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Assessing small hydropower plants impact on Eurasian otter. Case study: the Buzău River, Romania

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SUMMARY. In recent years, in Romania has been registered a substantial increase in the number of small hydropower plants (SHPs) as an alternative of renewable energy source. The construction of small hydropower plants on the rivers of Romania's NATURA 2000 areas is often controversial, being violated national and European legislation. This study aims to assess the otter distribution in the area of a SHP construction project and to find out which is the potential impact of such projects on otter. The standard otter survey methodology proposed by the IUCN Otter Specialist Group was applied for otter evaluation in the area of the SHPs construction and a literature review was used for assesing the impact of the SHPs before construction. The Eurasian otter presence was found in all the survey areas even if the species was absent from the data form of the Natura 2000 Site ROSCI0103 Buzau Everglade, where the study is located. The potential impact of the SHP construction on otter, was not assessed by the assessor in the environmental assessment impact study, for this reason. That's why we review the litterature and use the GIS technology, for understanding and evaluate the potential impact on otter. We found out that this protected top predator of the aquatic ecosystem, the Eurasian otter is potentially affected by the decrease of food resources, destruction of otter holts due to reduced river flow from 21.6 m³/s to less than 5 m³/s and the heavy machinery and workers who work in the riverbed.

Keywords: Conservation, Eurasian Otter, Impact, Small Hydropower Plant.

Introduction

The mountainous area of the Carpathians is the location for the construction of a large number of Small Hydropower Plants (SHPs). In Romania, over 411 small hydropower are in different stages of planning/authorization and construction, and

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more than a quarter of them are proposed to be located within or at the limit of protected areas. Nearly 300 projects have been approved for construction nationwide (Kraljevic *et al.,* 2013).

The Buzău river is found in the SE of Romania, in the Bending Carpathians, the Bending Subcarpathians and Buzău Plain, and is classed as Natura 2000 Site ROSCI0103 Buzau Everglade. The upstream of Buzău River was 'invaded' by small hydropower projects (SHPs) – 5 small hydropower plants with 1 catchment were proposed for this Natura 2000 site in 2012 (Zaharia, 2012).

These SHPs are supported by European Union funds and green certificates allocated on the basis of a national scheme with no ecological criteria attached.

Romania has pledged to increase the proportion of electricity production from renewable resources to 35 % by 2015, and to 38 % by 2020 (Ministry of Economy 2007).

In most of the projects, where small hydropower plants were being developed, despite the area's Natura 2000 status, a lot of problems arose right from the beginning. The most of the SHPs have: no spatial planning process, no proper public consultation, no Environmental Impact Assessment (EIA), nor cumulative impact assessment with other small hydropower projects from the area where is undertaken (Kraljevic *et al*., 2013). In most cases, neither the required Natura 2000 assessment or project permit issued by environmental protection authorities was obtained, also the connectivity of the Natura 2000 sites it was not taken into account. On the other side hydropower installations are considered under Annex II of the EU's EIA Directive, in most of the SHPs building projects, authorities decided that the SHPs should not be subject to an EIA procedure and pulled out from the EIA study at the screening stage.

The European Commission established environmental legislation criteria when proposing a new hydropower scheme. The developer must determine if it is likely to have a 'significant' effect on the integrity of a Natura site. If a significant effect is likely, the 'competent authorities' are required to carry out an 'appropriate assessment' to determine if these effects will be (a) significant; and (b) adverse. Key impacts on listed species and habitats may include anything potentially affecting (among others): number and distribution within the site; breeding success; survival and mortality rates (European Commission, 2000).

The European otter, top predator of the aquatic ecosystem (Clavero *et al.*, 2003), is directly affected by the decrease of food resources, destruction of otter holts due to reduced river flow from 21.6 m^3/s to less than 5 m^3/s and the workers and heavy machinery that work in the riverbed.

Some of the major short term impacts of the SHPs on otters are: (1) increase in accessibility and human presence; (2) movement of heavy machinery and workers; (3) deforestation with habitat loss and fragmentation; (4) change from lotic to lentic ecosystem; (5) lower prey availability and harsher capture; (6) changes in land use adjacent to the reservoir; (7) changing the course and the flow of the river; (8) hydrotechnical development and sewage of the river (Santos *et al.*, 2008).

It is expected, that otters will use "refuge" areas to respond to these impacts. "Refuge" areas are those where species would find refuge to avoid direct conflict with human interventions due to the implementation of the hydropower project.

The goal of this study is to understand the pre-impact and the expected post-impacts, through monitoring the threatened populations of the European otter (*Lutra lutra*) in the area of the Buzău river located in south-eastern Romania, by answering to the following questions:

(1) What is the conservation status of the otter, before project implementation?

(2) How does the otter respond to the project construction impacts and which phase is most critical?

(3) How does deforestation/digging in the riverbed/early flooding/reduced river flow affects otter population distribution?

(4) Which will be the otter distribution after the small hydropower plants building project in the area?

(5) Which are the "refuge" areas?

Materials and methods

The hydropower project is located on the upper Buzău river, in the Bending Subcarpathians, south - eastern Romania, Buzău County. This area is characterized by a highly heterogeneous species, characteristic of different ecosystem components, such as: the azonal meadow, forest fragments, shrub layer, herbaceous stratum, grasslands and agricultural fields.

The existing habitats on the site are: sand beaches - 36%; rivers, lakes - 9%; swamps, bogs - 8%; natural grasslands, steppes - 2%; arable land (crops) - 4%; grassland - 20%; other arable land - 15%; deciduous forest - 12%; other artificial land (settlements, mines, etc) - 2%.

Two types of habitats of community importance, which occupy 40% of the Natura 2000 site Meadow Buzău, are representative for the hydropower construction area: 3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos* (20%) and 92A0 *Salix alba* and *Populus alba* galleries (20%).

The climate is continental, with hot, dry summers (with precipitation mostly in the form of showers) and cold winters occasionally marked by strong blizzards, and heating intervals causing snow melting. Average temperature is of 12,7 ˚C, maximum temperature is 40,3 ˚C and minimum is – 18,4 ˚C. Annual precipitation levels vary between 500–700 mm (Ielenicz, 2007). The flow rate of the Buzău river in the project area is of 21.6 m³/s (National Administration "Romanian Waters" 2010). Human settlements are concentrated in cities and in villages located along the Buzău river course.

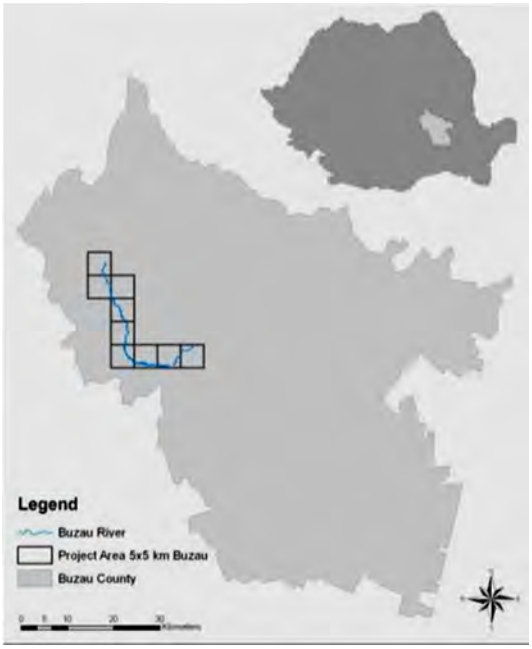

Figure 1. Study area

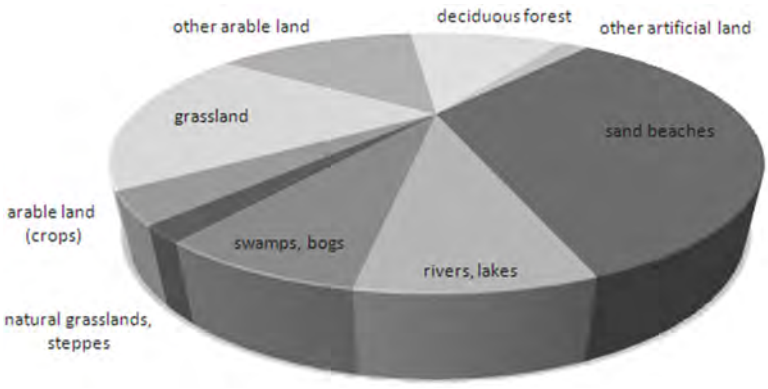

Figure 2. Type of habitats from the hydropower project area

In the initial phase of the study, it was monitored the status of the otter population impact before the construction of the hydropower project starts on the Buzău river and based on GIS data analysis we make assumptions on the distribution of otter after construction. Currently we present the preliminary results obtained in the monitoring before project's start, because the construction has not yet started due to lack of environmental permits.

Prior to field work it was designed a monitoring program based on available information regarding european otter from literature review of other european countries, since there was no available information for the study area. In addition otter was not even mentioned as being present in the area, judging by the standard data form of the Natura 2000 Site of Community Interest Meadow of Buzău.

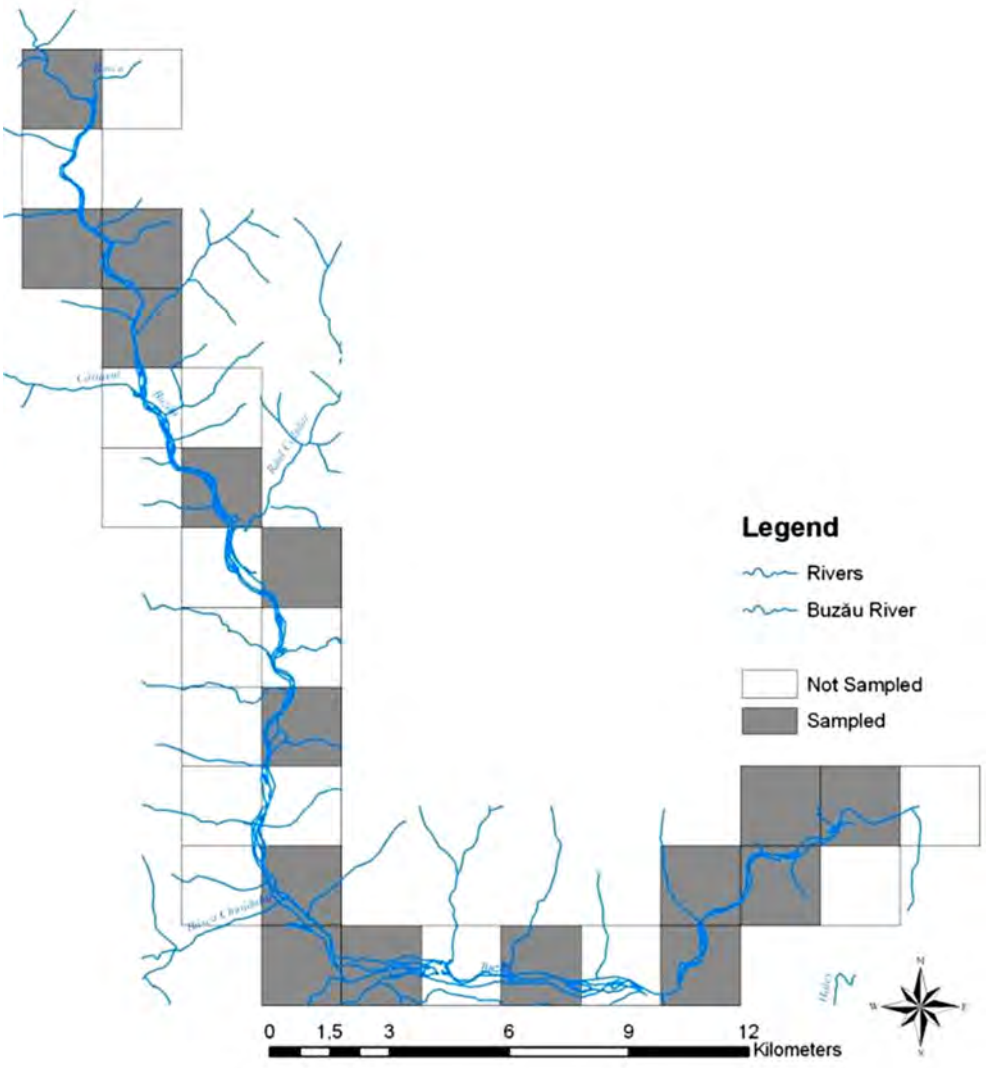

Figure 3. Sampling 2x2 km Grid and Selected Cells: Otter Presence Sampling

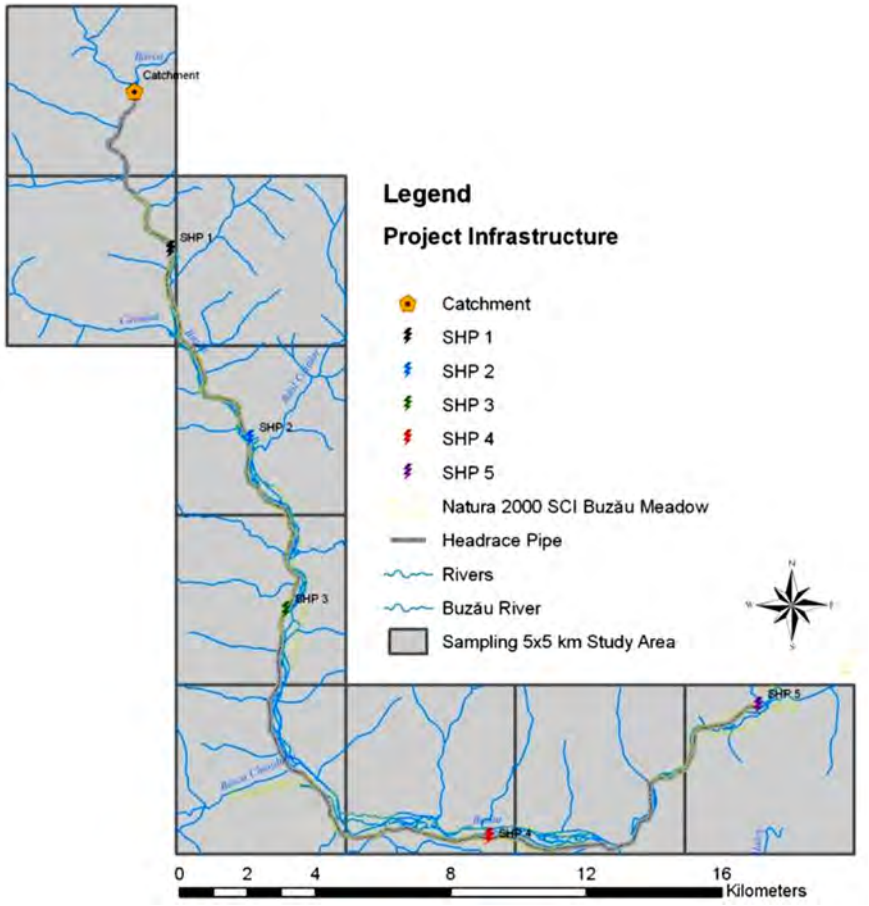

Figure 4. The Buzău River – SHPs Project Area, 5x5 Sampling Grid

The study area was subdivided into a grid of 5 km² cells of the Stereo 70 coordinate system for assessing community structure in the first phase of sampling (Fig. 4) and 2 km² cells randomly selected with different riverine and riparian habitats sampled for Europeean otter presence (Fig. 3). Also another criteria of choice of the cells was - areas where the hydropower project has a high impact: areas that will be built the 5 SHPs, area where will be construct the catchment, and sections where headrace pipeline undercrosses the riverbed.

Linear transects were walked by two observers. These cells were surveyed for otter presence in linear pedestrian transects along water components (rivers, streams and ponds) found within the cell, of at least 600 m (Reuther *et al.*, 2000).

Otter signs of presence (footprints, scats, latrines, burrows, scent marks) were identified and the geographical location was recorded with a GPS device, Garmin Etrex H for further mapping.

Table 1.

Digital data layers in GIS of the Buzău river, SHPs project assessment

Type of data	**Source**	**Format**	**Classes**
Landcover	Europeean Environment Agency	Polygon/Shapefile	CLC 2006
Project infrastructure	Contractor	Line/Shapefile	Catchment, SHPs, Headrace pipe
Water sources	geo-spatial.org	Line/Shapefile	Rivers and streams
Altitude	NASA/ Shuttle Radar Topography Mission	Raster/GeoTIFF	Level Curves
Otter presence data	Present Study	Point/Shapefile	Presence/absence
Otter impact data	Present Study	Point/Shapefile	Presence/absence
Prey availability	Present Study/ Patriche *et al*., 2012	Point/Shapefile	Presence/absence

To analyze the data it was created a Geographic Information System (GIS) database for area impacted by the construction of hydropower project. The Geospatial data used for this GIS database were from diverse sources; some of them were updated, and were used to evaluate species-habitats relationships.

Data on otter presence/absence was recorded as geographical locations. The Europeean otter presence data was plotted in maps of distribution.

Otter population nucleus area and boundaries were determined using a fixed kernel method applied to 100% of the geographic locations of otters presence.

This method was used to assess species distribution range expansion before the construction.

In order to understand the problem it was overlaped all the layers from the Table 1, to determine the most suitable areas for otters before the project implementation and evaluate which factors are contributing for otter's distribution after disturbance and which will be the "refuge" areas. It was examined the effect of land cover, project infrastructure, prey availability, water sources as potential explanatory variables driving range variation and/or habitat selection patterns. We used the landcover units from GIS data (Table 1) and extracted layers of suitable habitats for otter. Suitable habitats were selected accordingly to otter species requirements described in the literature and the results from our monitoring program, so for the otter we selected riparian vegetation, river courses and streams.

Results and discussion

The conservation status of the otter, before project implementation

The otter showed a great incidence in the project area, covering 75 % of the sampled area. A high density of signs of presence (majorly tracks and spraints), left by otters could be identified in the area where it should be built the hydropower project.

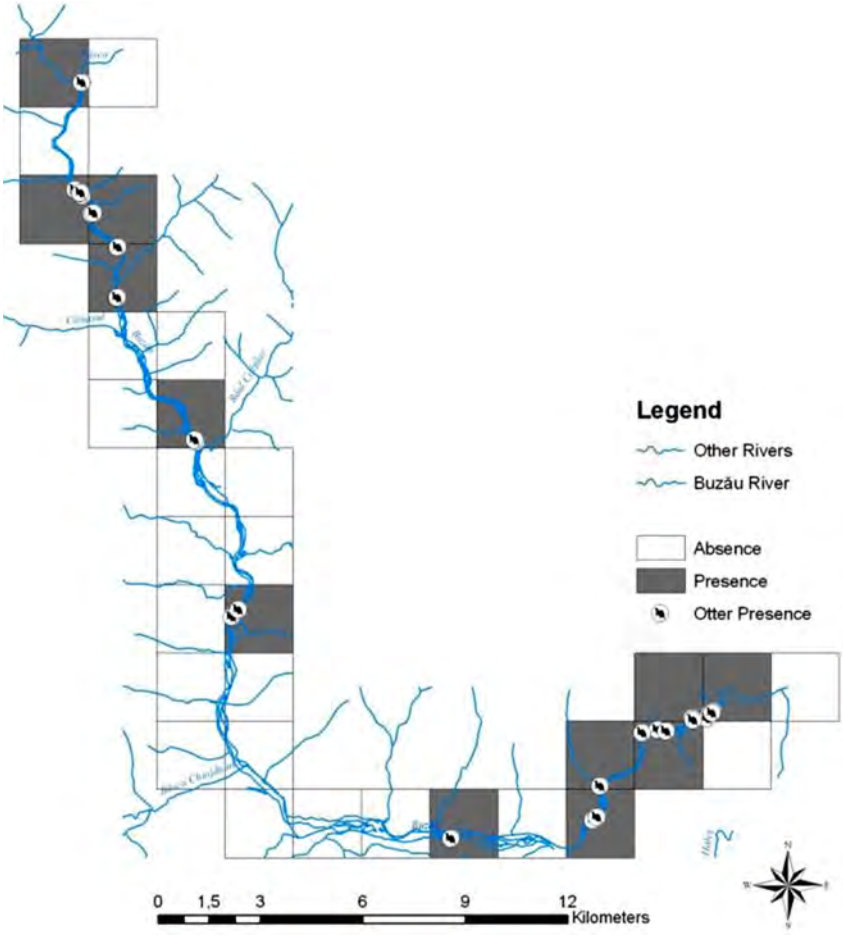

Figure 5. Otter distribution patterns before implementation of the SHPs project

During the survey, based on tracks, it were identified 3 female otters with cubs, thing that suggest a good reproduction rate and a strong and healthy population.

The study revealed two important hotspots, for the otters (Fig. 6), in the project area. One is situated in the north of the project area between the Catchment and the Small Hydropower Plant 1 and another one is situated in the south-east part of the project around Small Hydropower Plant 5. The presence of the otter it was not continous, the distribution is fragmented by the areas with a high level of human activities.

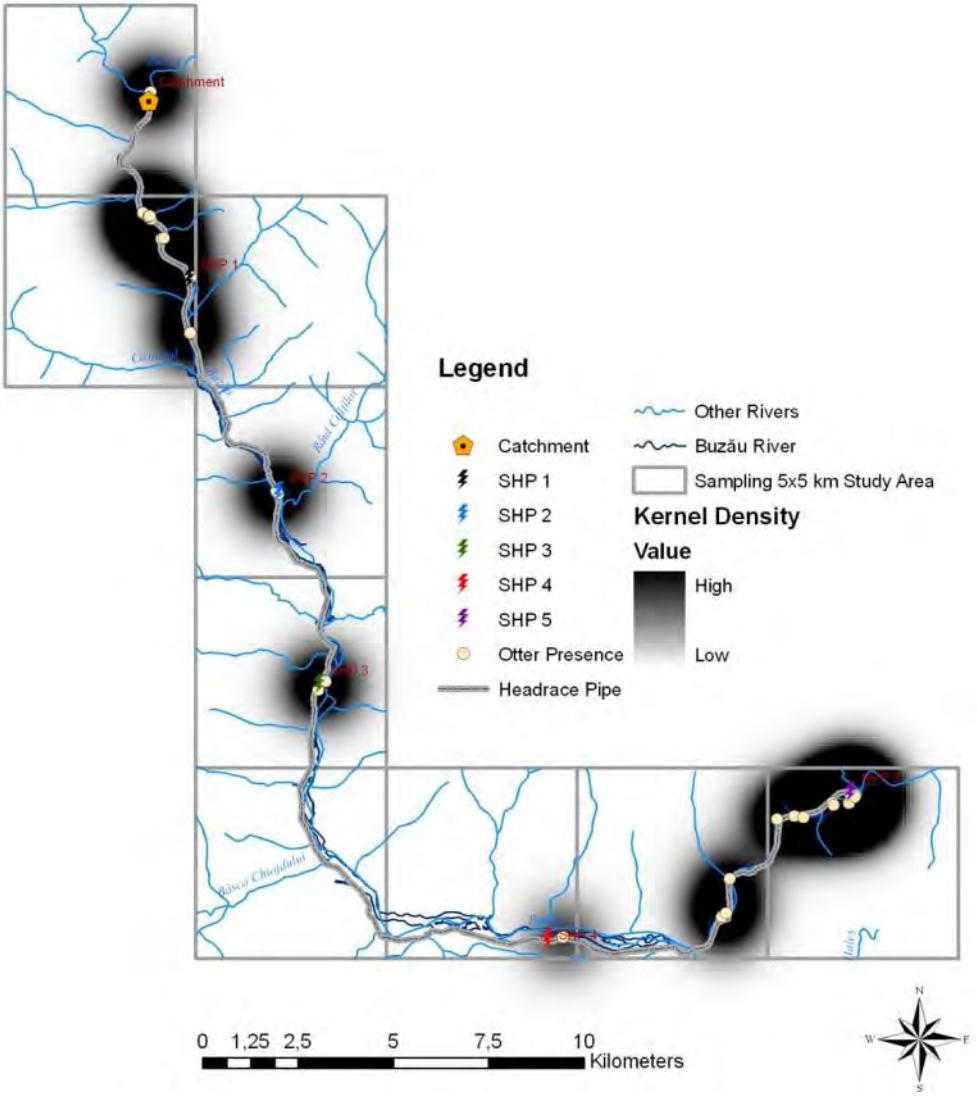

Figure 6. Otter Hotspots before the implementation of the SHPs project

In the study area numerous anthropogenic activities with a negative impact in the quality of the habitat occupied by the otter, were observed. The major threats on otter are: extraction of sand and gravel from the riverbed, incorrect storage of household waste, water pollution and modification of the river functions. (Macdonald *et al.*, 1983, Tüzün *et al.*, 2004).

Figure 7. Otter latrine on a stone in the Buzău riverbed

Signs of otter presence, were identified, also in areas with an intense human activity like: fishing, grazing, transport system (railway or major road) even if this activities had a daily presence.

The otters prefer this area with human activities due to rich trophic potential of fish and amphibian fauna, identified in the area. The high density and diversity of fishes and amphibians reveal a good ecological and chemical status, which was confirmed by a study made in 2010 by the National Administration "Romanian Waters".

In order to examine the role of prey availability in otter distribution, fishes and amphibians were considered the main food resource. Many captivity experiments studies have demonstrated otter preference for fish and, among fish, for larger (intermediate) sizes. (Erlinge, 1968, Topping and Kruuk, 1996). In 2012 for the project area, was made an ichthyologic survey, using as method the electro-fishing it were found 11 species of fishes and 10 species of amphibians in 14 monitoring stations located in key areas of the project: catchment, the 5 SHPs area and in the area where the headrace pipe undercross the river (Patriche *et al.*, 2012).

Before the construction has started, in this river sector that may be adversely affected by hydropower project, it was discovered a healthy and vigorous otter populations with a strong growth trend.

Project construction impacts on otter

In order to understand the impact of the project during the implementation, it is required to make a short brief description of the infrastructure, of its characteristics and operating mode.

The Catchment will have a capacity of 9,000 m³, it will be build in the riverbed and as building material will be used reinforced concrete, the river diverting will be also required. Catchment infrastructure located to the right bank will permanently occupy in the riverbed an area of 57.81 m².

Figure 8. The catchment and the surrounding area

The headrace pipe has a diameter of 3200 mm and a total length of 40,501 m. It will be buried in the ground and completely embedded in concrete in areas where is laid in the riverbed of the Buzău river. During the construction of the headrace pipe, in the riverbed and on riverbanks will be dug a trench with a width of 6 meters to allow handling of headrace pipe, this way will be used 20,112 m². For the temporary storage of the excavated material, along the route of the pipeline, will be used an extra 33,520 m² (a corridor of a width of approximately 10 m).

Digging for the headrace pipe will cause the destruction of riparian habitat that can not be mitigated or compensated through habitat creation because such ecosystems cannot be recreated. It can only return through natural succession which is believed to take few decades, and may not occur at all if too extensive an area is damaged. The riparian vegetation from the banks represent the perfect place for otter holts and for the otter resting places.

Figure 9. Small Hydropower Plant no. 1 and the surrounding area

For the Small Hydropower Plants placement will be used about 100 m² for each, so for the 5 SHPs, will be permanently occupied a total area of 500 m² and 1000 m² temporarily, during construction activities (200 m² for each building).

The temporary and the permanent infrastructure should occupy an area in the site, as small as possible. As less space is affected, the project is less harmful to otters, considering the fragile wetland habitat from the site.

In this project it is necessary the undercrossing of the Buzau riverbed by the headrace pipe, for making this work, the river will be diverted from a bank to another. The headrace pipe will undercross the Buzău river in 7 points.

Figure 10. Example of work in the riverbed – the Capra River, the Făgăraş Mountains (Source: *www.romaniapozitiva.ro*)

Heavy machinery such as bulldozers, cranes, excavators, pick hammers, trucks, concrete mixers will work in the riverbed: dig into the riverbed, divert the river, reinforce the banks with concrete, create access way and platforms for storing construction materials and will remove the riparian vegetation.Estimated construction time is 60 months.

In the construction phase a part of the otter holts will be destroyed by the heavy machineries or by the changing of the river course and by the flow decrease.

During this time almost all the otter activities in the area of the project will disapear because of the intense human activity and the synergy of pollution sources. Prior to project implementation start, the otter presence was 75%, but during the construction phase, the presence of the otter would be less than 10% of the area.

The otter impact will be also indirect, caused by the lack of trophic potential, food resources decrease due to accentuated water turbidity caused by the work in the river bed, and the long construction time (60 months), such the otter population concentrated in the area will focus on the Buzău river tributaries, having a high flow and a trophic potential that can meet the habitat requirements of the otter.

When the hydropower project is under construction, the disturbance produced by machinery, light, presence of workers and other activities affect the otters, which will then try to escape to adjacent habitats. In addition, the the lack of food resources displaces resident animals to nearby areas. A phenomenon known as the reservoir's extended effect affects mammalian species, which move from their original home range areas to adjacent areas already occupied by the same species (Alho, 2011).

Impact on otter during the operating phase

During operating phase there will be no further changes to the riverbed and terraces of the Buzău river. But the biggest change, which has also a major impact, will decrease by more than 3 times the flow of the Buzău river. From a multiannual flow of 21.6 m^3/s to be reduced to a minimum rate of 5 m^3/s.

In general, the closer the flow is to natural levels and patterns, the fewer species will be affected. Furthermore, flows adequate for water needs of the otter, may well be insufficient for maintaining healthy aquatic communities which provide food for otters. It is probably true to say that a minimum flow perceived as acceptable to maintain fish species assemblage and abundance would be enough to reduce or eliminate effects on otter.

The heavily altered ecosystem provides poor fish resources for otters (Chanin, 2003, Kloskowski *et al*., 2013). It might be argued that at high densities, small fish may form a rich food supply (Topping and Kruuk 1996), but with the very small prey size, the energetic costs of hunting and daily calorific requirements of otters may be difficult to balance (Mason and Macdonald, 1986).

Figure 11. The Buzău river flow in October

Figure 12. "Escape" areas for otters after hydropower project implementation

A minimum downstream compensation flow of 5 cubic meters per second is under discussion. This is unlikely to be sufficient to prevent problems for piscivorous vertebrates, like the otter, even the maximum release under discussion of 10 cubic meters per second is unlikely to mitigate all of the negative effects of a reduced flow. The compensation flow should be maintained as high as possible preferably 15 cubic meters per second (or more) also during the summer (The Wildlife Conservation Society, 1995).

At low flow levels of the river, the area affected by the hydropower project, could no longer sustain the present otter population, it will be forced to turn to other areas, called "refuge" areas.

Even during construction phase the otter population will be focused to quiet areas that could fulfill their habitat requirements. As can be seen in the „escape areas" map (Fig. 12) the most important rivers and lakes that could be a habitat for otters are: Bâsca (12.6 m^3/s), Bâsca Chiojdului and its tributaries, the Buzău River, upstream the Catchment and Siriu Lake (155 millions m^3 hydropower reservoir). All the areas of refuge are located upstream the project area, due to poor ecological quality of the river Buzău, high population density and intense human activities from downstream.

Forced to occupy new territories, the otters need to fulfill its daily needs and activities. Social contact, familiarity with the area, and social organization are factors that may influence the individuals daily activity, in addition to food gathering.

Otters are not moved into an empty space, but must fit into an existing biological context. This context implies occupied territories, already used home ranges, intra and inter competition for food, space and mate, behavioral interactions, carrying capacity based on offer of ecological resources, and so on (Alho, 2011).

During the initial phase of higher densities of animals in areas adjacent to the Buzău river Small Hydropower Plants project, the competition for food, otter holts, resting places and other ecological resources is tighter. Additionally, the phenomenon known in behavioral ecology as the principle of xenophobia makes free ranging individuals, without fixed home ranges, more vulnerable to be submissive in disputes with resident species for ecological resources, like available food, space and other vital requisites. The result is that soon the otters displaced by the effects of the hydropower project will die or move to another area, the previous ecological densities will return, and the final result is the unsuccessful attempt of the displaced otters to establish themselves in another area (Alho, 2011).

Conclusions

Otters surveys are known to be crucial because they provide important information on species distribution, abundance, habitat and may serve as potential indicators of the impacts of human activities on the aquatic environment. The hydropower projects often result in irreversible loss of habitat, which is particularly crucial for threatened carnivores as the otter who we addressed herein.

This study presents preliminary data; the results before the project's implementation and make assumptions on what will be the situation during construction and operation phases. The study will be continued if the projects similar with this will receive all approvals, analyzing then the real situation.

Monitoring the impact of Small Hydropower Plants project from Buzau river on otter population has shown that this project could have a major negative impacts in the population's distribution, abundance and habitat during and after the implementation.

The negative impact starts with the riparian habitat loss since the construction of the SHP project and finish with the decrease by more than 3 times the flow of the Buzău river, during the operating phase. At low flow levels of the river, the area affected by the hydropower project, could no longer sustain the present otter population, it will be forced to turn to other areas, called "refuge" areas.

Most impacts can be avoided or reasonably mitigated if the projects are correctly, planned, designed and controlled.

And also, more attention must be paid on especially cumulative impacts and monitoring studies on every process of planning and building of the Small Hydropower Plants.

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