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The influence of structural changes and ichtyofauna abundance on the ecological state of the Crisuri Hydrographic Area

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Abstract. The paper presents the research regarding the structure of fish communities with a view to assess the quality of water in the Crişuri Hydrographic Area. It is also a comparative study of the ichtyofauna composition in the '60s and the 2004-2009 period. In order to inventorize and describe the ichtyofauna of the Crişuri Hydrographic Area, periodical campaigns for fish sample prelevation by means of electric fishing were conducted over a period of six years. This inventory comprises the main Crişuri watercourses and their streams, totalizing a number of 98 prelevation sections. Consequently, 33 fish species were identified, some of which (*Thymallus thymallus, Eudontomyzon danfordi*) of very low density, some others (*Chondrostoma nasus, Squalius cephalus, Barbus barbus, Barbus petenyi*) in expansion for mountaineous regions. This upstream re-location of some species was noticed in each hydrographic basin.
Key Words: ichtyofauna structure, taxonomy, bioindicator, ecological monitoring.

Rezumat. În lucrare sunt prezentate cercetări privind structura comunităţilor de peşti în vederea aprecierii calităţii apelor din Spaţiul Hidrografic Crişuri. Totodată, s-a realizat şi un studiu comparativ între compozitia ihtiofaunei anilor `60 si cea a anilor 2004-2009. Pentru a inventaria şi caracteriza Spaţiul Hidrografic Crişuri din punct de vedere ihtiofaunistic, s-au realizat campanii periodice de prelevări probe peşti cu ajutorul pecuitului electric, timp de şase ani de zile. Acestă inventariere s-a realizat pe toate cursurile de ape principale cât şi pe afluenţii Crişurilor, incluzând în total 98 de secţiuni de prelevare. Astfel, in Spaţiul Hidrografic Crişuri s-au identificat 33 de specii de peşti. Unele specii ca *Thymallus thymallus, Eudontomyzon danfordi* s-au gasit în densitate foarte mică, altele, precum *Chondrostoma nasus, Squalius cephalus, Barbus barbus, Barbus petenyi* sunt în expansiune, cucerind teritorii din zonele montane. Deplasarea unor specii în amonte s-a observat în fiecare bazin hidrografic.
Cuvinte cheie: inventarierea ihtiofaunei, taxonomie, bioindicator, monitoring ecologic.

Introduction. The Crişuri Hydrographic Area lies in Western Romania and includes 5 main rivers: Crişul Alb (the White Criş), Crişul Negru (the Black Criş), Crişul Repede (the Quick Criş), Barcău and Ier, all of which transborder rivers, joining by twos on the territory of the Republic of Hungary, then in the Crişul Triplu (the Triple Criş) that flows into the Tisa (Gergely et al 2011; see Figure 1).

The monitoring of environmental quality has become more and more necessary after the very short evolution on an ecological scale of man who, by extraordinary multiplication, occupied, one way or the other, the whole planet, deeply modified it, affected or transformed natural ecosystems and provoked an unknown until then environmental scourge – pollution (Bonk & Pabijan 2010; Bud et al 2010; Holčik 1991; Lodge et al 1998; Malschi et al 2009; Negrea & Pricop 2009; Stăncioiu et al 2006).

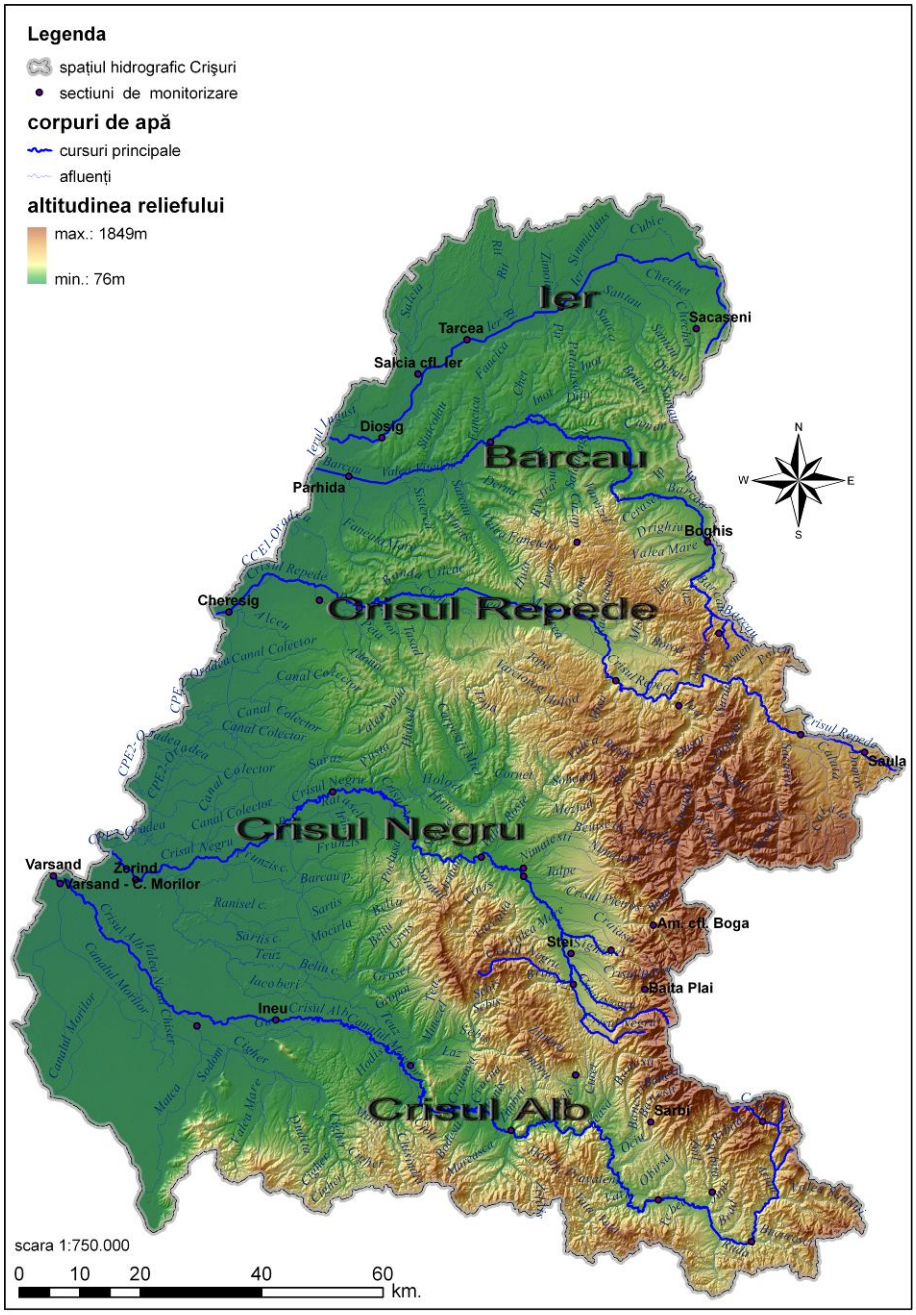

Figure 1. The Crişuri Hydrographic Area.

Fish as bioindicators of water quality are very useful as they live in almost every categories of waters, including those polluted, and their frequency (spatial distribution in a hydrographic basin) can offer relevant data about the quality of water and the tendency for improvement or decline of the aquatic ecosystem under survey (Schiemer 2000).

In the period 2004-2009, the use of state-of-the-art prelevation techniques and procedures helped obtaining the inventorization of ichtyofauna in all the basins of the Crişuri Hydrographic Area. To this aim, maps of spatial distribution of the 33 fish species identified in the Crişuri basin were drawn.

Material and Method. Two types of fishing devices (Scubla ELT 60 II GI – (Figure 2) and Scubla ELT 62 II GI (Figure 3) were used for electric current production and utilization (see their specifications in Table 1).

Figure 2. ELT60 II GI Aggregate.

Figure 3. ELT62 II (GI) Aggregate.

Table 1

Specifications for Scubla type electrical fishing device

Model	Scubla ELT 60 II GI	Scubla ELT 62 II GI
Engine	Honda GVX 50	Honda GVX 135
Engine power	1.8 KW/ 6,700 rot/min	2.6 KW/ 3,600 rot/min
Current type	Direct intermitent (with impulses)	Direct intermitent (with impulses)
Frequency	25-100 Hz adjustable	25-100 Hz adjustable
Tenssion	580-960 V	580-960 V
Generator power	1300W	2200W

Electric fishing was, as a rule, conducted in the daylight, from downstream to upstream so as the efficiency be not diminished by the troubled water. The above mentioned fishing devices were carried by one of the operators, while the other one was carrying the anode through the water. For rivers over 70 cm depth, a flat bottom inflatable boat with an up to 150 W engine was used (Figure 4).

Figure 4. Electric fishing in over 70 cm depth waters.

Depending on the dimension of the river, the minimum fishing length was modified as follows:
- small streams (under 5 m width) – approx. 20 m length/ stream width;
- small streams (5-15 m width) – approx. 50 m length/ stream width;
- canals and rivers (over 15 m width) – approx. 50 m/ one or both banks;
- large waters (over 15 m width and 70 cm depth) – approx. 100-200 square m.

Identification of species was done immediately after capture. Each individual was weighed and measured, its age was established and observations were made on diseases and parasites. The samples identifed and measured were then freed. Some samples were kept for laboratory work. All details about prelevation place, fishing activity, capture, biometrical measurements, fishing team, fishing duration etc were registered in the Prelevation and analysis of fish biological samples bulletin.

Results. Regarding the fishing area of the Romanian rivers, most researchers today acknowledge P. Bănărescu's 1964 version dividing it in 5 categories:
- the trout (*Salmo trutta fario*) area;
- the grayling (*Thymallus thymallus*) and the violet barbell (*Barbus petenyi*) area;
- the broad snout (*Chondrostoma nasus*) area;
- the common barbell (*Barbus barbus*) area;
- the carp (*Cyprinus carpio*) area.

This distribution is obvious in large rivers, while in small streams the division into areas is different: the first two may be absent, the last three may be replaced with the European chub (*Squalius cephalus*) instead of the broad snout (*Chondrostoma nasus*) and the barbell area (*Barbus barbus*), and the perch (*Perca fluviatilis*) instead of the carp area (*Cyprinus carpio*).

Bănărescu's view regarding the distribution of these areas in the Crişuri Hydrographic Area in the '60s can be seen in Figure 5. The fishing areas in the '60s are codified with different colours (red for trout, blue for grayling, green for broad snout, light violet for barbell, yellow for carp, dark green for perch, dark violet for chub).

The study of spatial distribution of the ichtyofauna in the '60s presents all five areas, beginning with the trout and ending with the carp. The dominant species of the mountainous regions was *Salmo trutta fario* and the accompanying species were *Cottus gobio* and *Phoxinus phoxinus*. Immediately after the trout area comes the grayling (*Thymallus thymallus)* and other accompanying species like *Barbus petenyi, Alburnoides bipunctatus, Gobio uranoscopus, Cobitis aurata.* These were found in the hydrographic basins of Crişul Alb (the White Criş), Crişul Negru (the Black Criş), Crişul Repede (the Quick Criş) and Barcău.

The broad snout area, coming immediately after the grayling area, dominated by the *Chondrostoma nasus* and some accompanying species like *Squalius cephalus* and *Barbus barbus* is characteristic for Crişul Alb (the White Criş), Crişul Negru (the Black Criş) and Crişul Repede (the Quick Criş).

The barbell area with *Barbus barbus, Chondrostoma nasus, Squalius cephalus, Alburnus alburnus* is characteristic for Crişul Alb (the White Criş) and Crişul Negru (the Black Criş). The other areas, such as the carp area, the perch area or the chub area were present in all the rivers of the Crişuri Hydrographic Area, in plain areas, with *Cyprinus carpio, Ictalurus nebulosus, Carassius auratus gibelio, Perca fluviatilis, Esox lucius, Abramis brama* etc.

The results of our research in the Crişuri Hydrographic Area between 2004 and 2009, in the 98 prelevation sections, indicated 33 fish species, as follows:
- *Alburnoides bipunctatus* – found in each watercourse of the Crişuri Hydrographic Area; it is a very frequent species in the hilly and plain waters, not very sensitive to pollution, present even in 3rd class quality waters, so of moderate ecological state;
- *Abramis brama* – appears in two watercourses, from Peţea on Crişul Repede (the Quick Criş), 3rd class quality waters, to the natural reservation at Băile 1 Mai, and Vărşand on Crişul Alb (the White Criş), downstream the village. The species is not present in Crişul Negru (the Black Criş), Barcău and Ier basins;

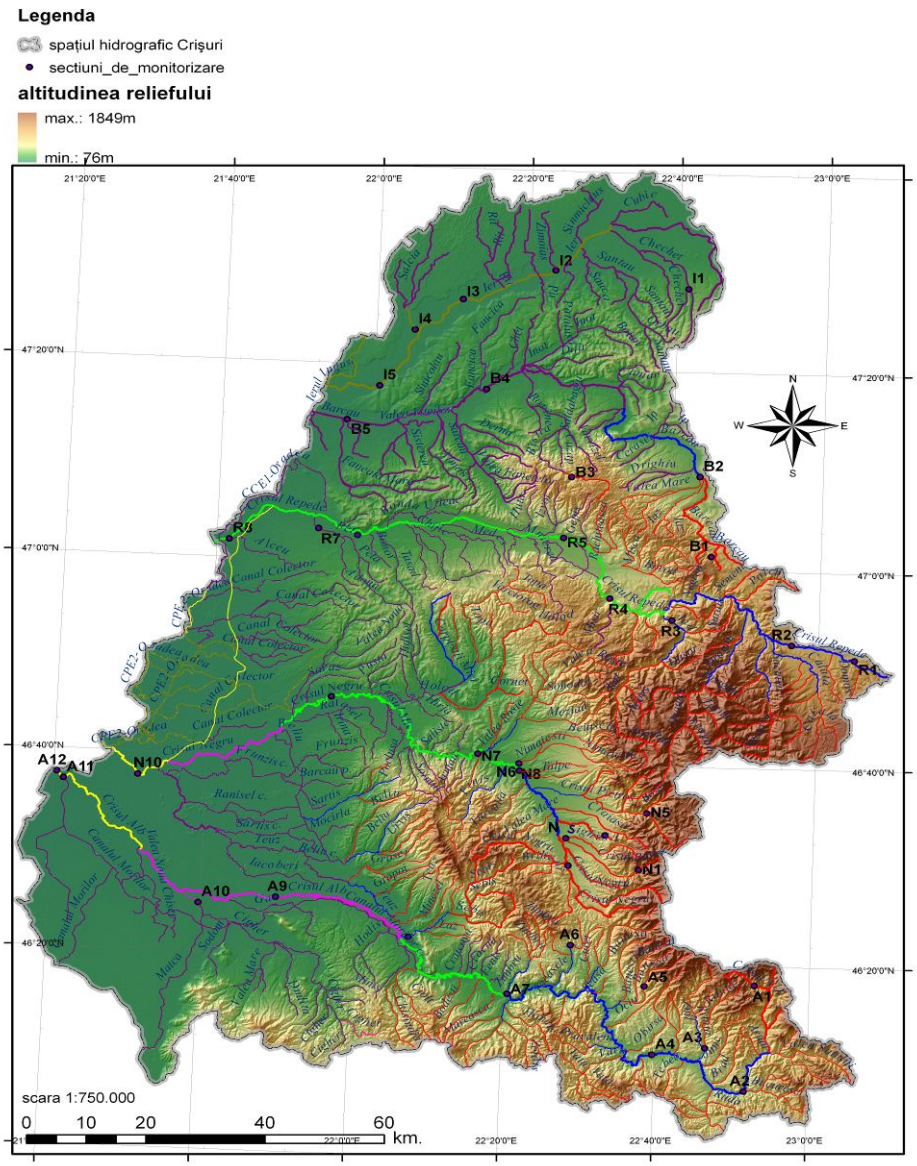

Figure 5. Map of ichtyofauna distribution (after Bănărescu 1964)

- *Alburnus alburnus* – present in Crişul Alb (the White Criş), from Zărand to Vărşand, and in several areas on Crişul Negru (the Black Criş), in Crişul Repede (the Quick Criş) at Vârciorog and upstream the city of Oradea. In Barcău it appears only in the Parhida area, but is frequent on Valea Ierului (the Ier Valley);
- *Barbus petenyi* - except Valea Ierului (the Ier Valley), in every watercourse up to 869 m altitude. In some sections of the basin, up to 1 kilo samples were captured. The species swims up to 1000 - 1400 m altitude and is also present upstream the accumulations at Drăgan and Leşu;
- *Barbus barbus* – no samples could be identified in Valea Ierului (the Ierului Valley). The species is present in the other hidrographic basins like Crişul Alb (the White Criş), Crişul Negru (the Black Criş), Crişul Repede (the Quick Criş) and Barcău. The most relevant samples were captured in the section Tinca - Uileacu de Beiuş on Crişul Negru (the Black Criş), approx. 70-80 individuals/ 100 square m;
- *Carassius auratus gibelio* – the species is very adaptable in all hydrographic basins, the largest populations being identified in Valea Ierului (the Ier Valley), from Andrid to Parhida. In Crişul Negru (the Black Criş) the species swims up to Uileacu de Beiuş, and in Crişul Repede (the Quick Criş) up to Vârciorog. It is present in 2nd to 4th classes water quality;
- *Cyprinus carpio* – in every hydrographic basin, under 150 m altitude;

- *Cobitis taenia* – no sample was captured in Valea Ierului (the Ier Valley), but it is present in all the other hydrographic basins;
- *Chondrostoma nasus* – the species is not characteristic of Barcău and Ier watercourses, being sensitive to pollution and small oxygen concentration. In Crişul Repede (the Quick Criş) it appears from Vârciorog to Tărian, in Crişul Negru (the Black Criş) from upstream Beiuş to upstream Tinca, and in Crişul Alb (the White Criş) from Baia de Criş to Vărşand border. The species is not present in 3rd and 4th classes water quality;
- *Cobitis barbatula* – samples were captured only upstream Drăgan acccumulation, seemingly kept there by the closing of the dam;
- *Cottus gobio* – samples were captured at over 400 m altitude in Crişul Alb (the White Criş), Crişul Negru (the Black Criş), Crişul Repede (the Quick Criş), and upstream the Pădurea Neagră village, on Bistra. No sample was identified in Valea Ierului (the Ier Valley);
- *Eudontomyzon danfordi* – samples were captured only in the prelevation section Şuşti on Crişul Negru (the Black Criş);
- *Esox lucius* – in all hydrographic basins with slow and rich in vegetation. It is very frequent on Valea Ierului (the Ier Valley), living in 2nd and 3rd class quality waters;
- *Gobio gobio* – no sample was identified in Crişul Negru (the Black Criş), the species being present in the other hydrographic basins, where water quality class does not go under 2;
- *Gobio uranoscopus* – samples were captured in Crişul Repede (the Quick Criş) at Vârciorog, the species is not present in the other basins;
- *Ictalurus nebulosus* – on Crişul Alb in Tauţ accumulation and at Vărşand, on Crişul Repede (the Quick Criş), Barcău and Ier, where the water is slow or even still, the species is not present in Crişul Negru (the Black Criş). It has a certain tolerance to 3rd and rarely 4th classes water quality;
- *Squalius cephalus* – one of the most abundant species in Criș hydrographic space, from 1400 to 90-100 m altitude;
- *Lepomis gibossus* – in waters with rich vegetation, also on Valea Ierului (the Ier Valley) and on Crişul Repede (the Quick Criş) where the water swamps (upstream Săbolciu accumulation, downstream Tileagd accumulation, on the former course of Crişul Repede/the Quick Criş), in 2nd and 3rd classes water quality;
- *Leuciscus leuciscus* – samples were identified in the reference section Tăcăşele - Avram Iancu, on Crişul Alb (the White Criş);
- *Perca fluviatilis* – the species is abundant on watercourses under 200 m altitude in each basin, the greatest abundence being registered in Valea Ierului (the Ier Valley). It lives also in 3rd class quality waters, so of moderate ecological state;
- *Phoxinus phoxinus* – characteristic of the trout area in all hydrographic basins, Valea Ierului (the Ier Valley) included, near its mouth. The species is sensitive to pollution and does not appear in under 2nd class quality waters;
- *Pseudorasbora parva* – samples were captured only at Peţea, downstream Oradea. The species is present in waters with high organic concentration, is resistent to the lack of oxygen dissolved in water, and appears in moderate to low ecological state waters;
- *Rhodeus sericerus amarus* – in all basins under 300 m altitude;
- *Rutilus rutilus* – downstream Lugaş accumulation on Crişul Repede (the Quick Criş) and on Valea Ierului (the Ier Valley), at Câmpia Valea Recea (the Valea Rece Plain) and on the affluent of the Ier river, at Salcia;
- *Sabanejewia aurata balcanica* – the species is not characteristic to Valea Ierului (the Ier Valley) but samples were captured in the other hydrographic basins;
- *Salmo trutta fario* – except the Ier basin, in all waters of the Crişuri Hydrographic Basin, in mountaineous areas. Samples were also captured in the affluent of Crişul Repede (the Quick Criş), at Dobricioneşti Cacuciul Vechi, downstream the trout farm at Măgeşti, 150 m altitude. Very sensitive to pollution, the species appears only in 1st and 2nd classes water quality, so of very good to good ecological state;
- *Scardinius erythrophtalmus* – under 200 m altitude, in slow to even still waters, abundant in the prelevation section upstream Oradea, in the swamps of the former course of Crişul Repede (the Quick Criş);

- *Scardinius racovitzai* – endemic species only in the Natural Reservation at Băile 1 Mai, and downstream the reservation to Rontău. *Scardinius Racovitzai*, a strictly thermophillic species, preferring a temperature between 27 ºC and 34 ºC, representative of the pre-glaciary tropical fauna, it survived and adapted to the warm waters of the Peţea stream;
- *Silurus glanis* – frequent in slow running waters with abundant vegetation. The species is present in Crişul Alb (the White Criş) at Zărand, in Crişul Negru (the Black Criş) at Zerind, in the CPE 2-Ant Collecting Canal at Beliu-Tăut, in Crişul Repede (the Quick Criş) at Tărian. In the Barcău watercourse the species is absent. The biggest samples were captured on Valea Ierului (the Ier Valley). The species is also present in 3rd quality class waters, of moderate ecological state;
- *Stizosteidon lucioperca* – was captured in two sections of the basin, in Crişul Negru (the Black Criş) at Zerind and in the Rezervation at Pădurea Rădvani (the Rădvani Wood) in the Collecting Canal on Crişul Repede (the Quick Criş);
- *Thymallus thymallus* – upstream the Leşu and Drăgan accumulations, and downstream the reference section Mnierea at Gălăşeni, on Crişul Repede (the Quick Criş). The species is rather sensitive to pollution but tolerant to a certain extent to a low level of oxygen concentration or a high slime content. It is present in 1st and 2nd classes quality waters, from very good to good ecological state;
- *Tinca tinca* – samples were captured on Valea Ierului (the Ier Valley), in Crişul Repede (the Quick Criş), upstream Oradea, in Crişul Negru (the Black Criş) at Ant and in Crişul Alb (the White Criş) at Vărşand;
- *Zingel streber* – identified in Crişul Negru (the Black Criş), upstream Tinca, but not in the other basins.

The analysis of the samples captured, the following conclusions regarding the actual state of the ichtyofauna in Crişuri Hydrographic Area could be drawn. Figure 6 presents the actual ecological state of the ichtyofauna in Crişuri Hydrographic Area. The previous colour codification is the same, the difference from Fig. 6 being the introduction of the violet barbell area which continues to be green-blue. These watercourses that drained over the past 20-30 years appear on maps as black lines.

The analysis of Figure 7 shows that the trout area is almost intact when compared to the one Bănărescu described in the '60s. A significant difference is that, unlike in its affluents (noted with N1 and N5), the trout area is no longer present on Crişul Negru (the Black Criş), the main course downstream the prelevation sections, being replaced by the barbell and its accompanying species.

Recent research shows that the grayling area disappeared in the basins of Crişul Alb (the White Criş), of Crişul Negru (the Black Criş) and the Barcău watercourse. The *Thymallus thymallus* species is present in very few area of the Crişuri hydrographic basin, upstream the prelevation sections on the left affluents (R2, R3, R4) of Crişul Repede (the Quick Criş), the Valleys Drăganului, Iadului and Mnierii.

The barbell area, also sensitive to polluted water, replaced the grayling and even the trout areas in the other hydrographic basins.

During our research, the phenomenon of cyprinide relocation (*Chondrostoma nasus, Squalius cephalus* etc) from downstream to upstream could be noticed.
In comparison with the '60s, the broad snout (*Chondrostoma nasus*) conquered new areas reaching the trout one. Significant broad snout populations were also identified in the hilly regions of rivers such as Crişul Alb (the White Criş), Crişul Negru (the Black Criş) and Crişul Repede (the Quick Criş).

Some species, such as *Eudontomyzon danfordi*, are almost extinct, some samples being present in Crişul Negru (the Black Criş), around Şuşti village (Bihor county).
The barbell and carp areas, the chub and the perch, respectively, due to their tolerance to the raising water pollutants concentration, are, from the point of view of the geographical position, quite similar to those in the '60s.

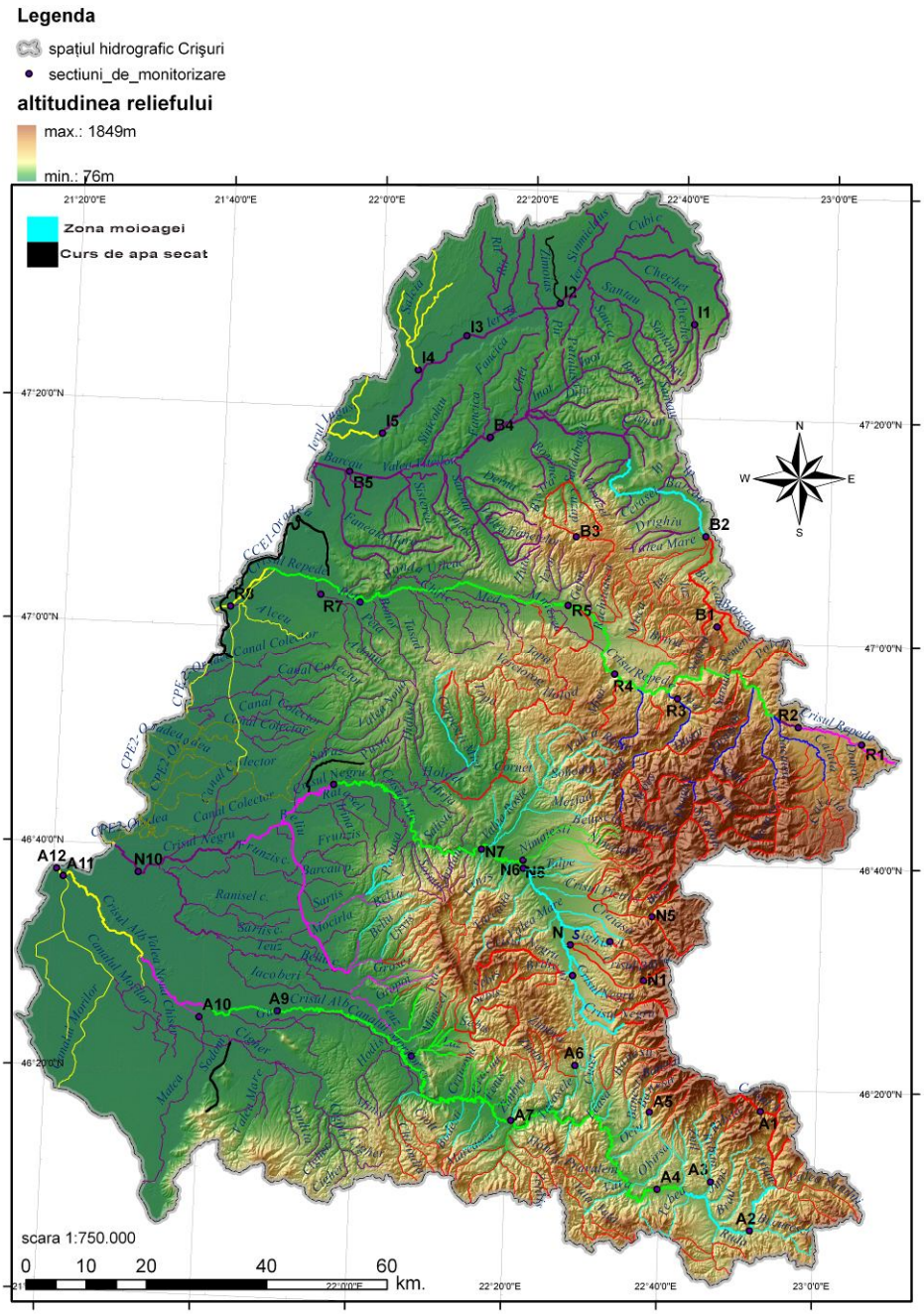

Figure 6. Map of 2004-2009 ichtyofauna distribution

Discussion and Conclusions. Different authors (P. Bănărescu and others) signaled the modification of spatial distribution of fish species and the relationships between them. By the modification of the ichtyofauna distribution we mainly understand the modification of the ecological distribution, of different fish species dispersal in the hydrographic basins under study.

The final conclusion concerning the ichtyofauna distribution nowadays is that certain species such as *Chondrostoma nasus, Squalius cephalus, Barbus petenyi* are moving from *good or moderate ecological state* waters towards *very good ecological state* waters.

As already mentioned for the grayling (*Thymallus thymallus*), this withdrawal (sometimes meaning even extinction) is quite obvious in the waters of the Criș Hydrographic Space. This phenomenon is partly due to lower river flows (as in the

upstream areas the water flow is not high enough for these species to survive), being replaced by the trout in its natural habitats.

The broad snout (*Chondrostoma nasus*) advanced very much in the Crişuri basin, the samples being captured in the grayling or the barbell areas, even the common barbell area downstream, where the ecological state of the water did not go under the level of good quality ecological state.

The research showed that the disappearance of the grayling area from the Crişuri Hydrographic Area is an actual problem and, as can be seen in Figure 7, the trout area tends to join the broad snout area, whereas the grayling area is going extinct.

Possible causes of this phenomenon in the Crişuri Hydrographic Area are as follows:

- the disappearance of the grayling area si mainly caused by exaggerated deforestation in these areas. Generally speaking, deforestation brings about water temperature raising, which favours the representatives of the cyprinide group and, in the same time, defavours the representatives of the salmonide and the cotide groups;
- the research on the benthic macroinvertebrates communities shows poor representation of the benthonic fauna in the mountaineous sector (e.g. the superior course of the Crişul Negru (the Black Criş); the disappearance of woody vegetation reduced the representatives of benthonic fauna, the main food for salmonides, but, in the same time, developed the periphyton and the aquatic macrophyte species, which is uncharacteristic of the grayling area.
- waters populated by the grayling in the '60s presented low slime content as compared to the epriod 2004-2009. In the Crişuri basin, after rains or snow melt, strong floods take place, killing the fish with the high slime content, whereas all this influences less the cyprinides.
- gravel pits in the Crişuri Space distroyed the grayling habitats. Following excavations (for ex. on Crişul Alb/the White Criş between A7-A2 prelevation stations), new areas where the water is over 2-2.5 m deep were created, thus reducing the flow speed and favouring species characteristic of inferior water courses or swamps to settle.
- the disappearance of the grayling area on Crişul Negru (the Black Criş) or on Crişul Alb (the White Criş) is also due to partially treated house waste water and mine water evacuation (the uranium mine at Poiana Vaşcău, the Băiţa and Nucet mines on Crişul Negru/the Black Criş, or the gold mine at Gurabarza – Hunedoara county, on Crişul Alb/the White Criş). Another negative effect on some species, making them relocate or worse disappear, is triggered by the river training of the watercourses in Crişuri Hydrographic Area.

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