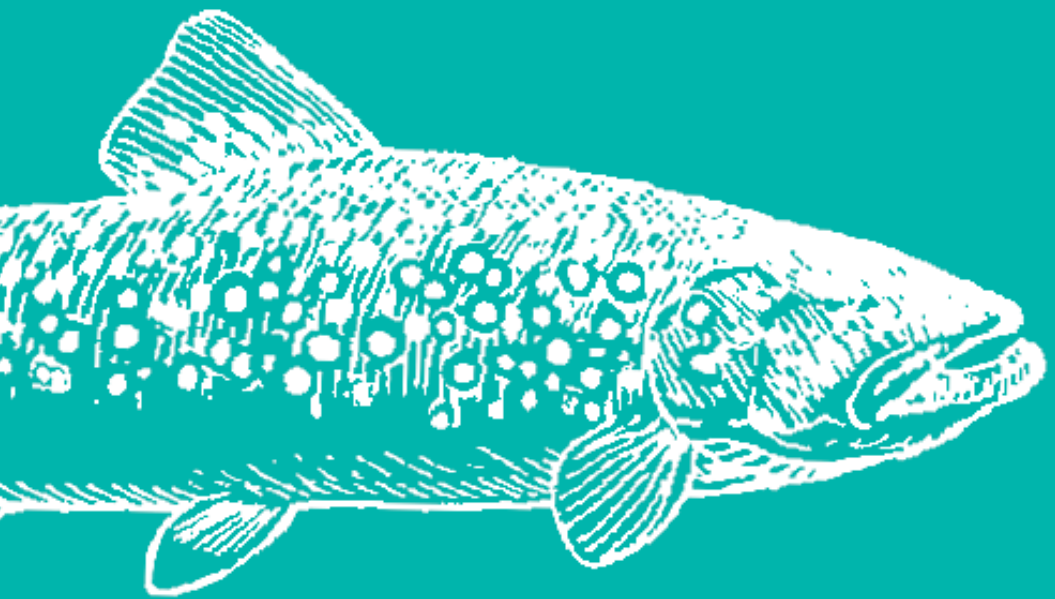
THE PRESPA TROUT

Salmo peristericus Karaman 1938

An endangered species in need of action

SPECIES ACTION PLAN



Alain J. Crivelli, Irene Koutseri & Svetozar Petkovski

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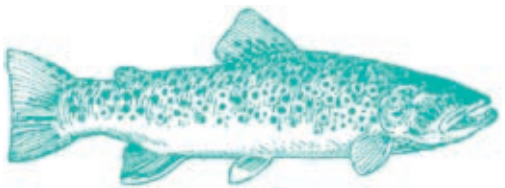

Agios Germanos, June 2008

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The Ministry of Environment of the FYR of Macedonia has made the sampling possible through the granting of a licence to the project team, while the Greek Ministry of Food and Agriculture and the Management Body of Prespa National Forest should be acknowledged for issuing licences to the Society for the Protection of Prespa for several years.

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Implementation and reviews

Preliminary research on the population densities have been undertaken within the last few years in the four catchment basins in Greece and the FYR of Macedonia, which sustain trout populations.

However, the degree of scientific knowledge and documentation available is not sufficient to provide answers to all the questions raised for the conservation of the species. Consequently, within this Action Plan, apart from the urgent conservation actions, further research and monitoring targeting specific questions are suggested.

Implementation of the actions described in this document is highly depended on the availability of funds and consequently does not constitute an obligation for the Society for the Protection of Prespa. Furthermore, the participation of other stakeholders in the implementation of this Species Action Plan is a necessary prerequisite due to the transboundary aspect of the proposed actions.

This Action Plan is designed to be reviewed within the next five years and to be followed by the completion of a "Management Plan for Prespa Trout Populations". Emergency reviews should be undertaken if any sudden major environmental changes occur within the geographical range of the species.

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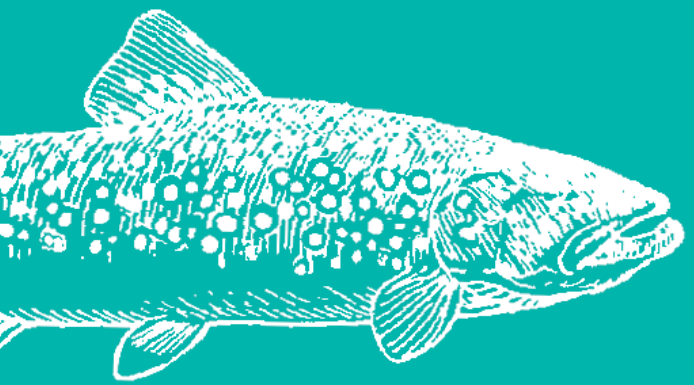


1. Introduction

From an ecological point of view Salmonids (salmon and trout) are among the most studied fish in the world due to their economic value and to sport fishing. However most of these studies have been undertaken in northern latitudes, salmonids being coolwater fish. The southern limit of salmonid distribution in Europe is the Mediterranean basin. Many studies on genetics, phylogeny, biogeography and a few on ecology have been carried out mainly in Spain, Greece, Italy, Turkey, Morocco, in the Balkans and in southern France.

What factor limits the southerly distribution of salmonids? The answer appears to be temperature, and the presence of perennial streams. One of the first consequences of global warming is the increase of the temperature regime, and the subsequent drying out and/or decrease of flow of streams in summer. Consequently, the study of southern salmonid populations is of prime importance if we want to conserve all those salmonid species endemic to southern Europe. Understanding the intrinsic and external factors influencing these populations on their distributional edge will be the key to ensure the viability of healthy trout populations and to conserve their stream biodiversity and stream ecosystems.

To our knowledge, there are no ecological studies (e.g. life history and population dynamics) on Balkan species of trout; only some studies on fisheries of trout living in lakes (e.g. Lake Ohrid), on distribution, taxonomy and on genetics are available (see below). This also applies to the Macro Prespa basin, where only genetic and taxonomical studies have been carried out, but ecological studies are missing.
The present Species Action Plan aims at describing the necessary actions to be undertaken within the five years of implementation, in order to:

1. document the current ecological situation of the remaining streams, which still hold populations of the Prespa trout and their catchments;
2. document the health of the remaining populations of Prespa trout;
3. develop a standardized long-term field monitoring scheme, to assess trout abundance and heath of populations;
4. attempt an assessment of the relative importance of suspected causes of the decline (threats) of trout populations;
5. propose first implementation measures to improve the situation and enhance trout populations and preserve stream and catchment ecosystems, and
6. promote sustainable development and conservation of the species by integrating stakeholder participation in the actions underlined within this Action Plan.

In summary, those aims can be grouped as (i) documentation and assessment, (ii) identification of threats and (iii) proposal of implementation measures and interventions for remediation.

2. The study area

2.1 General Information

The total Prespa area, combining the drainage basins and the lakes is 251,910 ha. The lakes Micro and Macro Prespa are situated at approximately 850 meters above sea level (m asl) amidst mountains rising to over 2,000m asl. In the eastern part, Pelister and Varnous mountains, in FYR of Macedonia and Greece respectively are characterised by impermeable to water granite rocks. On the eastern part permanent rivers are formed, all discharging into Lake Macro Prespa. These are the Golema, Kranska and Brajcinska Rivers in the FYR of Macedonia and Agios Germanos River in Greece. Agios Germanos River historically discharged into Lake Micro Prespa, but was diverted into Macro Prespa in 1936.

The Macro Prespa cathment basin area is presented in Figure 1 for the part of the catchment found in the FYR of Macedonia, and in Figure 2 for the Greek part of the catchment. Detailed data on the area in Albania, Greece and the FYR of Macedonia can be found in numerous reports (Catsadorakiset al 1996; BioPrespa Feasibility study 2002; DeCoursey 2004; KfW Feasibility study2005; Petkovski et al 2007).

2.2 The present situation: spatial distribution of trout

Figure 1: Lake Prespa Watershed (FYR of Macedonia) with existing hydro-meteorological stations (Petkovski et al. 2007)

New investigations have been made in Agios Germanos River by the Society for the Protection of Prespa (SPP) Greece and Tour du Valat (TdV) - France in 1998, 2000, and from 2005 to 2007. An exhaustive survey of the distribution of Prespa trout in the FYR of Macedonia part of the Macro Prespa basin has been made by BIOECO (FYR of Macedonia), SPP (Greece) and TdV (France) in 2006 and 2007 covering all perennial rivers of the Macro Prespa basin. Two new populations of Prespa trout have been found in Kranska River and in Leva Reka stream.

In the Albanian part of Macro Prespa basin, there are no perennial streams, and therefore no trout populations. Within the Albanian part of Macro Prespa Lake, fishermen catch trout very rarely (Dr Spase Shumka, pers. comm.).

In conclusion, today four streams within the Macro Prespa basin are known to have Prespa trout populations: Agios Germanos River in Greece (Figure 2) and Brajcinska River (Figure 3), Kranska River (Figure 4) and Leva Reka stream, a tributary of Golema River (Figure 5) in FYR of Macedonia. Their characteristics are presented in Table 1.

	Agios Germanos River	Brajcinska River	Kranska River	Leva Reka Stream
Catchment area (km2)	57	78	30.4	30.8
Length of the main stream (km)	14.5	15.8	11.1	9.4
Mean annual discharge (m3/sec)	0.559*	0.927**	0.459**	0.363**

Table 1: Main characteristics of the four streams within the Macro Prespa Basin sustaining trout populations (*DEH 1998, **Petkovski et al. 2007).

Figure 2 : Agios Germanos River Watreshed, Greece (Catsadorakis et al. 1996)

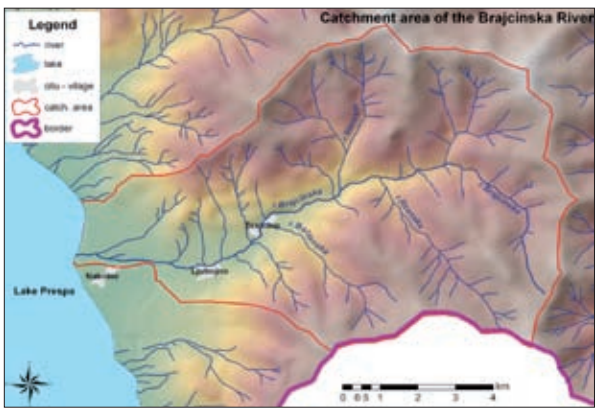


Figure 3: Brajcinska River Watershed (Petkovski et al. 2007)

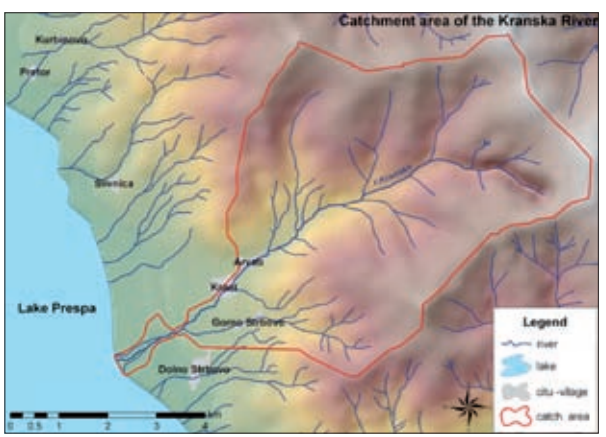


Figure 4: Kranska River Watershed (Petkovski et al. 2007)

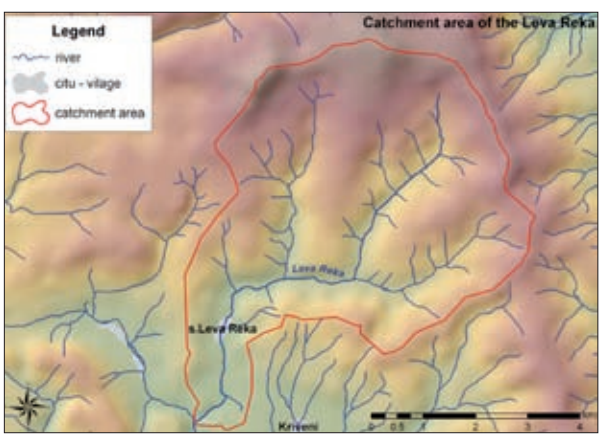


Figure 5: Leva Reka Stream Watershed (Petkovski et al. 2007)

3. The Species

3.1 Brief history of trout studies in the Macro Prespa basin

Already last century, Athanassopoulos (1922, 1923) mentioned the catch of small amounts of trout in the Macro Prespa Lake. These large trout were called « létnitsa », a slavish name for the Ohrid trout, a nearby lake. Athanassopoulos (1935) mentioned that these specimens were coming from Lake Ohrid by underground connections between the two lakes which would explain why they were rare. In the early fifties (1951 to 1954), stocking of trout from Lake Ohrid (274,520 fry of *Salmo letnica typicus*; 333,159 fry of *S. letnica balcanicus* and 100,000 fry of *S. letnica aestivalis*) into the Macro Prespa Lake did occur in the Yugoslavian part of the lake (Hadzisce, 1985). Today, it is extremely rare to catch trout in the Macro Prespa Lake; the few specimens that have been caught belong either to the rainbow trout, *Oncorhynchus mykiss*, an American species stocked at an unknown date or escaped from a fish farm along the Golema Reka River or to Brown trout of unknown origin.

In the rivers of the Macro Prespa basin, Karaman (1938) was the first to describe *Salmo peristericus* caught in the Brajcinska river and Lake Macro Prespa. Later, only the population of Agios Germanos River was the subject of new taxonomical investigations using morphology and genetics (see section on Taxonomical Status). However, an exhaustive survey of the distribution of Prespa trout within the Macro Prespa basin was missing.

3.2 Species Description

The Prespa Trout, also called Pelister Trout in the FYR of Macedonia, is a small Salmo species, which rarely exceeds 35 cm in length and 350 gr in weight. Distinction from other Balkan species of trout is not very easy, but the species is characterized by a small black spot on the opercle and small black spots on the upper third part of the lateral part of the body. Red spots are dispersed on the whole lateral part of the body and may vary in coloration from dark orange to purple. The number of gill rakers range from 16-18.

Detailed morphological and meristic characteristic are described in Karakousis et al. (1991) and by Delling (2003). There is no data available on the ecology and the biology (age at sexual maturation, lifetime, fecundity, spawning time, etc.).

Salmo peristericus

3.3 Ecological Requirements

The species was formerly considered to be a lacustrine species entering streams only to spawn. However, distribution is currently limited to the headwaters of four streams, whereas there is limited connectivity to the Lake Macro Prespa.

Despite the lack of detailed ecological studies, several inferences can be made regarding the preferred habitat type of the species, based on the general requirements of trout species. Apart from the standard requirements of a species (e.g. food availability), habitat quality in trout is also highly dependent on temperature (T) and oxygen content.

The optimum T for trout survival ranges between 8 – 19 ºC, while any value above 26 ºC may prove lethal. Furthermore, egg survival is ensured only within 0 – 15 ºC (Elliott, 1994).

Oxygen content requirements for brown trout and most members of the Salmonidae are higher than those for most other fish (Elliott, 1994). High oxygen content values are also closely related to the quality of spawning ground and the subsequent egg survival. All salmonids prefer to build redds in cold, well-oxygenated, gravel-bottomed streams to ensure that there is constant flow through the gravel, delivering oxygen to the eggs and removing waste products (Elliott 1994, Hunter 1991).

Lastly food availability is another factor that may affect individual and population survival. Trout prey is mainly comprised of fish, benthos, drift, and insects, while allochtonous input can bring an important amount of food for trout, especially during summer.

3.4 Habitat requirements

The Prespa trout, being a species confined to the headwaters of streams will depend on two habitats, the actual stream and the adjacent riparian forest.

Stream morphology affects a trout population, as it defines the actual carrying capacity of the stream. This carrying capacity is dependent on:

- **the availability of hiding places,**
- **the number and size of pools,**
- **the actual flooded area and**
- **the presence/absence of wood debris.**

Variation among streams will result in variation in the population structure and health.

Furthermore, barriers (natural and/or man-made) affect the longitudinal connectivity of a stream. For a healthy trout population, the longer two-way stretches of stream are (where trout can migrate both ways – downstream and upstream), the better

Typical *Salmo peristericus* habitat

will be the health and the viability of the trout population, while a highly fragmented habitat will result in the isolation of populations, and reduce their size and viability.

The riparian forest is an important interface between the aquatic and terrestrial ecosystems, ensuring good quality of habitat (bank stability, limited erosion, shading) and appropriate water temperature (shading). Riparian forest will limit erosion and fine sediments and ensure the quality of the streambed, while shading will help to maintain water temperature at the required low levels and contribute in reducing evaporation during the summer months.

3.5 The Prespa trout taxonomical status

Karaman (1938) recognized the trout of Prespa area as a subspecies, *Salmo trutta peristericus*, while recently it was recognized as a separate species *Salmo peristericus* by Kottelat and Freyhof (2007).

Based on morphological variability comparison among seven populations of Brown trout in Greece including the Agios Germanos stream, it was concluded that the populations were distinct (Karakousis et al. 1991). Later, a revision of the taxonomy of European trout (Delling, 2003) based on detailed morphological analysis showed that *Salmo peristericus* is well differentiated from other Balkan trout species (based on 10 specimens from Agios Germanos River).

Numerous genetic studies on Greek trout have occurred, with contrasting results. While allozyme data analysis supports the taxonomic distinctiveness of the Prespa trout and its Mediterranean origin (Karakousis & Triantaphyllidis 1988,1990, Karakousis et al. 1991; Apostolidis et al. 1996a), more recent studies using mitochondrial DNA (Apostolidis et al. 1996b, 1997), do not support the uniqueness of the Agios Germanos population, supporting that it is of Adriatic origin. Apostolidis et al. (1997) stated: «*Furthermore most of the populations examined had a unique genetic profile...This significant differentiation among the populations may be due to a long period of isolation coupled with bottleneck and subsequent genetic drift phenomena*».

Snoj et al. (*submitted*) in a recent study on trout specimens from Albania and the Macro Prespa Lake basin using mtDNA, found that that all populations analyzed in the Macro Prespa basin are of **Adriatic origin**, that **any introduction of foreign trout has never occurred** in the Macro Prespa basin and that it belongs to an **isolated form** without recent exchanges with *S. letnica* (Lake Ohrid), *S. pelagonicus* (river Vardar basin) or other *S. trutta* populations.

However, taxonomic discussions should not affect the conservation and management of a species and as stated by Laikre et al. (1999) "*Effective conservation of the brown trout must be based on the genetic differences between populations regardless of whether we call these populations species, subspecies or local populations*". We can consider therefore that trout found within the Macro Prespa basin constitute a distinct **Evolutionary Significant Unit** (ESU): ***"a group of conspecific populations that has substantial reproductive isolation, which has led to adaptive differences so that the populations represent a significant evolutionary component of the species"*** (Palsboll et al. 2006).

3.6 Delineation of Management Units according to population genetic structure

Pasboll et al. (2006) define Management Units (MUs) as: "*populations of conspecific individuals among which the degree of connectivity is sufficiently low so that each population should be monitored and managed separately*". According to Laikre et al.

(2005): ***"The key issue here is to identify genetically "homogenous" groups of individuals that will constitute the basic unit for conservation, management, and sustainable use"***.

Within a species, there will be groups of individuals that are typically more or less isolated from one another, while if there is limited exchange of reproducing individuals between groups there will be genetic differences between them. The basic unit is considered to be a group of individuals characterized by approximate random mating (panmixia) and site tenacity to a particular area.

Berrebi et al (2007) have carried out direct genetic analyses to conclude the following regarding the genetic population structure within the Macro Prespa Basin:

1. The low expected heterozygosities suggest isolation of the populations of each basin (Agios Germanos – Greece, Brajcinska Reka, Kranska Reka and Leva Reka – FYR of Macedonia).
2. There are genetic differences among the populations. Leva Reka stream and Kranska River are definitively different from the other populations (Brajcinska and Agios Germanos) and also between them.
3. Genetic differentiation is also observed within the same basin in Agios Germanos River and between some tributaries of Brajcinska River, suggesting further isolation of these populations within their basin due to fragmentation.
4. According to the genetic results, there is no evidence of any introduction of foreign trout and there is limited migration of trout from the rivers to the lake and never from the lake to any rivers.

Based on the latter results, it can be concluded that within Macro Prespa basin there are **four** isolated local populations (distinct populations) with no gene flow among them. This indicates that the populations' health is ultimately determined by the performance of individuals, summarized by their birth, death, and growth rates, and that those populations cannot count on recruitment of individuals from other populations to ensure their viability.

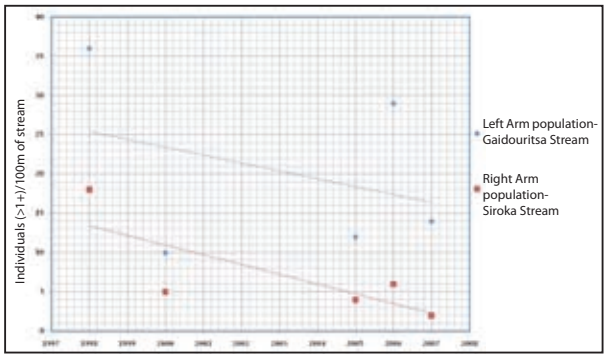
In conclusion, within the ESU of Prespa trout we have four Management Units (MUs): the Agios Germanos River, Brajcinska River, Kranska River and Leva Reka stream.

Conservation and management of Prespa trout will have to be considered separately for each of the four Management Units. The conservation of multiple, genetically distinct populations is necessary to ensure the long-term species survival and the functioning of ecosystems, which will require bilateral transboundary cooperation.

3.7 Population Status

Studies in the Agios Germanos River show large fluctuations of the population size within the last ten years (Graph 1). Such fluctuations among years in trout populations are normal and these do not necessarily indicate an actual decline, but rather the natural cycle of the population, particularly for the left arm of the river. Further population research and a long-term monitoring scheme will answer the questions related to the population status.

In table 2, the densities of trout populations within each tributary in the four catchments basins are presented . All the observed densities are low in comparison with general Brown trout ones (>5000 individuals/ha), but they are similar to



Graph 1: Trout population trend in Agios Germanos River (1997-2007)

Site and stations	Years (number of stations)	Surface Sampled (m2)	Length sampled (m)	Mean N trout (>1+/ha)	Mean N trout (> 1+/100m of stream)
Brajcinska basin streams and tributaries					
Main river	2006 (2)	858	205	664	28
	2007 (4)	1468	405	660	24
Baltanska	2006 (1)	220	100	136*	3
	2007 (2)	474	210	42*	1
Rzanska	2007 (2)	455	200	1121	26
Drmisar	2007 (2)	490	210	878	20
Kriva Kobila	2007 (1)	263	105	1709	43
Kranska basin streams and tributaries					
Main river	2006 (1)	289	98	519	15
	2007 (4)	1298	408	593	19
Upper Kranska	2007 (1)	287	100	174*	5
Srbino	2007 (1)	268	113	485	12
Leva Reka tributaries					
Sredna	2007 (2)	431	200	186*	4
Agios Germanos basin streams and tributaries					
Left arm	1998 (2)	680	200	530	18
	2000 (2)	538	200	167*	5
	2005 (2)	538	200	130*	4
	2006 (2)	538	200	205	6
	2007 (2)	538	200	74*	2
Right arm	1998 (8)	2920	813	1009	36
	2000 (8)	2476	813	343	10
	2005 (8)	2476	813	391	12
	2006 (8)	2476	813	966	29
	2007 (8)	2476	813	452	14

*The viability of populations with such low densities is questionable.

Table 2: Trout densities in all river/stream tributaries (Greece and FYROM)

those observed in Slovenia for Marble trout (Crivelli, pers. comm.). However, observed densities lower than 200 individuals/ha are quite low, and viability of those populations remains an issue.

For some tributaries (e.g. Baltanska, Sredna) the habitat can explain those low densities, while among the factors involved are the low flow in summer and the absence of large pools. For other tributaries poaching and/or angling could be the responsible factor. Long-term research into the factors affecting these trout population is needed, before any definite conclusion can be drawn, especially considering that trout populations fluctuate widely from a year to another.

However, even if the current study cannot document an actual decline of the population within the last ten years, it is noteworthy that there has been an indisputable historical decline of the populations and a limitation of the population in the headwaters of the streams.

According to local people, in both countries, the Prespa trout has declined in quantity (numbers of trout individuals) as well as in quality (less big fish). A reduction of the spatial distribution of trout has obviously occurred mainly due to water abstraction and pollution by sewage waste.

The part of Agios Germanos River downstream Agios Germanos village in Greece is deprived of trout due to water abstraction for the irrigation of agricultural land and the same is true in the Brajcinska River downstream the village of Ljubojno in the FYR of Macedonia. Furthermore, in the FYR of Macedonia, several tributaries have no trout anymore – although locals attest they used to – due to water abstraction upstream.

This long-term and ongoing research using various methodologies (electrofishing, marking scheme and density studies among others) has produced more results, which are currently under review and will be published on a later date.

4. Existing designations and regulations

4.1 Conservation Status

4.1.1 International Conservation Status

In a recent work on freshwater fishes endemic to the Mediterranean region, IUCN classified *Salmo peristericus* Karaman, 1938 as "Endangered" (Smith & Darwall, 2006). A taxon is Endangered when the best available evidence indicates that it meets certain criteria and it is therefore considered to be facing a **very high risk of extinction** in the wild. *Salmo peristericus* has been enlisted due to severe fragmentation of its habitat, limited extend and an observed continuing decline. It should be noted that this evaluation was done in 2006, based only on data from the Agios Germanos trout population and will need to be revised due to the discovery of new populations in the FYR of Macedonia.

4.1.2 National Conservation Status – Greece

The Greek Red Data book

The Greek Red Data Book of Threatened Vertebrates of Greece (Economidis, 1992) classifies the subspecies *Salmo trutta peristericus* as Endangered. An update of this old edition is expected to have recent information and to continue to classify the species as Endangered. The aim of compiling a Red List is to facilitate the establishment of conservation priorities and the guidance of conservation action, while it helps in influencing national and international policy.

4.1.3 National Conservation Status – the FYR of Macedonia

The FYR of Macedonia has not yet prepared a National Red List of threatened species and at the same time is at the process of developing new legislation in accordance with the "Programme for Approximation of the National Legislation to the Legislation of the European Union".

4.2 Protection Status

Apart from the conservation status of the species, several national laws and regulations apply to the four basins, thus promoting the protection of species at various degrees.

4.2.1 National Protection Status - Greece

The Habitats Directive

As a Member State of the European Union, Greece has incorporated several European Directives into National Law. *The Directive 92/43/EC on the conservation of natural habitats and of wild flora and fauna* (*Habitats Directive*) has been incorporated into National Law through the *Ministerial Decision 1289/1998* aiming at the protection of biodiversity and the establishment of Special Areas of Conservation (SACs) in a coherent network, part of the EU-wide NATURA 2000 Network.

The Greek National list, compiled in implementation of the "Habitats Directive", has incorporated the Basin of Agios Germanos River under the code GR1340003, which is now part of the Sites of Community Importance (SCIs) (*Commission Decision 2006/613/EC*). Furthermore, the River basin extends into another area of the NATURA 2000 network, the Prespa

National Park under the code GR1340001. This is very important as particular interest is given by the Directive on the coherence of the NATURA 2000 Network. In particular it refers to "*the management of features of the landscape which are of major importance for wild flora and fauna. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) … are essential for the migration, dispersal and genetic exchange of wild species*". The Agios Germanos River Basin is a typical example of such a case.

Furthermore, the Agios Germanos River runs along some of the habitats included in the Directive:

- "6230* - Species-rich *Nardus* grasslands, on silicious substrates in mountain areas" a priority habitat for the Directive
- "9130 – *Asperulo-Fagetum* beech forests"
- "9140 – Medio-European subalpine beech woods with *Acer* and *Rumex* arifolius"
- "92A0 – *Salix alba* and *Populus alba* galleries"

Hence, the Greek state has to observe the full array of standards and provisions under the Habitats Directive in order to manage and protect the Agios Germanos River Basin.

Relevant obligations within the Habitats directive include:

1. Establishing necessary conservation measures involving appropriate management plans,

2. Avoiding the deterioration of natural habitats and the disturbance of species,

3. Assessing the environmental impact of any plan or project not directly connected with or necessary to the management of the site, but likely to have significant implications for the site in view of the site's conservation objectives.

Other national laws and regulations affecting the Agios Germanos River basin

The lower parts of the river, from the mouth in Lake Macro Prespa up to the village of Laimos are included in the peripheral zone of the National Park of Prespa under the *Presidential Decree 46/1974 on the establishment of Prespa National Forest*.

The Presidential Decree 235/1979 on regulation of river fisheries states that the only permissible catching method is hooked gear, while there is a compulsory fishing ban for a period of 45 days between 1 April and 15 June. T*he Presidential Decree, 99/94/2003 on amateur and sport fishing* forbids any fishing by means of artificial light and the trade of catch, while *Presidential Decree 373/1985* had previously set the bag limit up to 2 kgr of fish or 3 individuals regardless of weight within 24 hours. Amateur fishing in lakes and rivers is allowed only by means of angling equipment.

All decisions on the application of yearly fishing bans are currently taken by the Prefecture of Florina, with the most recent one being applied from 1.4.2006 until 15.2.2007.

A very important recent development is that the Prespa National Forest Management Body (PNFMB) decided upon the ban of trout fishing in Agios Germanos River and will undertake actions and submit proposals to the relevant Ministries in due course (*PNFMB Decision 30/13.05.2008*).

It is worth mentioning that the *Special Environmental Study of Prespa (Ministry of Environment, 1999)*, which is still under approval as a *Common Ministerial Decision* is expected to improve the protection status of the Agios Germanos River basin, due to the

1. Incorporation of the catchment basin of Agios Germanos River into the Zone B of the Prespa National Park.

2. Characterization of the Agios Germanos River basin as a "Protection Zone" and the subsequent delineation of the "Protection Zone".

3. Prohibitions regarding the collection of species, hunting, planting, grazing and other interventions (i.e. constructions, felling of trees, sand removal, camping, hydroelectric power stations) within the "Protection Zone". Any relevant licenses regarding any of the above activities within the villages will be issued by the Prespa National Park Management Body.

4.2.2 National Protection Status – the FYR of Macedonia

The following laws and regulations are the most relevant to the protection of the river basins of the Prespa area in the FYR of Macedonia:

- The Law on Nature Protection (Official Gazette 67/2004), according to which one of the four protected areas within the watershed of Prespa is the National Park Pelister (NPP). The NPP boundaries have expanded recently to include a portion of the upper part of the Brajcino River Valley. The same law states that waters and water habitats, including springs, streams and rivers are a natural wealth and are preserved in their natural state.
- Following the expansion of the NPP and the inclusion of Brajcino Valley within the NPP, the fishing of trout in the tributaries of Brajcinska River that fall within the new borders of the NPP has been banned. Fishing is now allowed only in Baltanska tributary, which is outside the new borders of NPP and just off Brajcino village
- The Law on Ohrid, Prespa and Doyran Lakes Protection (Official Gazette 62/93) states that the waters, coastal areas, springs and watercourses of these lakes are proclaimed natural monuments and places them under special protection, due to their characteristics, features, values and economic relevance.

4.3 Transboundary aspects on the conservation of the Prespa trout

Agios Germanos catchment - Greece

The above mentioned statutes and characterisations on the protection and conservation status of the Prespa trout confirm its ecological significance at the international and national levels. Furthermore, they stress the importance of transboundary cooperation, which is "standing between" these two levels, for the realisation of long-term conservation management of the species, even if at present there is no connectivity of the four MUs of the trout.

In this respect, since May 2002 the need to apply administrative measures in the Greek part of Prespa was included as a necessary action aiming at the conservation of the Prespa trout in the Agios Germanos River in the preliminary phase of the Strategic Action Plan for the sustainable development of the Prespa Park (SPP, WWF-Greece, PPNEA & MAP 2005). The compilation of that Plan was the first joint activity of the three countries at the transboundary Prespa level. Following that basic and sizeable study and as an outcome of the continuous trilateral cooperation since 2000, more specific references and proposals on the Prespa trout were included in the GEF project document (UNDP 2005), which is the baseline of the current GEF project implemented in the three neighboring countries that supports significant conservation actions, and in the relevant Project Inception Report and Implementation Plan (Lopez 2007). The most important proposals on the Prespa trout deal with: the maintenance of in-stream water flow and quality in the four rivers/streams (Agios Germanos, Brajcinska, Kranska and Leva Reka), the improvement of habitat protection status in Greece and the FYR of Macedonia, efficient wardening in both countries and implementation of actions proposed by the present Species Action Plan.

Based on all these recent developments and stakeholders' attitude, as well as on its uniqueness as a genetic resource, it is evident that the Prespa trout can be considered a species of transboundary conservation concern in the Prespa Park which certainly deserves to be given special attention along with other significant wildlife species of the Park.

5. Threats and proposed protection measures

5.1 Threats

Several hypotheses are made on the possible causes of the decline of Prespa trout. These hypotheses include cause-and-effect relationships at multiple levels. As a result, there is some degree of overlapping and interaction among them. The current set of hypotheses includes the following:

1. The trout populations are affected the by low carrying capacity of streams, particularly in relation to food availability

The carrying capacity of a stream is defined by the food availability among other factors, which is highly depended on stream morphology. This carrying capacity is dependent on habitat morphology (e.g. hiding places), food availability, the flooding area, the number and size of pools and presence –absence of wood debris among others.

2. The trout populations are suffering from a lack of stream longitudinal connectivity

Lack of longitudinal connectivity results in habitat fragmentation and subsequently in trout population fragmentation. It has been observed that in the rivers and streams of the Prespa basin, lack of connectivity is either a result of stream morphology (e.g. natural impassable barriers) or human induced alterations (e.g. constructions for water abstraction for irrigation and weirs without fish passings).

3. Altered or destroyed riparian forest affects the health of the trout populations

Often riparian forest is altered due to heavy grazing, road building (logging) and various human-induced modifications of the habitat. Heavy flood (debris flood) could also alter riparian forest, while subsequent heavy grazing limits regeneration of the forest. This is particularly evident in the higher parts of Agios Germanos stream, where parts of the stream are completely deprived of riparian forest.

4. Increase in the amount of fine sediment in streams is responsible for the decline of trout through reproductive failure and low recruitment

The quality of the streambed gravel will depend on numerous factors, such as the presence (e.g. due to intense grazing) or absence of erosion, the presence or absence of healthy riparian forest, the extent of forest within the catchment of each stream, and the increased number of built road within the forested catchment for logging activities. The total length and distribution of forest roads has expanded dramatically the last years and this is a certain cause of increased erosion.

This could be of particular concern in the above-mentioned areas deprived of riparian forest, as well as in areas with heavy cattle grazing. Heavy deforestation within the basin of the Leva Reka stream may also be affecting the quality of streambed gravel.

5. The trout population is suffering from annual repeated reduction of population through direct removal of individuals

Removal of fish by different means could be a threat to trout populations, resulting in even more adverse effects in the

case of fragmented habitats and for small isolated trout populations. Poaching using various fishing devices is known to occur regularly in the Macro Prespa basin. Behaviour of anglers and intensity of angling could also be responsible for excessive removal, threatening the trout populations (Almodovar & Nicola, 2004). Heavy legal fishing and poaching of trout in the streams of the Prespa basin is a major threat for trout populations within the Prespa basin, and the lack of a relevant regulations and monitoring results in inadequate management of the streams and the populations.

In Greece there are certain regulations in place regarding amateur fishing (see: Protection status), such as the bag limit, the compulsory summer fishing ban and the compulsory use only of angling equipment in lakes and rivers. However, there is still a lack of a licensing system and of a catch-release policy, while existing regulations could be altered/extended (e.g. longer fishing ban, adding a size limit). Management should be adapted to individual river/ stream. In the FYR of Macedonia no such regulations are effective, although there has been a recent ban of trout fishing.

6. Degraded water quality and altered hydrological regime due to water abstraction affect negatively the health of trout populations

Water abstraction for irrigation and for domestic drinking water can reduce the abundance and the distribution of trout tremendously. Caption of water for small hydropower stations do also reduce abundance of trout or may even totally wipe out the trout populations. Water abstraction reduces flow, habitat and food availability, especially during the growing season in summer. Degraded water quality downstream villages due to sewage water can also reduce trout population through oxygen content reduction. Water abstraction and pollution are particularly evident downstream the villages of Agios Germanos (for Agios Germanos River in Greece), the Brajcino village (for Brajcinska River).

7. Global climatic changes might be responsible of the trout decline today or in the future

Climatic changes are thought to modify the hydrological regime of streams and lead to a significant increase in annual water temperature (Lehner et al., 2006). Snowfall reduction and changes in the rainfall pattern throughout the year will alter the hydrological regime of the streams, thus having an impact on trout populations, especially during summer, with repeated low flow (reduced carrying capacity, increasing intraspecific competition) and high temperature (increasing mortality). Temperature changes can affect trout in many ways: growth, reproduction, diseases (pathogens and parasites). The ecological health of the catchment forests will greatly affect the influence that global climatic changes will exert on the trout habitat and population. Degraded forest and limited forest management contribute in erosion, in-stream water temperature alterations and a subsequent reduction in food availability, among other adverse effects.

8. The decline of Prespa trout is due to a combination of the above-mentioned factors with a varying degree of significance for each factor in the four different streams of Macro Prespa basin.

The different potential causes are mutually dependent and linked to each other and to various intrinsic and extrinsic factors. Stream variation with respect to the health status of the trout populations should also be taken into account. Stream differences might be due to variations in natural factors such as the quality of the catchment of the stream, but also to different types of anthropogenic influences. All these factors may and will affect positively or negatively the viability of the trout populations in each of the four basins. The concept of **integrated management** must be applied at the **stream**

catchment level to guarantee the compatibility of human activities with the preservation of biodiversity and ecosystem functioning (Crivelli, 2002).

9. Lack of management of trout habitats and populations leads to habitat degradation and decline of populations

Present legal regulations and their implementations could be inadequately adapted to the current status of Prespa trout in the Macro Prespa basin. The current lack of management of Prespa trout populations could affect further the declining populations.

This is particularly important for the issues of angling/ poaching, as well as for the regulations that should be applied regarding water abstraction for irrigation and for the creation of hydropower stations in the streams of the Prespa basin.

The current lack of management stresses the necessity for common transboundary strategic planning, the necessity for compatibility among the management plans and the possibility for bilateral cooperation among relevant stakeholders in the two countries for monitoring and effective conservation of trout populations.

5.2 Proposed Actions to be undertaken within the next five years

Considering the above-mentioned threats, several actions and proposals are presented in this section. These are planned within a time-frame of five years. Following the accomplishment of the following actions or upon completing five years from the publication of the Action Plan, the document should be revised and adapted to strategic planning for the following years.

The benefit from the following proposal will be greatly improved if some of the actions are carried out jointly, promoting transboundary cooperation. For example, all the research/ survey and Public Awareness actions should be undertaken as joint projects, despite the fact that each basin is considered a different MU. Joint actions will facilitate the exchange of information and of know-how among the stakeholders of the two countries and strengthen their cooperation, subsequently promoting the effective conservation of the species and the sustainable development of communities involved.

Action 1

Considering the importance of food availability during the summer growth period, when also water within a stream may be limited, an estimation of benthos in June and July during these five years will be a good indicator of food availability and potential stream carrying capacity. Furthermore, water quality can be assessed using standard methodologies for invertebrates.

Proposed Methodology: Water quality score and benthos biomass
Deliverables: A "Food Availability report" and a "Water Quality Report" based on the assessment of the above indices will be the deliverables of this Action (Year 2).

Action 2

The degree of fragmentation of streams and tributaries with trout should be determined [mapping all impassable barriers (GPS), defining their origin (natural/ man-made)]. During this survey, presence-absence of trout will be noted, and the total

trout populations will be estimated for the four basins. Riparian forest (Action 3), presence/ absence of large debris wood and water abstraction points (Action 7) could also be assessed as part of this survey.

Proposed Methodology: Estimation of trout population within each isolated stretch of stream
Deliverables: A report based on the assessment of trout populations will be the deliverable of this Action (Year 2).

Action 3

Within the first year of implementation of the present Species Action Plan riparian forest along the four streams with trout populations should be surveyed and a long-term water temperature (T) monitoring scheme applied (installation of T loggers). Within the second year, a Restoration Feasibility study should be completed, examining the necessity for restoration projects (location), relevant planting techniques, fencing methods against grazing and monitoring techniques (Pollock et al., 2005). Restoration and subsequent monitoring could be implemented from the third to the fifth year of the Action Plan.

Proposed Methodology: T data and assessment of riparian forest
Deliverables: Annual assessment reports on T data and on the riparian forests assessment (Year 2), Restoration Feasibility Study (Year 3), Restoration project (Year 4) and restoration monitoring reports (Year 4 & 5) will be the indicators for this Action.

Action 4

Assessment of the availability of suitable spawning grounds should be undertaken using standardized methodology. Two suggested descriptors of substrate composition are: (a) the geometric mean diameter (dg) and (b) the Fredle index (fi). The latter incorporates elements that integrate gravel permeability and pore size (Chapman, 1988; Kondolf & Wolman, 1993; Rubin, 1998). Both measures are related to survival of eggs and larvae of salmonids, while the Fredle index is generally better correlated to survival (Chapman, 1988).

Proposed Methodology: Geometric mean Diameter (dg) and Fredle Index (fi)
Deliverables: A "Spawning Ground Suitability" report based on the scores of the above indices will be the deliverable of this Action (Year 3).

Action 5

Assessment of poaching and angling in the four streams with Prespa trout populations should be undertaken within the five years of the Action Plan. Assessment should be carried out in cooperation with local stakeholders and if possible incorporated within a simple wardening scheme. If wardening cannot be undertaken by the respective relevant local authorities, then it should be undertaken within the scope of a Public Awareness Campaign (see below – Action 9) by local stakeholders, within which anglers and poachers will be informed on the importance of this trout species and the catchment where it is found. This should be especially undertaken during weekends, public holidays and summer, when angling/ poaching is more likely to occur. The potential to collect information from anglers with personal interviews or by using questionnaires could also be explored. Such "Wardening-Monitoring" action will help in the assessment of the angling and poaching activities, and the diminution of the negative effects of poaching.

Proposed Methodology: "Wardening – Monitoring" patrols and long-term trout abundance trend monitoring.
Deliverables: Annual reports on the "Wardening – Monitoring" scheme will be one part of deliverables of this Action. The monitoring scheme for Prespa trout will be developed within the 5-years of this Action Plan and will contribute to the assessment of the trend of abundance of trout and will be the second deliverable for this Action.

Action 6

All existing water captions and small hydropower stations in the four river catchments where trout is present should be identified and their impacts on trout populations should be assessed. Also, within this "Water Caption Survey" all existing plans for new water captions and/or new hydropower stations in the four river catchments where trout is present should be listed. Within this survey, water quality downstream the villages should be assessed. New hydropower stations should not be planned for the river catchments with trout.
Sewage stations for every village should be planned/ built and monitoring of quality and quantity of water should be funded.

Proposed Methodology: Survey on the number and location of sewage stations planned and built within the timeframe of the Action Plan
Deliverables: A "Water Caption Survey" will be the deliverable of this action and it should be used as a supporting document for stopping hydrological regime alterations (Year 2).

Action 7

A detailed study on the hydrology balance, including assessment of spring discharge, precipitation analysis, water diversion and extraction of the four catchments with Prespa trout should be undertaken. This "Hydrological Balance Study" should also recommend actions for maintaining the best hydrological regime for healthy streams and viable trout populations within a 100-year framework.
An "Integrated Ecological Forest Management Plan" is suggested to be undertaken for the four catchments, which among other issues will identify and assess the effects of past and current logging activities, suggestion measures to tackle over-exploitation and illegal logging.
According to the recommendations of those studies (including the studies and surveys of Actions 1, 2, 4 and 6), implementation of management actions could take place in the third to the fifth year of the plan in order to improve the situation.

Proposed Methodology: Implementation of management actions
Deliverables: "Hydrological Balance Study" (Year 3) and "Integrated Ecological Forest Management Plan" (Year 3) and a report on the implementation of management actions to improve the situation (Year 5) will be the deliverables for this action.

Action 8

For each stream basin, intense public awareness campaigns will be developed towards local people and the people of the wider region in both countries (Greece and FYR of Macedonia). This work should be planned on a long-term basis, as changes of mentality will need time. Based on the results of the other actions, the viability of the trout populations in the four

stream basins will be assessed. More specifically Public Awareness Material targeting different groups (local stakeholders/ authorities, visitors, etc.) and Environmental Education material for local and visiting schools should be produced.
Public awareness should be planned and implemented jointly by stakeholders in both countries and implemented as a joint bilateral transboundary action.
The designation of the Prespa trout as a "flagship" species in the Prespa Park area should be promoted. Due to its endemism, transboundary presence and the potential for sustainable development through conservation, this species can influence the conservation of the entire riverine ecosystems of the four study catchments and benefit a wide array of species. The designation of trout as a flagship species will build a sense of shared responsibility for its conservation, can multiply the species' visibility and the impact of awareness-raising activities and increase the pressure for pure conservation actions,

Ecological forest management benefits trout populations

measures and interventions at the national level in the two countries involved. Finally, its "promotion" as a flagship species may attract international funding and attention, while it can also serve as a model for collaborative cross-border conservation of a species that does not actually move across borders, but uses similar habitats on the two sides of national borders.

Proposed Methodology: **Population Viability Analysis (PVA)**
Deliverables: **The produced material of the public awareness campaign (Year 2 & 3), the designation of Prespa trout as a flagship species (Year 1), a report on Population Viability Analysis (Year 3) and a report on the implementation of the Public Awareness Campaign (Year 5) are the deliverables for this action.**

Action 9

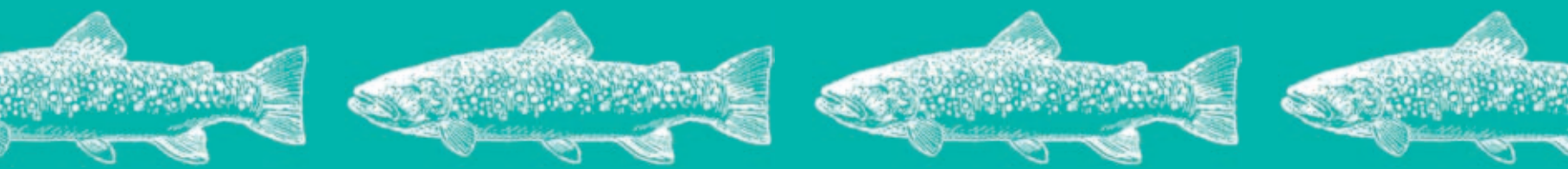
Absence of management and/or mismanagement should be solved by implementing new regulations for angling, such as (i) establishment of local licenses, (ii) establishing a bag limit, (iii) raising the size limit and (iv) setting stretches with a catch and release policy, alternating with other stretches used as fishing reserves. The possibility of applying a fishing ban for 5 years should be considered, which will be readjusted following the research results within this Action Plan after the five year implementation period.
Within the Public Awareness campaign (Action 8), there should be material focusing on angling/ poaching and targeting anglers. In parallel to Action the "Wardening-Monitoring" scheme (Action 7), all trout catches within the Macro Prespa lake should be monitored.
Furthermore, regulations should be applied regarding water abstraction for irrigation and hydropower stations. This should be promoted in particular to the local, regional and national authorities by local stakeholders interested in the conservation of the endemic trout.
The results of the Actions (1-8) throughout the 5-year implementation of this Action Plan will be incorporated in a "Management Plan for Prespa Trout Populations". This Management Plan will address all the threats, assess the interventions carried out during the 5-year period, propose modifications in management regimes and laws/ regulations, and suggest immediate and long-term measures and monitoring schemes. Furthermore, it should address the role of the various stakeholders involved in the conservation of the Prespa trout and promote sustainable development through the management actions. The proposed actions of the Management Plan should be adapted to all MUs, thus enhancing bilateral transboundary cooperation and promoting joint conservation measures for the whole Prespa catchment basin, avoiding future divergence in the protection level and status of the trout populations.

Proposed Methodology: **Incorporation of results in a "Management Plan for Prespa Trout Populations"**
Deliverables: A **"Management Plan for Prespa Trout populations" should be compiled incorporating the conservation needs of the species and suggesting alteration/ additions to current regulations to be implemented in the future (Year 5).**

6. Conclusion

The Prespa trout *Salmo peristericus* is one of the endemic species of the Prespa Basin and it is highly dependent on the health of riparian habitats within this basin. The species survival is threatened by its restricted distribution and the small size of populations, while the current and imminent habitat degradation is also threatening.

All the actions described above are necessary to implement scientifically sound management in order to ensure the viability and the enhancement of the Prespa trout populations and their stream ecosystems in the long-term. This preservation will be beneficial not only to trout but also to the biodiversity of the whole catchment and to the people living within these stream catchments.



Glossary

Allochthonous input	Input not produced on site, but coming from a different source (Here: trout prey not produced in-stream, e.g. insects from riparian forest)
Drift	Invertebrates that are carried downstream by the river flow (comprise the main food of trout)
Flagship Species	Species chosen to represent an environmental cause, such as an ecosystem in need of conservation. These species are chosen for their vulnerability, attractiveness or distinctiveness in order to best engender support and acknowledgement from the public at large. Thus, the concept of a flagship species holds that by giving publicity to a few key species, the support given to those species will successfully leverage conservation of entire ecosystems and all species contained therein.
Gill rakers	Forward projections (usually bony) along the anterior edge of the gill arch
Lacustrine	Related to lakes
Meristic characters	Countable structures occurring in series (e.g. vertebrae, fin rays) in fish. These characters are among the characters most commonly used for differentiation of species and populations. In the salmonids, scale counts have been most widely used for the differentiation of populations within species.
Opercle	The group of bones and associated membranes (usually movable) which cover the gills
Redd	Salmonid "nest", usually constructed at the head of a rifle or the downstream edge of a pool. Due to redd morphology, the constant flow of water ensures oxygen supply to and waste product removal from the developing eggs.

The definitions in this Glossary are derived from:

- Hunter, C.J. 1991. Better Trout Habitat: A Guide to Stream Restoration and Management. Montana Land Reliance, USA
- http://en.wikipedia.org/
- Kottelat, M. and J. Freyhof. 2007. Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany

References

Almodovar, A. & Nicola, G.G. 2004. Angling impact on conservation of Spanish stream-dwelling brown trout *Salmo trutta*. Fisheries Management and Ecology, 11, 176-182.

Apostolidis, A., Karakousis, Y. & Triantaphyllidis, C. 1996a. Genetic divergence and phylogenetic relationships among brown trout (*Salmo trutta* L.) populations from Greece and other European countries. Heredity, 76, 551-560.

Apostolidis, A., Karakousis, Y. & Triantaphyllidis, C. 1996b. Genetic differentiation and phylogenetic relationships among Greek *Salmo trutta* L. (brown trout) populations as revealed by RFLP analysis of PCR amplified mitochondrial DNA segments. Heredity, 77, 608-618.

Apostolidis, A.P., Triantaphyllidis, C., Kouvatsi, A. & Economidis, P.S. 1997. Mitochondrial DNA sequence variation and phylogeography among *Salmo trutta* L. (Greek brown trout) populations. Molecular Ecology, 6, 531-542.

Argyropoulos, D & Giannakis, N. (Coordinators). 2001. Special Environmental Study for Prespa. Prefecture of Florina (*Updated Version of the 1998 original version, in Greek*).

Athanassopoulos, M.G. 1922. Le plateau des lacs de la Macédoine occidentale. Int. Rev. Ges. Hydrobiol., 10, 31-39.

Athanassopoulos, M.G. 1923. La faune ichtyologique et la production des lacs de Macédoine, Thessalie etc, durant les années 1919 à 1922. Bull. Pêche et Aquiculture, 10-12, 115-117.

Athanassopoulos, M.G. 1935. Particularités de la distribution de l'ichthyofaune des eaux douces en Grèce. Proc. Int. Assn. Theor. Appl. Limnol., 7, 117-121.

Berrebi, P., Dubois, S. & Meldgaard, T. 2007. Biodiversité de *Salmo peristericus* dans le bassin du lac Macro Prespa. Université Montpellier 2, internal report.

BioPrespa Feasibility Study 2002. U.S. Agency for International Development.

Catsadorakis, G., Malakou, M. and Crivelli A.J. 1996. The Prespa Barbel *Barbus prespensis*, Karaman 1924, in the Prespa Basin, Nortwestern Greece. Tour du Valat, Arles, 79 p.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Trans. Am. Fish. Soc., 117, 1-21.

Crivelli, A.J. 2002. The role of protected areas in freshwater fish conservation. In: Freshwater Fish Conservation: options for the Future (Collares-Pereira, M.J., Coelho, M.M. & Cowx, I.G. eds). Fishing News Book, Blackwell Publishers, England. pp 373-388

ΔΕΗ - ΔΕΗ. 1998. Επιπτώσεις και Επανορθωτικά μέτρα ΜΥΗΕ Αγ. Γερμανού Πρεσπών ν. Φλώρινας. Αθήνα 1998.

DeCoursey, M. 2004. Integrated Ecosystem Management of the Prespa Transboundary Park: Analysis of socio-economic factors and trends affecting biodiversity and water quality. Albania and Macedonia. UNDP.

Delling, B. 2003. Species diversity and phylogeny of *Salmo* with emphasis on southern trouts (Teleostei, Salmonidae). PhD thesis, Stockholm University, 22pp + Annexes.

Doadrio, I, A. Perdices, & A. Machordom. 1996. Allozymic variation of the endangered killifish *Aphanius iberus* and its application to conservation. Environ. Biol. Fish., 45, 259-271.

Economidis, P.S. 1992. Fish, p. 41-81. In: (Karandinos, M. & A. Legakis, eds) The Red Data Book of Threatened Vertebrates of Greece. Hellenic Zoological Society, Hellenic Ornithological Society, WWF. Athens, 356 pp. + photographs.

Elliott, J. M. 1994. Quantitative Ecology and the Brown Trout. Oxford University Press. USA

Frankham, R. 1995. Effective population size/adult population size ratio in wildlife: a review. Genetical Research, 66, 95-107.

Hadzisce, S. 1985. Kunstliche Vermehrung der Salmoniden des Ohridsees mit gezuchteten Fishlarven in den Jahren 1935/36 bis 1953/54. Edition jubilaire consacrée en l'honneur du 50 eme anniverssaire de la Fondation de l'Institut hydrobiologique, Ohrid. Station Hydrobiologique- Ohrid, livre I., 97-136.

Hunter, C.J. 1991. Better Trout Habitat: A Guide to Stream Restoration and Management. Montana Land Reliance, USA.
KfW Feasibility Study. Transboundary Prespa Park Project 2005. KfW Development Bank Report.

Karakousis, Y. & C. Triantaphyllidis 1988. Genetic relationship among three greek brown trout (*Salmo trutta* L.) populations. Pols. Arch. Hydrobiol., 35, 279-285.

Karakousis, Y. & C. Triantaphyllidis 1990. Genetic structure and differentiation among Greek brown trout (*Salmo trutta* L.) populations. Heredity, 64, 297-304.

Karakousis, Y., C. Triantaphyllidis, & P.S. Economidis 1991. Morphological variability among seven populations of brown trout, *Salmo trutta* L., in Greece. J. Fish Biol., 38, 807-817.

Karaman, S. 1938. 11. Beitrag zur Kenntnis der Susswasserfische Jugoslaviens (Salmoniden 1. Teil). Bulletin de la Société Scientifique de Skopje, 18 (6): 131-139.

Kottelat, M. and J. Freyhof. 2007. Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany

Kondolf, G.M. & M.G. Wolman 1993. The sizes of Salmonid spawning gravels. Water Resources Research, 29, 2275-2285.

Laikre, L. (Ed) 1999. *Conservation Genetic Management of Brown Trout (S. trutta) in Europe*. Report by the Concerted action on identification, management and exploitation of genetic resources in the brown trout (*Salmo trutta*) ("TROUTCONCERT"; EU FAIR CT97-3882). 91 pp.

Laikre, L.; S. Palm, & N. Ryman 2005. Genetic population structure of fishes: implications for coastal zone management. Ambio, 34, 111-119

Lehner, B., Döll, P., Alcamo, J., Henrichs, T. & Kaspar, F. 2006. Estimating the impact of global change on flood and drought risks in Europe: a continetal integrated analysis. Climatic Changes, 75, 273-299.

Lopez, A. 2007. Project Inception Report and Implementation Plan (Draft). UNDP/GEF Prespa Basin Regional Project "Integrated Ecosystem Management in the Prespa Lakes Basin of Albania, FYR of Macedonia and Greece". United Nations Development Programme. Global Environment Facility.

Palsboll, P.J., Bérubé, M. & F.W. Allendorf. 2006. Identification of management units using population genetic data. TREE, 22, 11-16.

Petkovski, S., Sidorovska, V., Stavric, V., Smith, D. & Milevski, J. 2007. Conservation of the Brown trout (*Salmo peristericus*): preliminary study of the population. BIOECO report for SPP.

Pollock, M., Beechie, T.J., Chan, S.S. & Bigley, R. 2005. Monitoring restoration of riparian forests. In: Monitoring stream and watershed restoration (Roni, P. & Quimby, E. , eds). American Fisheries Society, Bethesda, USA, Pp 67-96.

Rubin, J-F. 1998. Survival and emergence pattern of sea trout fry in substrata of different compositions. J. Fish Biol., 53, 84-92.

Smith, K.G. & Darwall, W.R.T (Compilers) 2006. The Status and Distribution of Freshwater Fish Endemic to the Mediterranean Basin. IUCN, Gland, Switzerland and Cambridge, U.K. v + 34 pp.

Snoj, A., Maric, S., Berrebi, P., Crivelli, A.J., Shumka, S. & Susnik, S. . Genetic architecture of trout from Albania as revealed by mtDNA control region. Heredity, Submitted.

Society for the Protection of Prespa, WWF-Greece, Protection and Preservation of Natural Environment in Albania & Macedonian Alliance for Prespa. 2005. Strategic Action Plan for the sustainable development of the Prespa Park.

UNDP. 2005. UNDP Project Document on "Integrated Ecosystem Management in the Prespa Lakes Basin of Albania, FYR-Macedonia and Greece". Governments of Albania and FYR-Macedonia. United Nations Development Programme. Global Environment Facility

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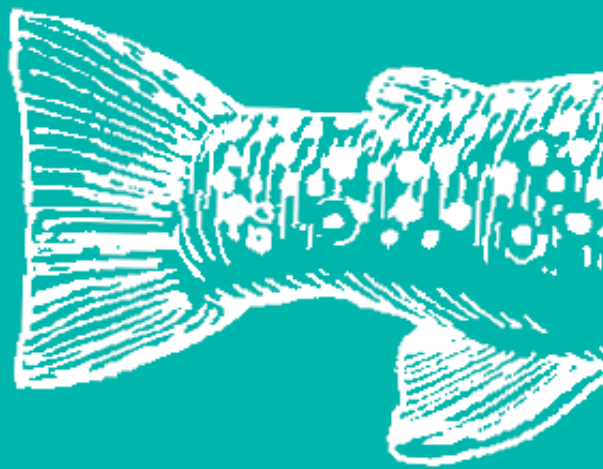

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