

CONSERVATION OF AQUATIC HABITATS AND SPECIES IN HIGH MOUNTAINS OF THE PYRENEES



EDITORIAL



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Welcome to the first edition of the LIFE+ LIMNOPIRINEUS newsletter (2014-2019). With this issue we begin a series of digital publications with the main objective to present the progress of this project and to share with you information on many interesting and often unknown aspects of the characteristics and conservation status of aquatic habitats in high mountains of the Pyrenees.

The main objective of this LIFE project is to improve the conservation status of lakes, rivers and wetlands, and a number of endangered species dependent on these habitats directly or indirectly.

Often when we carry out conservation actions in high mountain aquatic environments we find that there is a certain lack of knowledge of the natural richness of these habitats and their fragility to human induced alterations. For this reason public awareness of the natural heritage and what are their main threats is also one of the objectives of the project.

In this first issue, apart from reporting the first news since the start of the project, we have focused on the conservation status of lakes and wetlands, the two main habitats of the project.

INVASIVE SPECIES IN HIGH MOUNTAIN LAKES

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Fish in high mountain lakes

High mountain lakes are originally fishless due to natural barriers that have prevented the natural colonisation of fish species from lower streams. However, mainly during the last centuries there has been a global process of fish introductions in high mountain areas resulting in fish being present in a significant number of lakes.

In mountain ranges around the world, releases have been carried out during the second half of the nineteenth century and throughout the twentieth century. In the Pyrenees, there has been a process of introduction and historical exploitation initially affecting approximately 25% of the lakes that at least goes back to the fourteenth and fifteenth centuries. These historical introductions used native trout fry from nearby rivers.

During the second half of the twentieth century there has been a significant increase in trout releases using large quantities of juvenile fish of different species (Figure 1) from local fish farms. These modern practices have resulted in an increase in the proportion of high mountain lakes with fish up to 40%

and 90% depending on the area.

Salmonids introduced in the Pyrenees include brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*), although the northern side of the Pyrenees were also stocked with arctic char (*Salvelinus alpinus*) and American Great Lakes trout (*Salvelinus namaycush*). The European minnow (*Phoxinus phoxinus*) is a small cyprinid introduced in many of the lakes in the Pyrenees, but in this case, the arrival is related with its use as live bait for fishing, which is a form of traditional fishing practiced frequently on the northern side of the mountain range, and that is forbidden in the southern side of the Pyrenees.

At present, nearly 75% of the lakes in Aigüestortes i Estany de Sant Maurici National Park have been stocked with fish. Amongst salmonids brown trout is the main species introduced, although rainbow trout and brook trout are also present in some basins. The European minnow is also found in many of the lakes together with some of the aforementioned salmonids. In some particular lakes trout has disappeared and minnows have become the only species left. It is a gregarious species, forming

dense shoals on the lake shore where they are protected from trout predation.

Effects of the fish in high mountain lakes: invasive species

We refer as exotic, non-native or introduced to those species not native of the particular site or area where they are living. Furthermore when an exotic species damages its receiver ecosystem, then we define it as an invasive species

The impact of introduced trout to high mountain lake ecosystems has been widely documented at north temperate areas. Introduced trout become the top predators of high mountain lake ecosystems leading to profound ecological changes. Predation on native fauna can lead to the elimination of amphibian and reptile species, changes in zooplankton and benthic macro-invertebrate species composition and size structure, alteration of ecosystem process such as nutrient cycling and indirect effects through resource depletion. Trout introductions are therefore a threat for the conservation of high mountain lake biodiversity in general and in particular for the most conspicuous animal groups.

The impact of fish introduction on nutrient cycles of high mountain lakes has been shown that it results with an increase of algal production. This is a consequence of some fish feeding on crustaceans that originally feed on algae, or due to the fertilisation effect of fish excreting nutrients at the water column that were originally obtained from feeding at the bottom or littoral

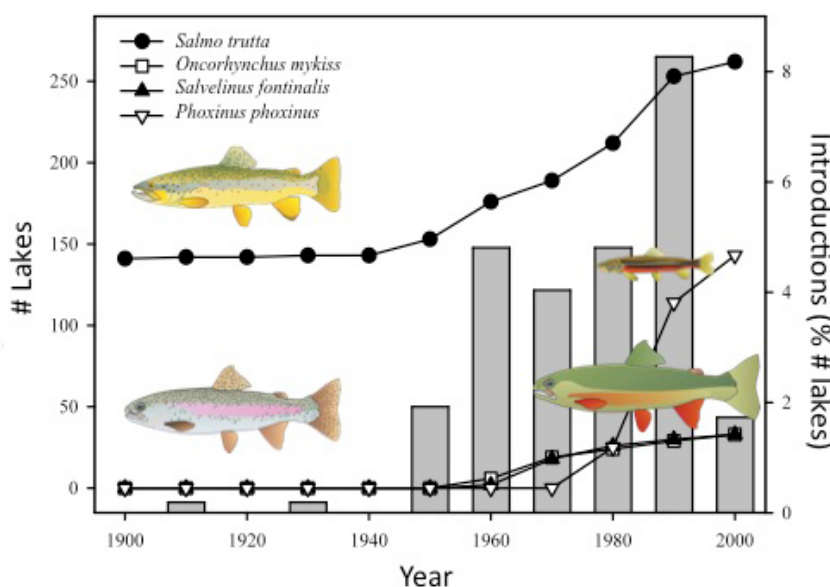


Figure 1. Process of introduction of non-native fish species in the southern Pyrenean lakes during the 20th century. Vertical gray bars are the decadal total number of lakes that have suffered fish introductions in percentage of the total number of lakes >0.5 ha.

of lakes, or by direct sediment resuspension that allow nutrients to circulate to the water column. Regarding the effects on native fauna, in lakes from different mountain ranges from the Iberian Peninsula, Europe or North America, it has been described that amphibians, invertebrates inhabiting the bottom or littoral of the lakes, and some crustacean species living at the water column also suffer significant alterations. In some cases the number and abundance of some of these species decrease, but others as in the case of amphibians completely disappear.

Amphibians are declining group worldwide, threatened by multiple factors, being the introduction of exotic species one of the most relevant. Fish introduced into high mountain lakes prey mainly on tadpoles and juvenile frogs decreasing rapidly their populations. In the particular case of Pyrenean lakes we have also found a clear relationship between the presence of fish and amphibian absence, a pattern found for almost all species of amphibians present in the Pyrenees such as the Pyrenean brook salamander (*Calotriton asper*), the palmate newt (*Lissotriton helveticus*), the midwife toad (*Alytes obstetricans*) and the common brown frog (*Rana temporaria*). The only

exception is the common toad (*Bufo bufo*) due to its secretion of a toxin that avoids it being caught by fish.

Finally, recent studies have also shown that introduced fish also cause a significant impact on species living in nearby ecosystems and that often feed on species emerging from high mountain lakes. It has been shown that the number of insects that emerge from lakes is reduced up to 98% when fish are present

For more information please refer to:

Miró, A., 2011. Les truites als estanys dels Pirineus: Tradicions, vivències i implicacions per a la conservació. Pagès Editors.

Miró, A. and Ventura, M., 2013. Biol. Conserv. 167, 17-24.

Miró, A. and Ventura, M., 2015. Biological Invasions 17, 791-803



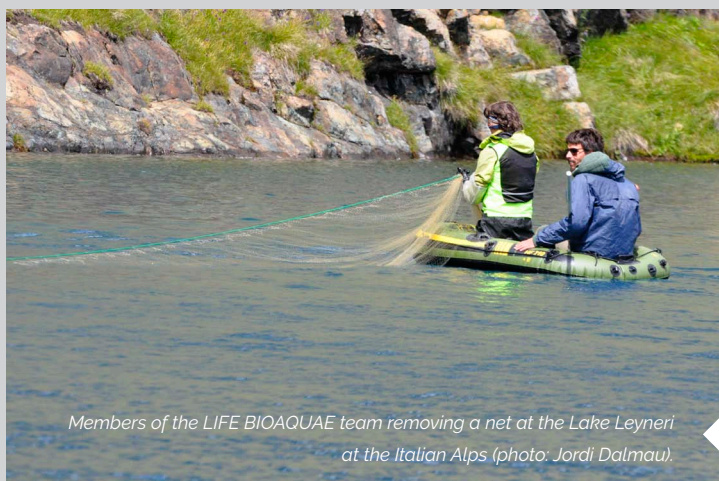
Figure 2. The European minnow is a gregarious fish, in the image swimming near the bottom of a lake of the Pyrenees (photo: Enric Ballesteros)

Restoration experiences in high mountain lakes

Studies from other mountain ranges of the northern hemisphere have shown that introduced fish alterations are not irreversible. When fish are removed, most of disappeared species return to colonise the lakes in a relatively short period of time, re-establishing progressively the ecosystem equilibrium. This recovery is only possible if fishless lakes remain nearby, acting as a refuge.

Most experiences of invasive fish removal in high mountain lakes have been performed at western mountain ranges of North America, and have focussed on salmonids. A closer example took place at the end of the 90s at the Lake Laguna Grande de Peñalara, a lake from the Sierra de Guadarrama (Spain), where most of the species eradicated by fish returned to the lake quite quickly.

Another example is currently running at the Gran Paradiso National Park, at the Italian Alps through the LIFE project BIOAQUAE (<http://www.bioaquae.eu/>). The project started at 2012 and is returning different lakes to their fishless natural state. The introduced salmonid species at this area is the brook trout. After two years of work the team of BIOAQUAE is very optimistic regarding the restoration of these lakes.



Members of the LIFE BIOAQUAE team removing a net at the Lake Leyneri at the Italian Alps (photo: Jordi Dalmau).



The project LIFE+ LIMNOPIRINEUS

The high recovery capacity of high mountain lakes after the restoration of their fishless natural status support the initiative of removing introduced fish species to allow the return of the autochthonous species previously displaced. This is one of the actions proposed within the project LIFE+ LIMNOPIRINEUS that amongst other objectives intends the restoration of different lakes of the Aigüestortes i Estany de Sant Maurici National Park and the Alt Pirineu Natural Park through the eradication or control of exotic fish that were previously introduced.

The aim is to recover the lakes as a whole ecosystem and especially the autochthonous amphibian species of the area. The project also has actions focussed on wetland restoration and calcareous springs at both Parks, the restoration and recovery of the Pyrenean sculpin (*Cottus hispaniolensis*), a small endemic fish from the northern slopes of the Pyrenees, and the hydraulic regulation and access of the lake Estanho de Vilac, at the Aran Valley, the only known site with the aquatic plant *Luronium natans*.

Detailed information can be found at the project web site:
www.lifelimnopirineus.eu



► Panoramic view of the lakes Tres Estanys, Pallars Sobirà (photo: Alexandre Miró).

THE FRAGILE PYRENEAN WETLANDS

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A noticeable feature of High Mountain, especially in the areas formed by granite and slate, is the abundance and diversity of places with surface water. This is because the high rainfall, the low permeability of the rocks mentioned, and the glacial relief. This last aspect, apparent as valley bottoms gently sloped or flat, alpine cirques and sudden slope changes, is even enhanced by the variation in geological materials. All in all, these high mountain landscapes include many springs, streams, alpine lakes and wetlands. Alpine wetlands occur in water-soaked areas that in most cases occupy just a few square meters, irregularly set along streams or lake banks, but sometimes cover noticeable extensions.

Although the abundance of water may suggest that wetlands will be an optimal environment for plants, they actually represent a very restrictive place to live, so that just a few herbs and mosses can thrive there. The soil always soaked with water makes root respiration very difficult. This effect, called root anoxia, is the main limitation found by plants and other organisms living in flooded areas. Sedges, grass-like plants of the genus *Carex*, stand among the plants able to grow in wetlands. These sedges make even lawns one to four decimetres high on dense systems of fibrous roots and rhizomes. Part of their success in these environments is because both the leaves and roots and rhizomes include a spongy tissue, the aerenchyma, that facilitates some gas diffusion within the plant, and therefore respiration of the underground parts. This system allows different *Carex* species (*C. nigra*, *C. panicea*, *C. davalliana*, *C. lepidocarpa*, *C. rostrata*, etc.) and other sedges or small rushes (*Eriophorum* sp.pl., *Scirpus cespitosus*, *Juncus alpinoarticulatus*, etc.) play a dominant role in the high mountain wetlands, which are then called fens.

In between the turfs of sedges, mosses are frequent, sometimes scanty but often in the form of continuous, thick networks on the



► Pleta de Sotllo, in the LIC Alt Pallars, showing typical glacial morphology in the U-shaped valley bottom where curled streams, ponds and wetlands. In that of the foreground water flows through the surface (photo: A. Pérez-Haase, 24/07/2014).



► Wetlands at the bank of the small reservoir Font Grossa, in the LIC Aiguestortes. At the foreground stands a *Juncus articulatus* lawn settling on a sandy substrate, and farther a luxuriant fen of *Carex rostrata* (photo: E. Carrillo, 26/07/2014).

ground. This is particularly so with the mosses of genus *Sphagnum*, as they are relatively robust and accumulate significant amounts of small twigs and leaves soaked in water. Thus, year after year they build thick carpets that rise on the floor of the swamp, called bogs. In the Pyrenees, most *Sphagnum* bogs achieve small heights and are mostly fed by ground water, and only in places with high humidity and rainfall the bogs rise to some decimetres on the marsh and are then chiefly fed by rainwater. Raised bogs mainly occur in the valleys under Atlantic influence, but they are also found at the rainiest headers of some Iberian valleys.

The soil waterlogging also makes the break down of dead parts of plants very slow. The same anoxia affecting plants makes soil microorganisms (fungi and bacteria) to have a very limited activity. Thus, dead roots, rhizomes, leaves, and also the hats of mosses accumulate in the form of a network of fibres that becomes humus very slowly. Therefore marsh soils always are very rich in organic matter, which gives them a very dark, almost black colour. In most cases this organic matter forms thick accumulations of a few decimetres -exceptionally a few metres- of peat above the mineral soil, making typical peat bogs.

High mountain wetlands are generally nutrient-poor environments for plants, since the abundance of water makes minerals to be found in very low concentrations. The situation is not as extreme where water comes from springs rich in minerals, such as the lime-rich sources, but where coming from siliceous soils groundwater is very poor in nutrients and more or less acidic. Poorness and acidity are even enhanced at the top of raised bogs, where water comes mainly from rain. In fact, the same *Sphagnum* peat increases the water acidity and so makes the environment very restrictive. A few plant species show singular adaptations to live in such nutrient-poor environments, typically the small insectivorous plants (*Drosera rotundifolia*, *Pinguicula grandiflora*) that capture and digest small insects by means of their viscid leaves, to obtain nitrogen compounds.

An interesting aspect of peat is that, in between the fibres and hu-

mus, some resistant plant and animal structures remain quite intact: pollen grains, small seeds, shells of molluscs and other invertebrates, etc. So, as year to year peat accumulates at the bog surface, these remains become orderly stored, from deep to the surface, the oldest to the most recent. The study of these remains in samples taken from bogs reveals organisms that lived long ago and evidences the ecological changes occurred long ago.

Pyrenean high mountain wetlands are special from many points of view. Although the word marsh properly describes this set of environments of soaked soil, the diversity of ecological factors involved gives way to a number of community types particular in their structure, species composition and local hydrologic characteristics. In addition, while these ecosystems are very extensive in the boreal and arctic areas, they become gradually rarer towards the Alpine mountains. They still occupy small areas in the Pyrenees but virtually disappear southwards. Most plants and animals living there are very specific to these environments, so most of them are rare or very rare in the Pyrenean massif. Finally, the ecological conditions typical of fens and bogs are very sensitive to any change in the circulation of water, as those derived from hydroelectric facilities or water catchments, as well as to other alterations such as continued trampling or eutrophication (increase of nitrogen and other nutrients) in the own ecosystem or in neighbouring running waters.

The European Union recognized years ago these particular ecosystems and selected some types of fens and bogs as Habitats of Community Interest. Their conservation, and restoration when needed, is a priority in the protected areas of the Pyrenees and is also one of the objectives of the LIFE LimnoPirineus in the Sites of Community Importance Alt Pallars and Aigüestortes.





▶ In the moistest Pyrenean valleys, wetlands include noticeable moss carpets among the turfs of sedges or *Scirpus cespitosus*. The most apparent are that formed by *Sphagnum* (such as *S. capillifolium*, the reddish moss in the photo) and secondly those of *Polytrichum* (such as *P. strictum*, the green shots with acute leaflets) (photo: J. Colomer, 27/07/2014).



▶ Insectivorous plants respond to the poorness of nutrients in wetlands, which is illustrated by this *Drosera rotundifolia* growing on a *Sphagnum* bog (photo: A. Pérez-Haase, 24/07/2014).



THE SHORT NEWS



06/06/2014

Presentation of the LIFE+ LIMNOPIRINEUS

On June 5th 2014, held the first public presentation of the LIFE project at Centre for Advanced Studies of Blanes. Marc Ventura, researcher in CEAB and LIFE project coordinator, explained the objectives of LIFE+ LIMNOPIRINEUS and the actions that will be developed over the next five years.



11/08/2014

We start with fieldwork in high mountain lakes

From July 14th to August 10th the LIFE+ LimnoPirineus team has been busy sampling lakes from the targeted areas included in the project.

During the fieldwork we have sampled 28 lakes in Aigüestortes i Estany de Sant Maurici National Park, Alt Pirineu Natural Park and the Estanho de Vilac situated in Val d'Aran.

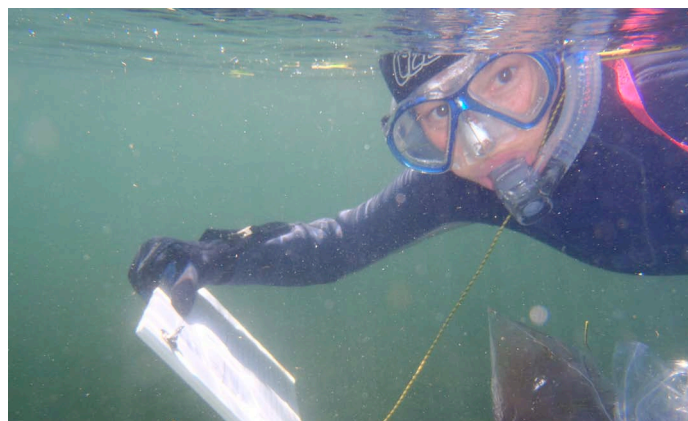
The sampling will provide information on the ecological status of lakes before starting the conservation actions next summer and the following 4 years and will allow us to build up action protocols.



Members of the LIFE project collecting information close to a targeted lake
(photo: Ibor Sabas).



Aquatic macroinvertebrates emergence trap collected last summer (photo: Eglantine Chappuis).



Mapping submerged aquatic vegetation last summer (photo: Marc Ventura).

23/08/2014

Members of LIFE+ LIMNOPIRINEUS visiting action sites of LIFE BIOAQUAE in Italy

From August 19th to 22nd some members of the LIFE+ LIMNOPIRINEUS Technical Office (CEAB-CSIC) and SORELLO visited some action sites of LIFE BIOAQUAE in the Gran Paradiso National Park in the Italian Alps. We visited for two days lake Dress and Leynir where the main project actions take place and we exchanged experiences and knowledge to improve development of both projects.

LIFE BIOAQUAE started two years ago working to promote restoration of ecological status of high mountain lakes through exotic fish eradication in line with what we want to do with the project LIFE+ LIMNOPIRINEUS.

We feel confident that we are at the beginning of a fruitful collaboration between both projects



Meeting with members of the LIFE BIOAQUAE team in Italy to exchange experiences and to visit action sites (photo: Teresa Buchaca).

06/10/2014

Catalan public television echoes LIFE+ LIMNOPIRINEUS project

TV3 news team came to visit us for a day of sampling in Lake Cabana at the Aigüestortes i Estany de Sant Maurici National Park.



Recording the interview to LIFE project coordinator (photo: Alexandre Miró).

04/10/2014

LIMNOPIRINEUS participate in the XXII Course for Interpretive Guides of Aigüestortes i Estany de Sant Maurici National Park

From September 15th to October 10th it took place the XXII Course for Interpretive Guides of Aigüestortes i Estany de Sant Maurici National Park. LIMNOPIRINEUS has been present in the course with a demonstrative session focused on invasive species of high mountain lakes. Alexandre Miró, member of the LIFE Technical Office was there to summarize the main objectives of LIMNOPIRINEUS project.



Image of a visit to Lake Dellui during the XXII Course for Interpretive Guides (photo: Josep Maria Rispa).

19/11/2014

LIMNOPIRINEUS participates in the science week

Members of the Technical Office of the Project have visited the secondary schools of Tremp and Pobla de Segur to give a lecture on ecology and conservation of Pyrenean lakes.

Also during the days 19, 20 and 21st of November the Technical Office has participated at the open door action of the Centre for Advanced Studies of Blanes (CEAB-CSIC). We have prepared a workshop for different ages with the objective to describe the main characteristics of lakes and ponds as ecosystem, the species inhabiting in these habitats and their conservation status. During the 3 days that the activity lasted we received 657 students in 19 groups of primary and secondary school, from 14 different schools.



Students following one of the workshops prepared for the open door activity organised by CEAB (photo: Teresa Buchaca).

27/12/2014

Public presentation of the project LIFE+ LIMNOPIRINEUS

The public presentation of the project took place the 6th of December at the Ecomuseu de les Valls d'Àneu at Esterri d'Àneu with the presence of all the partners. At the event participated Ramón Villuendas, mayor of Esterri d'Àneu, Llàtzer Sibis, President of the Consell Comarcal del Pallars Sobirà and Gerard Sabarich, Deputy of the Diputació de Lleida and vicepresident of the Patronat de turisme of Lleida. During the event the conference "The conservation of aquatic high mountain areas of the Pyrenees, a bet for the future" was given by Marc Ventura, coordinator of the LIFE+ LimnoPirineus project and researcher of the Centre for Advanced Studies of Blanes (CEAB-CSIC). At the presentation and conference assisted more than 70 people.



Public presentation event of the Project LIFE+ LIMNOPIRINEUS (photo: Teresa Buchaca).



The Project is co-financed by the European Program LIFE+ that promotes conservation actions and restoration of habitats and species of flora and fauna at protected sites of the European Union within the Natura 2000 network.

LIFE LimnoPirineus
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