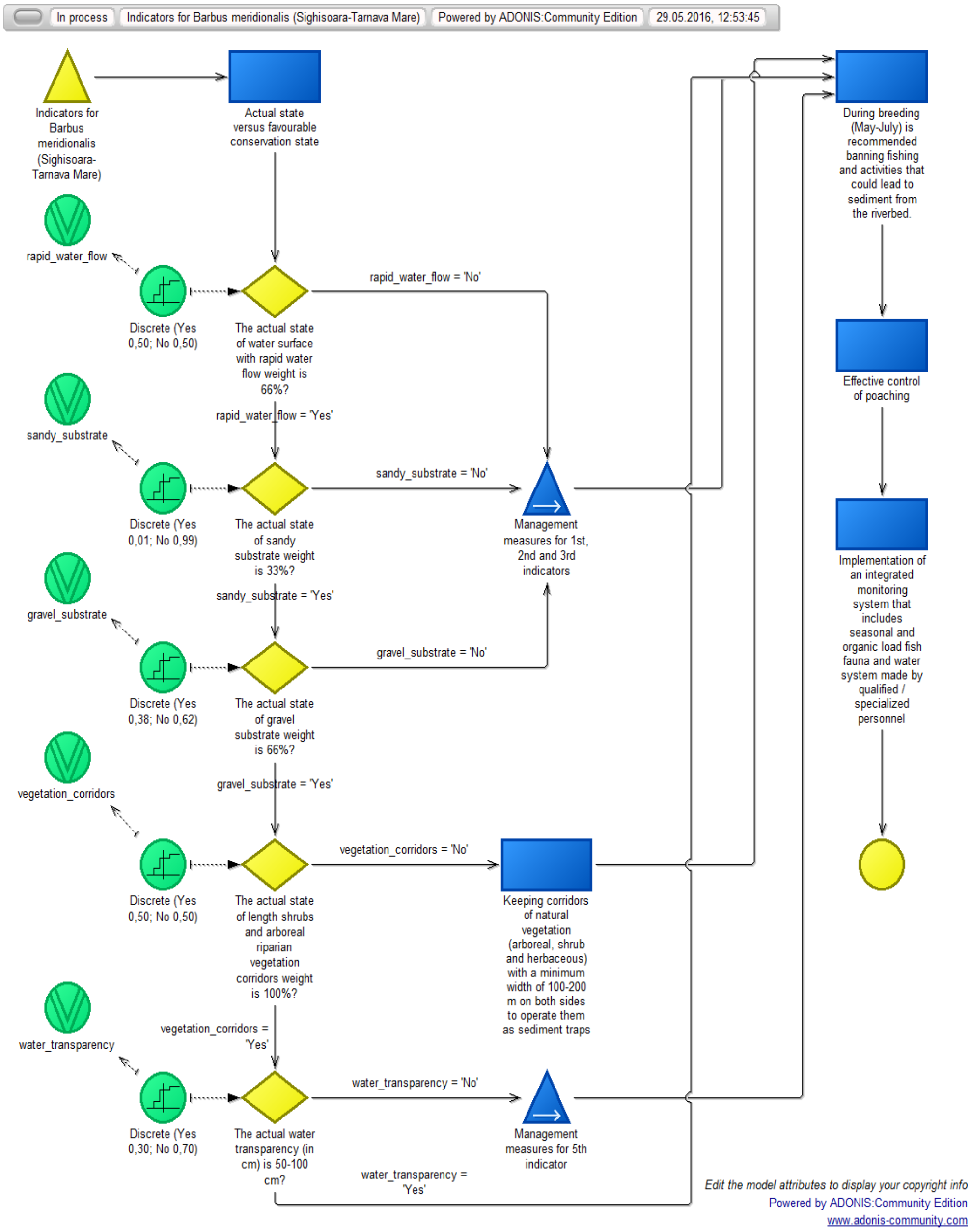

Fig. 5. *Barbus meridionalis* indicators – subprocess.

The subprocess Indicators for *Barbus meridionalis* (Sighişoara-Târnava Mare) (Fig. 5) starts with activity Actual state *versus* favorable conservation state where are mentioned the values for actual state (measured on the field) and favorable state for the possible indicators. Then follows a chain of five decisions, which are the possible indicators: water surface with rapid water flow weight, sandy substrate weight, gravel substrate weight, length shrubs and arboreal riparian vegetation corridors weight, water transparency (in cm). The process continues using decisions and goes through each indicator. If the current value of the indicator measured is the same as favorable, then it comes to the next indicator. If the current value is not the same as favorable, then it follows the sub-processes (Figs. 6 and 7) or activities – that the management measures recommended. Regardless of the route followed, the process ends with the last three activities, namely: banning fishing and activities that lead to excessive sedimentation during the breeding season (May–July); more effective control of the intense and quasi-permanent patching on all sectors of interest rivers; and implementation of an integrated seasonal monitoring system that includes fish fauna and organic pollution.

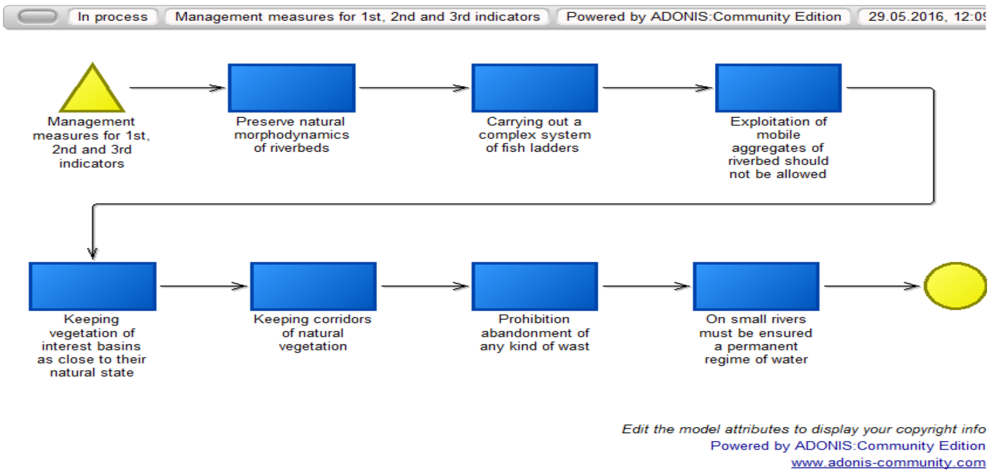

Fig. 6. Management measures for $1^{st,}$ 2^{nd} and 3^{rd} indicators – subprocess.

For example, if the programme chooses the YES branch through the first indicator (decision = "The actual state of water surface with rapid water flow weight is 66%?", variable = "rapid_water_flow", probability = 50% for YES) and for the second indicator the NO branch (decision = "The actual state of sandy substrate weight is 33%?", variable = "sandy_substrate", probability = 99% for NO) then it follows sub-process Management measures for 1st, 2nd and 3rd indicators, and its related activities (Fig. 6).

If the programme selects the YES branch through each indicator until reaching the fourth indicator and goes on NO branch (decision = "The actual state of water surface with rapid water flow weight is 66%?", variable = "rapid_water_flow", probability = 50% for YES, decision = “The actual state of sandy substrate weight is 33%?”, variable = “sandy_substrate”, probability = 1% for YES, decision = “The actual state of gravel substrate weight is 66%?”, variable = “gravel_substrate”, probability = 38% for YES, decision = “The actual state of length shrubs and arboreal riparian vegetation corridors weight is 100%?”, variable = “vegetation_corridors”, probability = 50% for NO), then here, as management measure to be taken is described only one activity, namely: keeping corridors of natural vegetation (arboreal, shrub and herbaceous) with a minimum width of 100–200 m on both sides to operate them as sediment traps.

If you go on YES branch for each indicator (decision = “The actual state of water surface with rapid water flow weight is 66%?”, variable = “rapid_water_flow”, probability = 50% for YES, decision = “The actual state of sandy substrate weight is 33%?”, variable = “sandy_substrate”, probability = 1% for YES, decision = “The actual state of gravel substrate weight is 66%?”, variable = “gravel_substrate”, probability = 38% for YES, decision = “The actual state of length shrubs and arboreal riparian vegetation corridors weight is 100%?”, variable = “vegetation_corridors”, probability = 50% for YES) and for the last indicator (5th) the NO branch (decision=” The actual water transparency (in cm) is 50–100 cm?”, variable = “water_transparency”, probability = 70% for NO), then follows subprocess Management measures for 5th indicator (Fig. 7), after which it continues with the latest activities described above and the process ends.

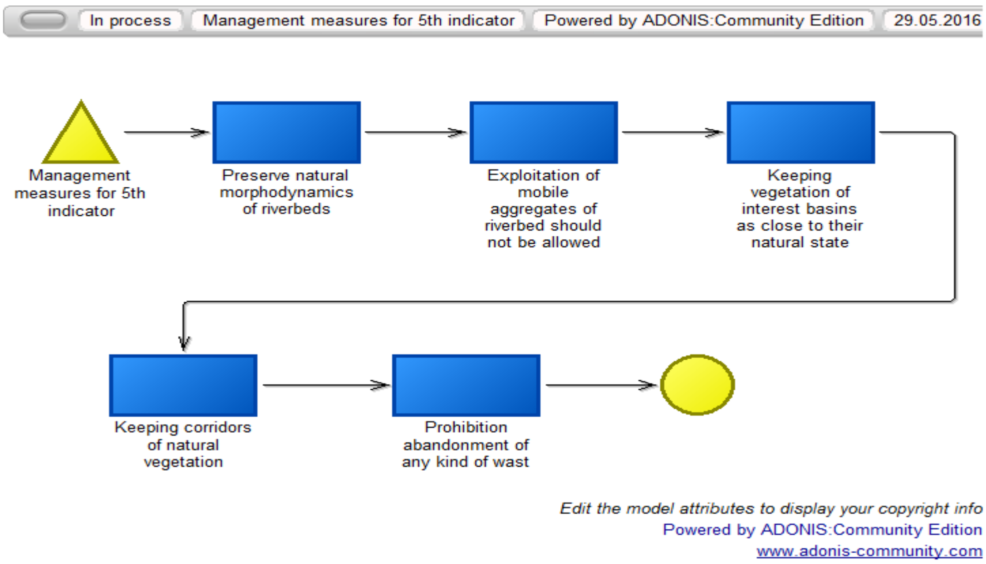

Fig. 7. Management measures for 5^{th} indicator – subprocess.

The subprocesses Management measures for the 1st, 2nd and 3rd indicators and Management measures for the 5th indicator are made of a sequence of activities (the first sub-process – seven activities, the second sub-process – five activities) and represents management measures that should be taken to ensure the favorable conservation status of the species.

CONCLUSIONS

The main identified pressures and threats to the fish species *Barbus meridionalis* conservation status in the ROSCI0227 Natura 2000 site are: sedimentation of aquatic habitats with silt due to poor agricultural habits, poorly accomplished river channel altering works, riverine areas flooding and washing by precipitations due to diminishing riparian vegetation; constant diffuse pollution; appearance and expansion of competitor invasive fish species; expansion of competitor tolerant fish species; lotic habitat fragmentation due to anthropogenic physical and/or chemical barriers; poaching; waste deposited near or in rivers and streams; river regularization and riverbed mineral overexploitation.

Important management measures for *Barbus meridionalis* conservation are: the natural morphodynamics of the lotic systems must be maintained; complex fish passages must be built to decrease the impact of dams and semi-stagnant sectors in the sectors where there is mineral exploitation; mineral exploitation should be forbidden for the streams like Şapartoc, Scroafa, Şaeş, Laslea, Biertan, and Valchid, for the Târnava Mare River a minimum 5 km distance between these exploitations should be maintained and the exploited quantities should not be greater than the natural self-restoration capacity; plant protection, especially shrubs and trees, in the riverine areas is needed to reduce silt erosion and transport; encouragement of use of agricultural crops that do not need tillage would also act to reduce silt erosion; between April–July (reproduction period) it is advisable to ban fishing and also any human actions that can move the river substrata sediments; an effective control is needed in respect of the permanent poaching issue; the illegal deposition of wastes of any categories in lotic system areas have to be controlled and banned; we must keep human impacts from organic and chemical pollution as low as possible; and it is strongly recommended that an annual monitoring system is established, which should include the fish fauna and organic pollution elements.

The ADONIS: CE software was used in this study to build a management model for *Barbus meridionalis*, a fish species of conservation interest under Natura 2000. The model included its principal necessities for habitat, and the indicators that reveal a good ecological status – the management measures, and the threats and pressures which influence this species. We recommend that this tool be used to build a larger management model for all the fish fauna in the region.

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