MANAGEMENT DECISIONS SUPPORT SYSTEM FOR *RHODEUS AMARUS* (BLOCH, 1782) SPECIES POPULATIONS IN OLTUL MIJLOCIU – CIBIN – HÂRTIBACIU NATURA 2000 SITE (ROMANIA)

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ABSTRACT: The main threats to the Rhodeus amarus (Bloch, 1782) populations in the Natura 2000 site Oltul Mijlociu – Cibin – Hârtibaciu are the hydro technical modifications of the riverbeds, chemical pollution and poachery. ADONIS:CE is used in general for modeling business processes, but here was used in ecology/biology domain. The authors obtained a Rhodeus amarus model which included all the habitat species requirements, the indicators that provide favourable conservation status and the existing threats and pressures. The maintaining of the minor riverbed morphodynamics is very important – the meanders presence is very important for the local molluscs which are living in the inner U shape parts of the river. The places, where the sediments (sand, mud) are relatively stable, provide suitable habitats for molluscs important for the breeding of Rhodeus amarus. The maintaining of the actual regimes of liquid flows and oxygenation, and the avoidance of increasing of the sediments deposition rate in the water are necessary also for those molluscs species presence conservation. The extraction of sediments in these rivers should be made in correspondence with their natural rate of refilling and at sites at a distance of minimum five kilometres from each other.

KEY WORDS: Rhodeus amarus, threats, pressures, habitat fish species requirements, management process modelling.

1. INTRODUCTION

Romania as all European Union member states, have to assure a strict protection of the species listed in the Habitats Directive Annex 2 and not allow the deterioration of ecological status induced by human activities (*, 1992).

The Natura 2000 sites in Romania, including also those for fish species protection, were proposed for conservation of their ecological status. The proposals were based on specific criteria, such as: typical natural habitats, well preserved, stable and healthy fish populations, favorable geographical position, and relatively low human impact. In general, there are few major ways, through which the Natura 2000 network initiative can improve the EU member states nature protection: the extension of the natural areas' surface, institutional capacity building, raising awareness, as well as the implementation of correct management plans for the protected areas. (Bănăduc, 2001, 2007a, 2008a, b, 2010, 2011, Bănăduc et. al., 2012, Curtean-Bănăduc and Bănăduc, 2008).

One of the fish species of Community interest is the European bitterling, *Rhodeus amarus* (Bloch, 1782). These species individuals are living in fresh and standing or slow flowing water, preferably among macrophytic vegetations, over sand and muddy bottom. The species achieves sexual maturity at age one and at about 30-35 mm standard length. The spawning occurs in the end of April till August and it is closely related with freshwater mussels (*Unio* and/or *Anodonta*). (Bănărescu 1964; Bănărescu and Bănăduc, 2007). During the spawning season, males develop bright nuptial coloration and defend area around mussel, while females develop long ovipositors using to deposit eggs onto the gills through the exhalant siphon. Males fertilize the eggs by releasing sperm into the inhalant siphon of the mussel which carries the sperm to the eggs (Smith *et al*., 2004). Embryos reside inside the mussel for approximately one month up to active swimming capacity (Aldridge, 1999). The species feeds mainly on filamentous green algae, diatoms and plant detritus, and rarely on crustaceans and insect larvae. It has a short life span; maximum reported age is five years. In the population, males usually predominate over females, especially on the spawning grounds (Bănărescu, 1964, Holcik, 1999, Bănărescu and Bănăduc, 2007). The species is vulnerable to water pollution and ambient temperature changes, and alteration in its proper habitat (Holcik 1999).

On the Romanian national territory the range of the *Rhodeus amarus* becomes more fragmented, especially in the last half of the century, due to the human impacts, which are different from one basin/basin sector to another and even in some protected areas (Ardelean and Wilhelm, 2007b, Battes *et al*., 2003, 2005, 2009, Bănăduc, 2001, 2005, 2007, 2008a, b; Bănăduc and Curtean-Bănăduc, 2013, Bănăduc *et al*., 2013, Bănărescu, 1964, Bănărescu and Bănăduc, 2007, Costiniuc and Gorgan, 2004,

Costiniuc *et al*., 2006a, b; Florea and Contoman, 2014a, b, Oţel, 2007, Pintileasa *et al*., 2011, Pricope *et al*., 2001, Radu *et al*., 2008, Simalcsik *et al*., 2004, Telcean, 1999, 2010, Telcean and Bănărescu, 2002, Telcean and Cupşa, 2009a, b, Meşter *et al*., 2003, Momeu et al., 2009, Năstase *et al*., 2008, Năvodaru, 2004, Năvodaru and Năstase, 2006, Ureche, 2008, Ureche *et al*., 2010, 2013, Vornicu *et al*., 2006).

The current structural composition of the fish communities, including *Rhodeus amarus*, in the Natura 2000 site Oltul Mijlociu – Cibin – Hârtibaciu (ROSCI0132) shows decreased numbers as a result of historical continuous human impact. The distribution patterns of the fish communities and their abundance variation in this protected area reflects the associated effect of river habitat quality in the Olt River basin (Bănăduc 1999, 2000, 2001, 2005, Curtean-Bănăduc *et al*., 2007, Curtean-Bănăduc and Bănăduc 2001, 2004a, b, Curtean *et al*. 1999).

In a general context in which aquatic ecosystems become a priceless resource, the human impact on them is expected to increase (Curtean-Bănăduc and Bănăduc 2012).

In this context, no general management elements can be strictly used based on a copy paste approach in all protected areas due to the fact that different location conditions should be assessed and monitored, and only after that the appropriate management measures should be adapted and used for the local specific conditions.

Recently, process modeling techniques are increasingly being used to have "the big picture" of different systems/actions of any domain and also are used to facilitate understanding of the process steps for an efficient management. Modeling tools are software products that are used by analysts, business managers, or developers to create models of business organizations, to analyze models, and to save information about models and serve three primary functions. First, they document an existing situation. Second, they assist in analyzing the effects of possible changes. Third, they document plans to change the existing situation in some way. As a result they provide the ability to create various types of diagrams with valuable management elements. (Hall and Harmon, 2005)

The aims of the present research are: to highlight the current state of Rhodeus amarus population in the Natura 2000 site Oltul Mijlociu – Cibin – Hârtibaciu; to underline the current human pressures and threats; to reveal management measures for the preservation and improvement of the species conservation status with the help of management model based on specific requirements of the species and specific habitat indicators, as a management decision support system.

2. STUDY AREA AND METHODS

The Natura 2000 site Oltul Mijlociu – Cibin – Hârtibaciu, (24.324444 longitude, 45.682778 latitude, 2826.10 ha surface, 314 m minimum altitude, 568 m maximum altitude) is situated in Sibiu, Braşov and Vâlcea counties, a part of the Alpine and Continental biogeographic regions. The protected site was proposed also for ten fish species of the Habitats Directive (92/43/EEC) (*), (*Rhodeus sericeus amarus* Natura 2000 code 1134, *Pelecus cultratus* code 2511, *Barbus meridionalis* Natura 2000 code 1138, *Cobitis taenia* code 1149, *Sabanejewia aurata* code 1146, *Gobio kessleri* 2511, *Zingel streber* 1160, *Zingel zingel* 1159, *Aspius aspius* code 1130, *Gobio uranoscpus* code 1122).

Study area and river sectors where *Rhodeus amarus* individuals were sampled are shown in Fig. 1.

The fish individuals were sampled in 2011-2014 period, with specific fishing nets (active and/or passive fishing nets) and by electrofishing, followed by on site identification up to a species level, and an unharmed release immediately afterwards in their natural habitats.

The *Rhodeus amarus* species populations were monitored and their conservation status assessed in different sectors in relation to the human pressures and threats identified in this species habitats.

The fish populations status was assesses based on population size, balanced distribution of individuals on age classes, distribution area size, and percentage of individuals of the species of interest in the structure of fish communities.
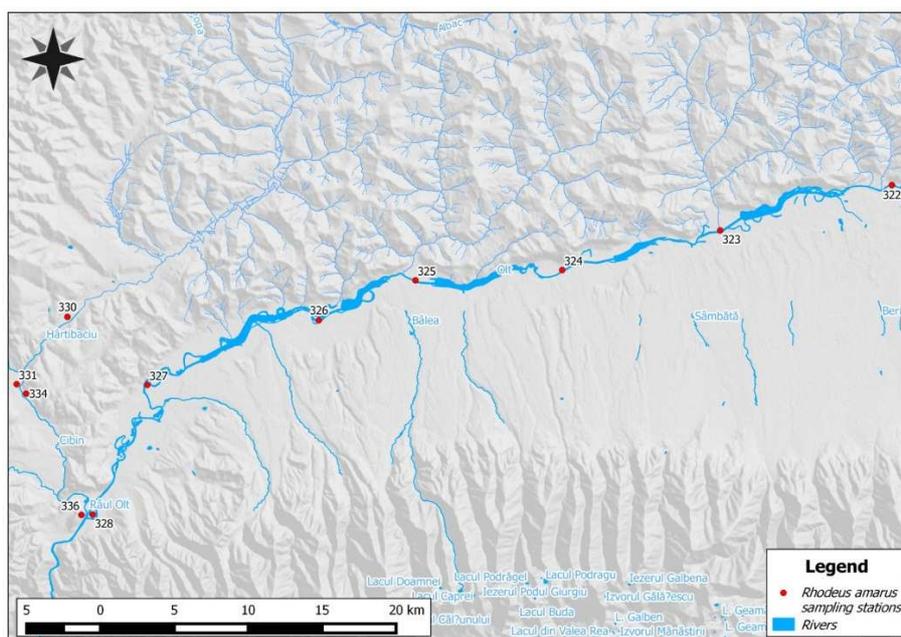

Figure 1. *Rhodeus amarus* individuals sampling stations: Cibin River 334 and 336, Hârtibaciu River 330 and 331 and Olt River 322, 323, 324, 325, 326, 327 and 328 (Geographic Information System support Mr. Pătrulescu A.).

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The pressures, threats, and the specific species requirements were identified and selected in the field based on their relation to the fish communities' status.

In order to select the management measures that have to be taken to ensure the species favourable conservation status and illustrate the process, a management model was used. The model was ADONIS:CE, developed by Business Object Consulting. ADONIS: Community Edition is a free tool provided by the BOC Group which serves as a perfect entry point to professional Business Process Management and as a way to become familiar with ADONIS. ADONIS:CE is a functional and feature rich stand-alone version of ADONIS with some limitations in comparison to the commercial edition. BPMN (Business Process Model and Notation) is an international standardized modeling language used for the illustration of processes. Processes can be modeled simply, quickly and intuitively, using uniform notation (**). In Table 1 and Fig. 2, are extracted and explained the basic objects of ADONIS: CE (Hall and Harmon, 2005), used to model *Rhodeus amarus* species management.

3. RESULTS AND DISCUSSIONS

Rhodeus amarus species populations state assessment

The state of populations of *Rhodeus amarus* in the **Olt** River in the sectors 328, 327, 326, 325, 324 and 323 (Fig 1) was very good in conformity with: population size, balanced distribution of individuals on age classes, distribution area size, and a high percentage of individuals of the species of interest in the structure of fish communities. The exception is the sector 322 where the population state of the species was poor due to the poor habitat conditions. In the Olt River, the habitats in the sectors, in which the species was identified, were in an average condition, excepting sector 322 with a low condition.

The *Rhodeus amarus* population in the **Cibin** River in sector 334 (Fig 1) was low because of: population size, unbalanced distribution of the fish individuals on age classes, and a low percentage of the species individuals in the fish fauna. The characteristic habitat was in an average/low state. In sector 336 (Fig 1) the species was in very good state based on: population size, balanced distribution of the fish individuals on age classes, and a high percentage of individuals of species of interest in the fish fauna. In this sector, the characteristic habitat of the species of interest was in an average/good status.

The *Rhodeus amarus* population state in the **Hârtibaciu** River in the sectors 331 and 330 (Fig 1) was very good/good in conformity with: population size, balanced distribution of the individuals on age classes, and a high percentage of species individuals in the fish fauna structure. The habitats, where the individuals of this species were found, were in a good state.

Current human preassures and threats

In the Olt, Cibin and Hârtibaciu rivers, the following direct pressures on this fish species were identified: destroyng or significant reduction of habitats quality of watercourses due to regularization, pouching including in the reproduction period (April-August); and populations isolation/habitat fragmentation. The indirect pressure was the organic pollution, which caused restricted distribution of mollusc populations, on which the reproduction of *Rhodeus amarus* depends. The identified threats were: loss of habitat features (ponds in the floodplain, the river bends) due to hydraulic structures (accruals, embankments, ballast exploatation, water pollution, poaching through indiscriminate fishing methods).

Rhodeus amarus specific requirements

The adults need freshwater areas of rivers slowly flowing or stagnant, shallow, muddy bottom. The reproduction of this species individuals depends on the presence of these types of habitats, and also on the presence of mussels (*Unio* and *Anodonta* genera) because the female individuals lay their eggs in the mussel paleal cavity, where the larval development takes place (Holcik 1999, Bănărescu and Bănăduc, 2007).

Specific habitat indicators

Based on this species presence and abundance in the studied rivers, the following specific habitat indicators can be considered: areas in the river channel with a water depth less than 0.5 m (66%); weight muddy substrate (33-66%); presence of dead branches and wetlands adjacent to the watercourses (10-33%); plant fragments percentage in the substrate/channel (15%); percentage of slow-water surface (66%).

Management measures

This fish species conservation status can be improved if some management measures will be inforced and maintained, such as: protect the river dead branches and wetlands adjacent to the watercourses; ban of fishing in the breeding period (April-August); control of poaching, which is very intense and cquasi-permanent, in all sectors of the rivers; maintain the liquid flow, the drain current regime, and a regime of relatively good oxygenation of the water, as well as avoid increasing of the amount of different pollutants in water in order to protect all molusks habitats essential for the reproduction of the fish species of interest; maintain the natural minor riverbed-meanders morphodynamics – meanders presence is important for molluscs living in the river bends where sediments (silt, sand) are more stable; preserve the natural vegetation corridors (arboreal, shrub and herbaceous) with a minimum width of 25-100 m on both sides of the water courses, vegetation debries are necessary to ensure the reproduction habitat quality; prohibit the waste abandonment of any kind in the river bed and wetland areas adjacent watercourses; avoid extracting sediments or disturbance by other means of minor riverbed substrate structure of small water courses, maintain of a minimum distance of five kilometers from every river bed mining sectors to the next one; implement integrated monitoring system including for the ichtyofauna.

Site adapted management model

The basic process for the on site management model is based on activities (squares) and decisions (triangles) (Figs. 2-4a-h).

In Table 1, are extracted and explained (from Hall and Harmon, 2005 - Version 1.1, November, 2005, http://mhc-net.com/whitepapers_presentations/2005_Process_Trends_(040306).pdf) the basic objects of ADONIS: CE, used to model the *Rhodeus amarus* species management:

In the left window of the program, you can see all the processes that are modeled as a table of contents (Figure 2). You can browse through them by a simple click. The same happens with the subprocesses created (e.g. Indicators, Management Measures for the first indicator).
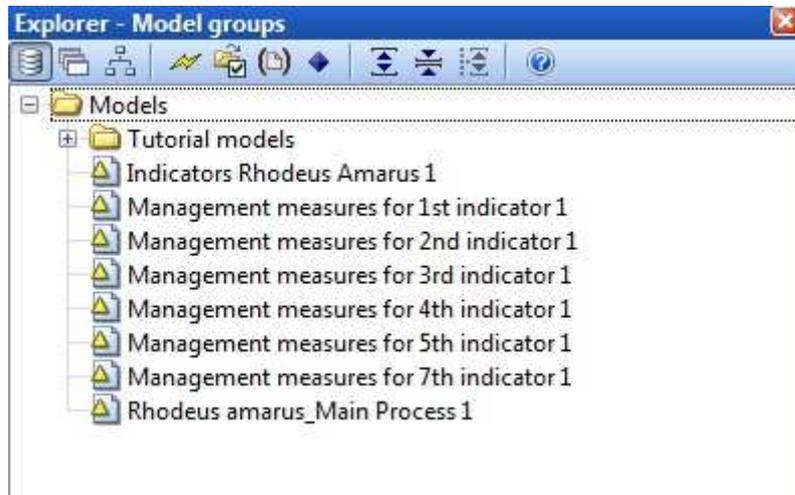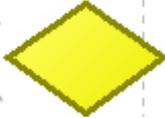
Figure 2. Content/structure of modeled processes.

Table 1. The 2005 Enterprise Architecture, Process Modelling and Simulation Tools Report, Version 1.1, November, 2005.

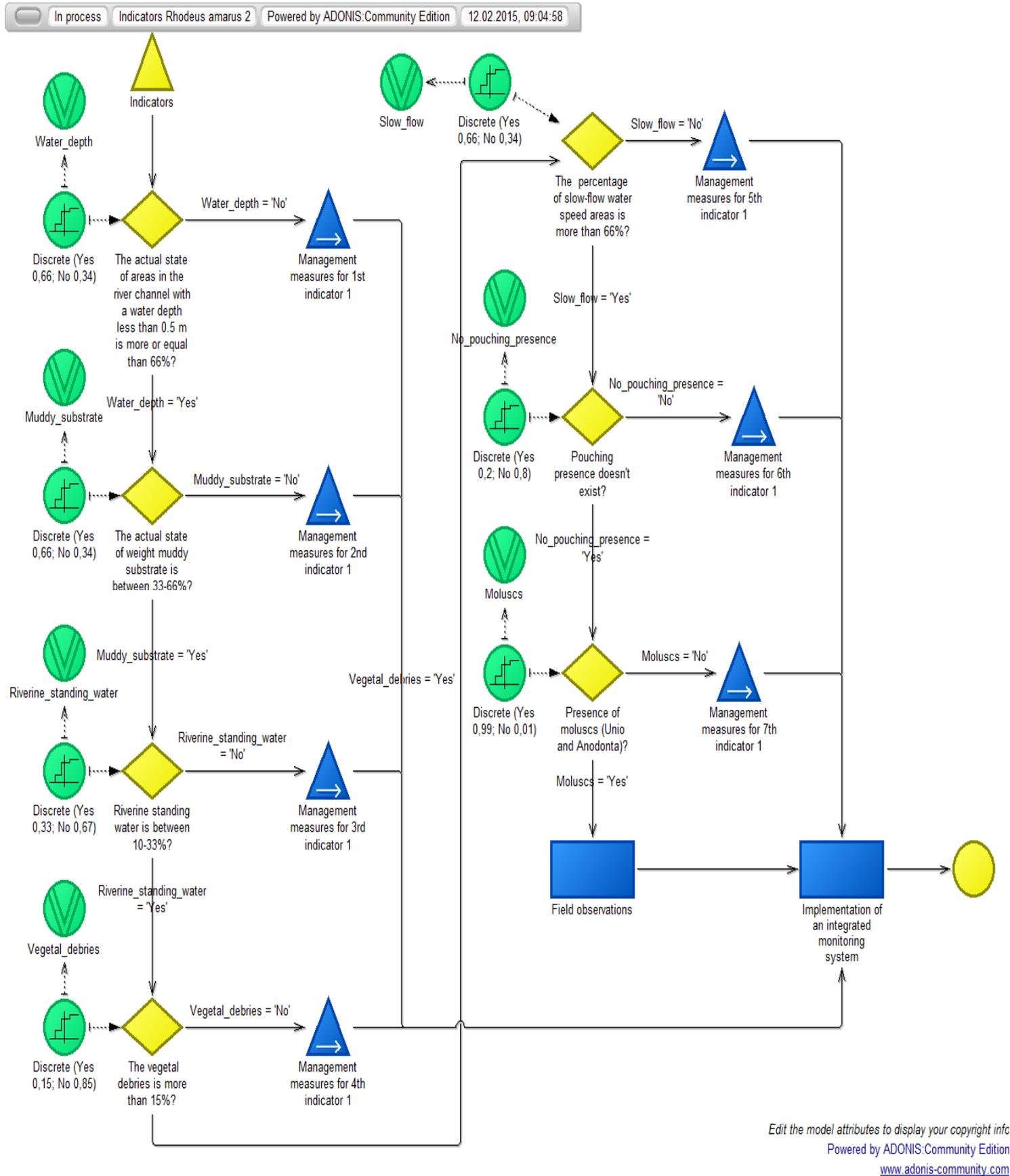|	
Process	A process is any sequence of steps that is initiated by an event; transforms information or materials. Most metamodels and notation systems use the term activity as the smallest unit of a process that is normally pictured on a graphical diagram.
Activity	Activities in ADONIS are used to graphically describe which tasks are executed within a process. Because they can link many elements, activities are key modelling objects. Activities usually define a unit of work that is performed by one or a group of employees following the same procedure, or by a single software module. Some activities are well-defined procedures, while others involve the application of rules and decisions.
Decision rule	The ability to associate rules with activities or decision points within a process is an important feature of any modeling tool because it allows end-users to define activities and processes specifically and accurately. Rules that alter a process sequence are captured and depicted through logical operators, objects, or connectors as is appropriate to the notation used. Transition condition and probability are documented for each branch of the process.
Variable	Variables will be assigned with values in ADONIS process models through assignment objects and will be queried during the process. This way, after branching in the process, paths can be passed according to the assignment of variables - defined in the transition conditions. Transition conditions indicate under which conditions a subsequent connector will pass through a process model during the simulation.
Random generator	Random generator sets a value to a variable to which it is connected. The field "Value" contains the current distribution (the current value of the attribute for which the support dialogue was called). The functional group "Parameter" contains the actual input support. This looks different for every distribution type for being able to define the proper parameters. Choose the type of distribution from the list "Distribution type". The input support is adjusted accordingly.
Subprocess	The ability to use subprocesses can be useful as it provides the ability to drill down to the core level and get a more granular view of a process.
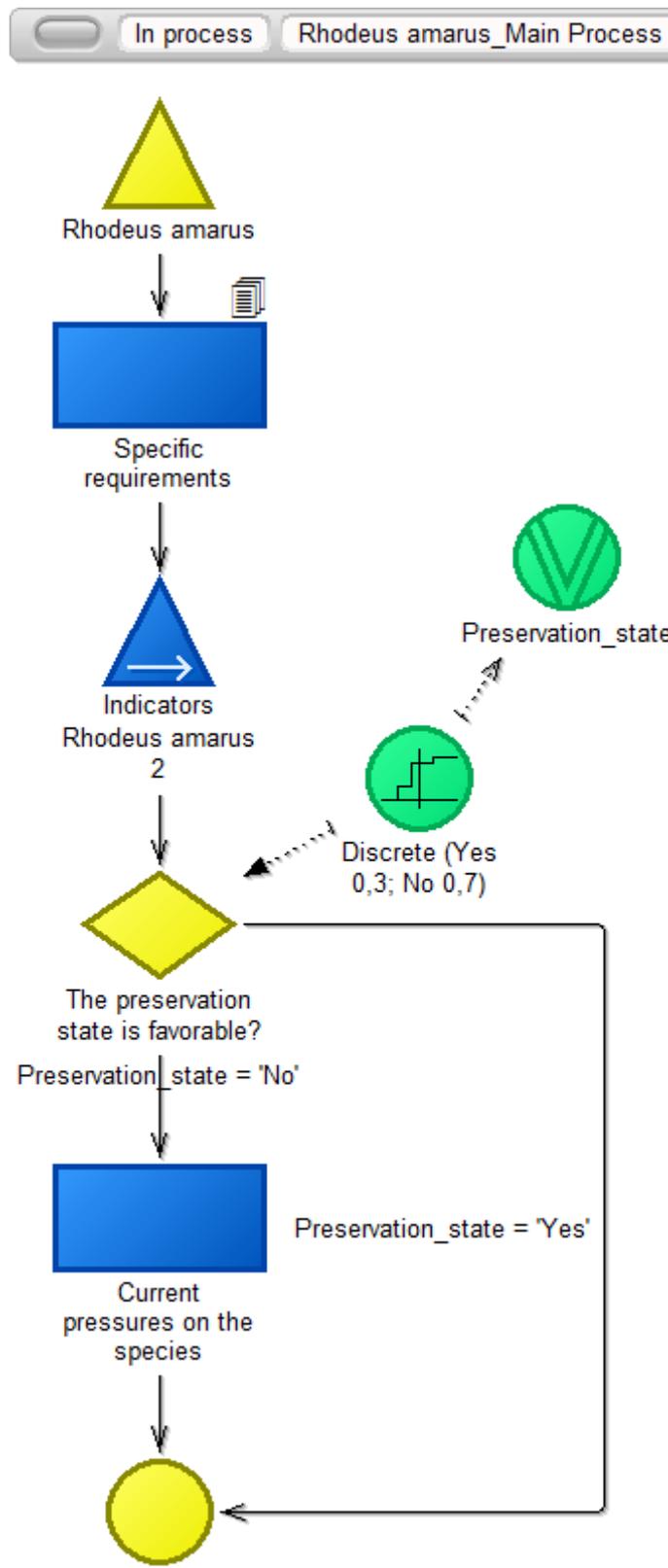
Figure 3. Model of *Rhodeus amarus* species management – Main process / Starting process.

The basic process is called Model of *Rhodeus amarus* species and represents all the characteristics of the species: habitat specific requirements - can be accompanied by a document which explains these requirements, subprocess Indicators of the species - which contains all indicators, a decision on whether the conservation status is favourable. If the preservation state is in parameters, then the process ends. If the condition is not favourable, then the pressures on the species can be determined and the process ends. A variable and a generator can be assigned

to every decision. The generator assigns a discrete variable that represents the probability of decision (e.g. If Preservation state = 0.7 we follow the branch "No" of the decision; if Preservation state = 0.3, we follow the branch "Yes" of the decision).

Water_depth

Discrete (Yes 0,66; No 0,34)

Water_depth = 'No'

The actual state of areas in the river channel with a water depth less than 0.5 m is more or equal than 66%?

Management measures for 1st indicator 1

Muddy_substrate

Water_depth = 'Yes'

Discrete (Yes 0,66; No 0,34)

Muddy_substrate = 'No'

The actual state of weight muddy substrate is between 33-66%?

Management measures for 2nd indicator 1

Riverine_standing_water

Muddy_substrate = 'Yes'

Discrete (Yes 0,33; No 0,67)

Riverine_standing_water = 'No'

Riverine standing water is between 10-33%?

Management measures for 3rd indicator 1

Vegetal_debries = 'Yes'

Vegetal_debries

Riverine_standing_water = 'Yes'

Discrete (Yes 0,15; No 0,85)

Vegetal_debries = 'No'

The vegetal debries is more than 15%?

Management measures for 4th indicator 1

Indicators

Slow_flow

Discrete (Yes 0,66; No 0,34)

Slow_flow = 'No'

The percentage of slow-flow water speed areas is more than 66%?

Management measures for 5th indicator 1

No_pouching_presence

Slow_flow = 'Yes'

Discrete (Yes 0,2; No 0,8)

No_pouching_presence = 'No'

Pouching presence doesn't exist?

Management measures for 6th indicator 1

No_pouching_presence = 'Yes'

Moluscs

Discrete (Yes 0,99; No 0,01)

Moluscs = 'No'

Presence of moluscs (Unio and Anodonta)?

Management measures for 7th indicator 1

Moluscs = 'Yes'

Field observations

Implementation of an integrated monitoring system

Figure 4. a: Model of current state for habitats of *Rhodeus amarus* vs. favourable preservation status indicators.

This model represents subprocess Indicators of the species *Rhodeus amarus* basic model and models all the indicators that we should consider for the species preservation. Depending on the probability in which they are found, we should take appropriate management measures (e.g. Management Measures indicator for 1st, 2nd and 7th). If a condition indicator fulfils its

standards, then the process goes from one indicator to another until the last activity, namely the implementation of an integrated monitoring system. If a condition indicator does   not fulfil the standards, then certain management measures need to be taken for the welfare of the species. All these management measures are modelled as subprocesses in order not to load the model and to facilitate its understanding (Figures 4a-h).
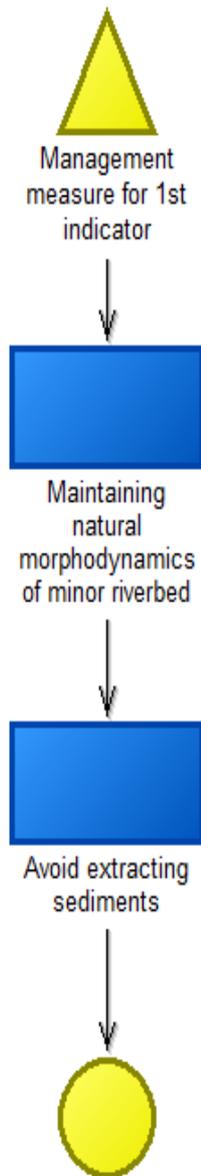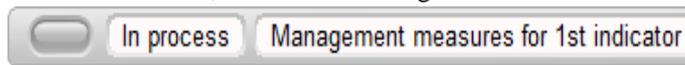
Figure 4. b: Model of Management measures – the first indicator.
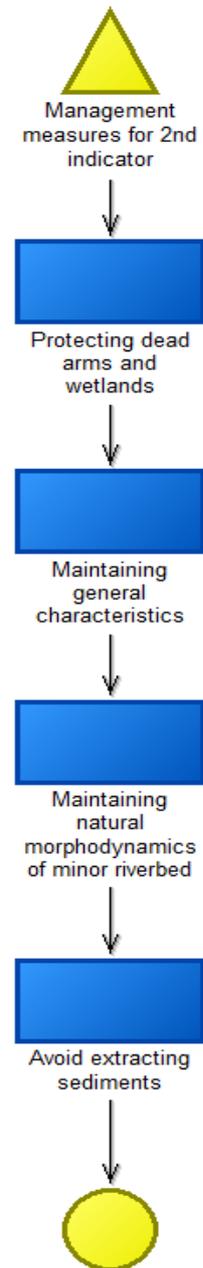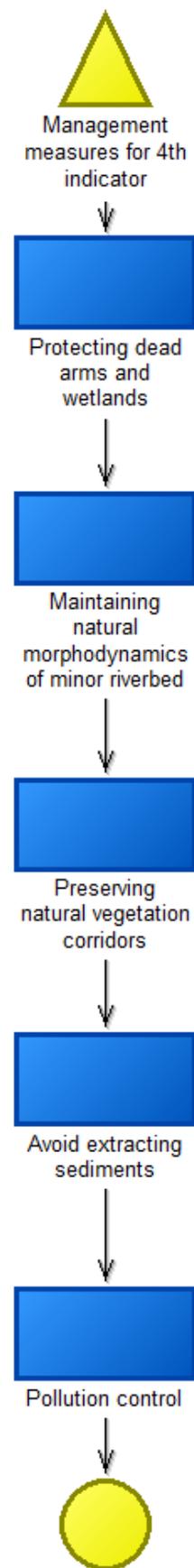

Figure 4. c: Model of Management measures - the second indicator.

Each subprocess that provides management measures (Figures 4a-h) is modeled using only activities to facilitate the easy understanding and visualization of the steps that must be taken in order to ensure the preservation of species indeed.

Management measures for 3rd indicator

Protecting dead arms and wetlands

Maintaining general characteristics

Maintaining natural morphodynamics of minor riverbed

Preserving natural vegetation corridors

Avoid extracting sediments

Management measures for 4th indicator

Protecting dead arms and wetlands

Maintaining natural morphodynamics of minor riverbed

Preserving natural vegetation corridors

Avoid extracting sediments

Pollution control

Figure 4. d: Model of Management measures - the third indicator.

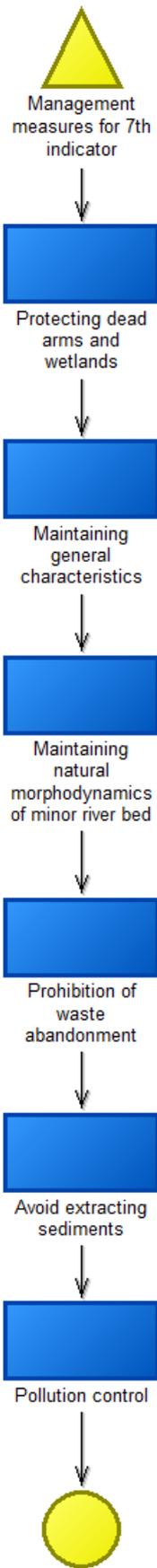**Figure 4**. e: Model of Management measures – the fourth indicator.

Figure 4. f: Model of Management measures - the fifth indicator.

Figure 4. g: Model of Management measures - the sixth indicator.

Figure 4. h: Model of Management measures - the seventh indicator.

4. CONCLUSIONS

The current main threat to the *Rhodeus amarus* populations in the Natura 2000 site Oltul Mijlociu – Cibin – Hârtibaciu are the hydrotechnical modifications of the riverbeds, which induced the ecological state modification of this fish species and also of *Unio* and *Anodonta* species. At this threat it should to add chemical pollution and poaching.

The rivers Cibin, Hârtibaciu and Olt should be managed with the significant purpose of keeping a good chemical quality of the water.

The maintaining of the minor riverbed morphodynamics is very important – the meanders presence is very important for the local molluscs which are living in the inner U shape parts of the river. The places, where the sediments (sand, mud) are relatively stable, provide suitable habitats for the molluscs important for the breeding of *Rhodeus amarus.*

The maintaining of the actual regimes of liquid flows and oxygenation, and avoidance of the increase in the sediments deposition rate in the water are necessary also for those mollusc species presence conservation.

The extraction of sediments in these rivers should be made in correspondence with their natural rate of refilling and at sites at a distance of minimum five km from each other.

In this paper, was presented the "big picture" of *Rhodeus amarus* species. ADONIS:CE was used here in ecology/biology domain, and we obtained a *Rhodeus amarus* model with all habitat species requirements, with indicators that provide favourable conservation status, with existing threats and pressures.

For further approaches, should be shaped such management systems for other fish species of conservative interest of Oltul Mijlociu – Cibin – Hârtibaciu Natura 2000 site.

5. AKNOWLEDGEMENTS

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