FROM SEA TO SOURCE

International guidance for the restoration of fish migration highways

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EXAMPLE

Assessing the impact of barriers on connectivity of endangered native fishes in the face of salmonid invasions in Southern Chile

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INTRODUCTION

With 44 native freshwater fishes (Habit *et al.*, 2006) and 15 exotic species (Campos *et al.*, 1998), the freshwater fish biodiversity of Chile is relatively low, although it maintains high levels of endemism. Three factors account for its unique freshwater fauna: (1) the country represents a biogeographic island isolated by the Atacama desert in the north, the Antarctic glaciers in the south, and the Andes in the east, (2) the steep gradient of Andean rivers imposes a high degree of ecological specialisation, and (3) the history of tectonic activity and glaciations have further increased the degree of geographical isolation (Campos *et al.*, 1998). An estimated 66% of the native freshwater fishes are of conservation concern (CONAMA, 2010; www.mma.gob.cl), mainly due to habitat degradation, the introduction of exotic species (Gajardo & Laikre, 2002; Habit *et al.*, 2010) and, more recently, also due to hydroelectric developments that constrain dispersal and connectivity (CERM, 2009).

Eighty nine large hydroelectric projects are currently in operation or undergoing the Environmental Impact Assessment required by law in Chile (SEA, 2010). Fifteen of these developments will be located in the *Los Rios* region (The Rivers region) and nineteen in *Los Lagos* (X) region (The Lake region), whose names highlight the relevance of watercourses and lakes to a number of endangered native fishes including *Cheirodon australe, Cheirodon kiliani, Diplomystes camposensis, Trichomycterus areolatus, Galaxias globiceps, Odontesthes brevianalis, Odontesthes mauleanum, Aplochiton zebra, Aplochiton taeniatus,* and *Percillia gillisi*. In addition to these high profile hydroelectric developments, there are many more smaller barriers that can also block upstream fish passage, including weirs that divert water to salmonid hatcheries, concrete ramps under bridges to prevent erosion, and flood defenses and similar works that change the flow and may impact on upstream fish passage.

WHAT ARE WE DOING?

In collaboration with stakeholders who seek protection of local aquatic resources, we began a baseline evaluation of fish populations in five rivers of the *Rio Bueno* basin, where hydroelectric power plants are scheduled. Our focus, in line with the Convention of Biological Diversity (CBD) signed by Chile, is to have an inventory of na-

tive fishes throughout the basin. We then plan to use a range of ecological tools including stable isotope analysis (Shröder & Garcia de Leaniz, 2011) and a suite of recently developed molecular markers (Vanhaecke *et al.*, 2011) to monitor the spatio-temporal distribution and connectivity of fish populations, both in impacted and control rivers (without artificial barriers). By taking a multidisciplinary approach, we are hoping to have good pre- and post-intervention data that will help to establish sound guidelines for the protection of endangered fish fauna.

LESSONS LEARNED

Through a DEFRA (UK) funded Darwin Initiative (www.biodiversity.cl) we are meeting with government and stakeholders to discuss threats to native fish fauna, alerting them about the potential synergistic effect posed by the interaction of barriers and invasive salmonids (Garcia de Leaniz *et al.*, 2010), and the need to have good scientific data and a monitoring programme in place. Our study has already served to disseminate the need to conserve critical freshwater habitats, and our approach will help us estimate the extent of population fragmentation. This is critical for native diadromous species that migrate to coastal-estuarine areas to spawn, and which use different parts of the basin to complete their life cycles. Clearly, the life cycle of such species could be significantly altered by barriers, but whether this will augment, or perhaps mitigate, the impact of invasive salmonids is not clear and requires careful study.

PULLINQUE HYDROELECTRIC STATION IN THE LOS RÍOS REGION (VALDIVIA, CHILE)

A 4.6 km canal diverts water from Lake Pullinque to the power house to produce 51.4 MW of electricity via 3 vertical Francis turbines. The plant was built in 1962 with no specific provisions for the passage of fish.