MANAGEMENT DECISIONS SUPPORT SYSTEM FOR RHODEUS AMARUS (BLOCH, 1782) SPECIES POPULATIONS IN OLTUL MIJLOCUI – 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 poaching. 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).


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


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 assessed 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.

![Map of study area and river sectors](image_url)
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: destroying or significant reduction of habitats quality of watercourses due to regularization, poaching 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 exploitation, 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 enforced 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 equis-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 mollusks habitats essential for the reproduction of the fish species of interest; maintain the natural minor riverbed-meanders morphodynamics – meanders presence is important for mollusks 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 debrizes 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. 2-4 a-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_Proces 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).
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<td><strong>Process</strong></td>
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<td><strong>Random generator</strong></td>
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<td><strong>Subprocess</strong></td>
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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).

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 fulfill 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).

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.
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 main current threat to the Rhodeus amarus populations in the Natura 2000 site Olțul 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 Olț 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 Olțul Mijlociu – Cibin – Hârtibaciu Natura 2000 site.

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6. REFERENCES


50. Telcean, I., Cupșa, D., (2009b) Fishfauna from the lowland Mureș River and the Floodplain Natural Park area


