Resilience of alpine lakes invertebrates after the eradication of introduced brook trout *Salvelinus fontinalis*

Stefano Brighenti[1], Rocco Iacobuzio[2], Matteo Rolla[3], von Hardenberg Achaz[4], Bruno Bassano[1], Rocco Tiberti[1,5,*]

[1] Alpine Wildlife Research Centre, Gran Paradiso National Park, Italy; [2] DBS-Dipartimento di Bioscienze, Università degli Studi di Milano, Italy; [3] Department of BioSciences, Swansea University, UK; [4] Department of Biological Sciences, University of Chester, UK; [5] DSTA-Dipartimento di Scienze della Terra e dell'Ambiente, University of Pavia, Italy. * e-mail contact: rocco.tiberti@gmail.com

INTRODUCTION

Alien fish seriously affect once fishless mountain lakes ecosystems [1]. In the 1960s, the brook trout (*Salvelinus fontinalis*; Fig. 1) was introduced in several lakes of the Gran Paradiso National Park (GPNP, Western Italian Alps) exerting an heavy **impact on native biota** [2,3]. The GPNP undertook an **eradication campaign**, within the LIFE+ BIOAQUAE (Biodiversity Improvement of Aquatic Alpine Ecosystems) project.

Fig. 1 Young brook trout (*Salvelinus fontinalis*) captured during an electrofishing session.

ERADICATION AND MONITORING METHODS

The eradication started in June 2013. **Intensive gill netting and electrofishing** have been used as non-invasive eradication techniques, without lethal effects for native species (invertebrates and amphibians) [4]. The nets have been left in the lakes for the whole duration of the project, including the ice-cover season (October-May). The effects of the eradication are being monitored along with the eradication campaign, comparing the lakes subject of the eradication project with a set of control lakes (both naturally fishless lakes and lakes still containing brook trout) as a reference to quantify the **ecosystem resilience** (Fig.2) using littoral macroinvertebrates (30 standard swepts -1 m long- using a standard D-frame hand net, mesh size 0.5 mm; [3]) and pelagic zooplankton (vertical tows with a conical plankton net, 40 cm diameter, 48 µm mesh, at the deepest point of each lake; [3]) as bioindicators.

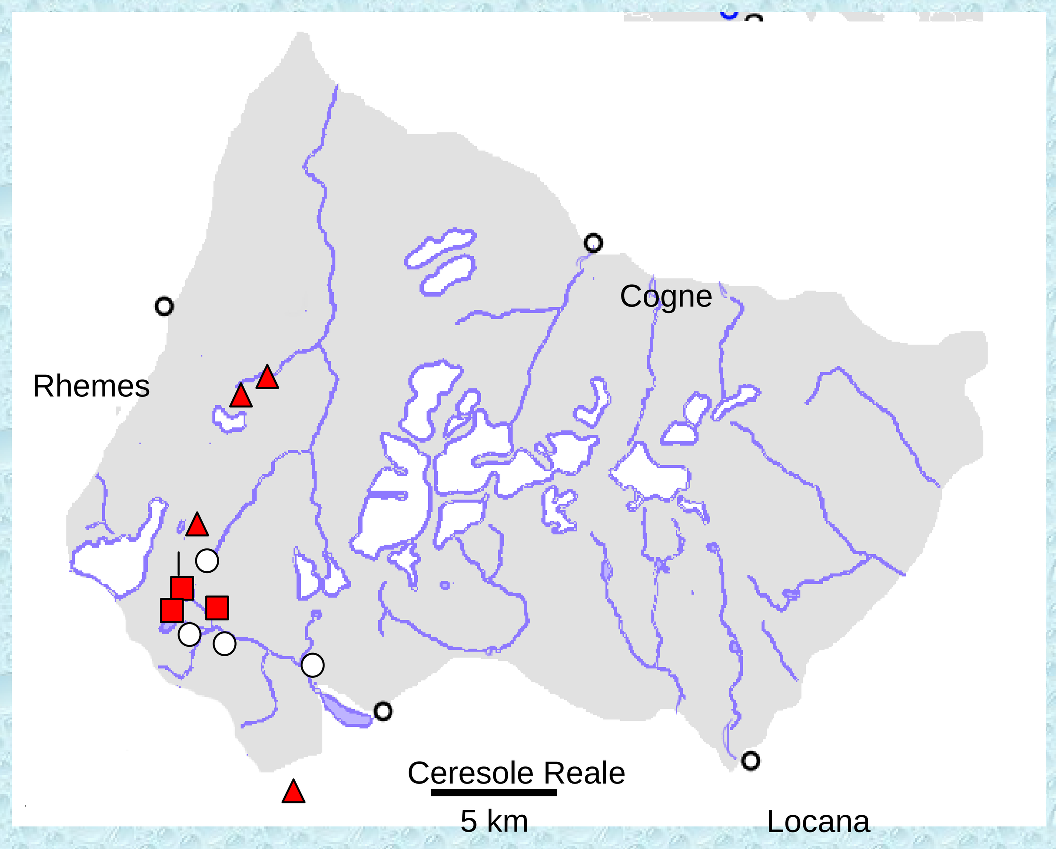

Fig. 2 Gran Paradiso National Park (Western Italian Alps) and studied lakes: naturally fishless control-lakes (white circles), stocked control-lakes (red squares) and "eradication" lakes (red triangles).

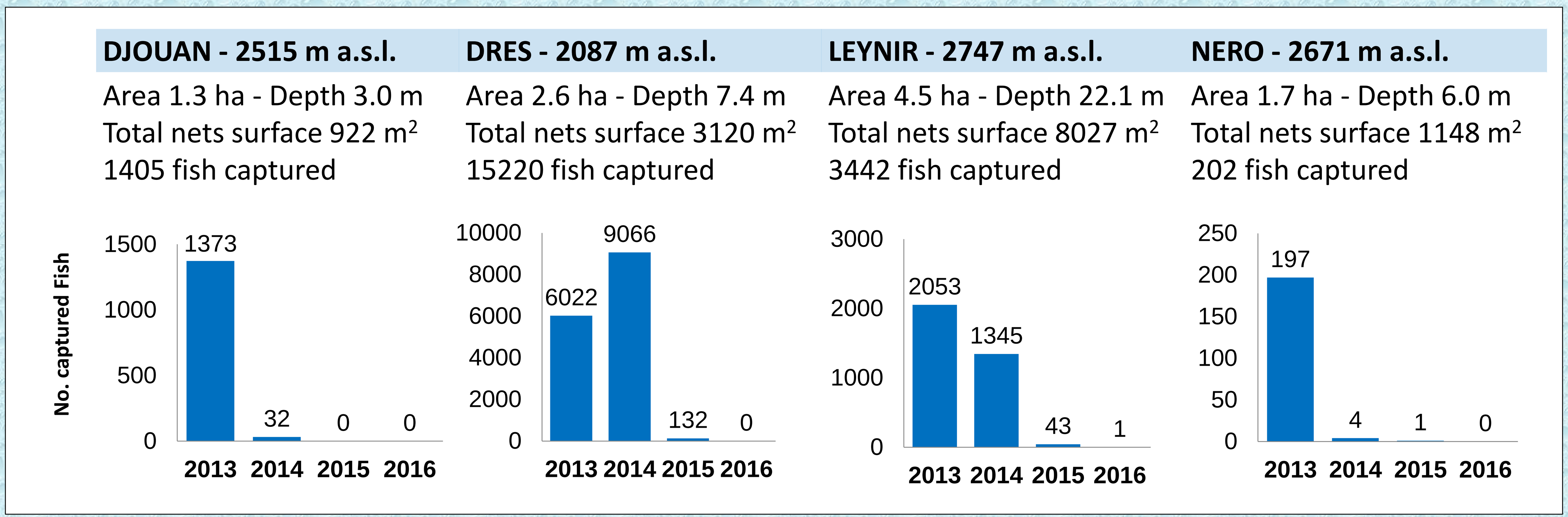

Fig. 3 Progress of the brook trout eradication from 2013 to 2016. The fish captures from 2014 to 2016 include also the fish gillnetted during the ice-covered season, removed from the nets at thaw.

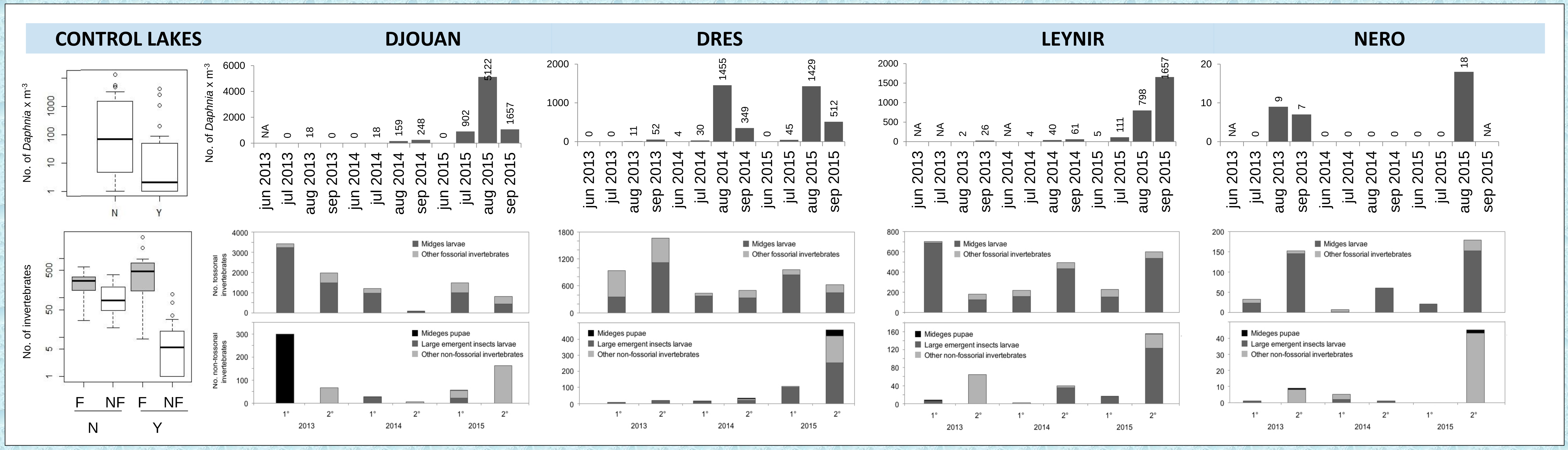

Fig. 4 Resilience of *D.* gr. *longispina* (1st row panels) and of the littoral macroinvertebrates during and after the fish eradication, compared to their mean abundance in the control lakes (naturally fishless = N; still containing fish = Y). Fossorial invertebrates (F; 2nd row panels) mainly include Diptera larvae, Bivalvia, and Oligocheta; non fossorial invertebrates (NF; 3rd row panels) mainly include nektonic (aquatic Coleoptera and Hemiptera) and benthonic taxa (Plecoptera, Trichoptera, Acarina, Odonata, and emerging Diptera pupae).

RESULTS AND DISCUSSION

At its fourth field campaign (June-September 2013-2016) the removal of introduced fish (Fig. 3) enabled the recovery of many invertebrate taxa. In particular many benthonic and nektonic invertebrates (non-fossorial; Fig. 4) rapidly recolonized the lakes (Fig. 4a), while *Daphnia* gr. *longispina* (the most impacted zooplankton species, due to its large body size) returned to dominate the community of three treated lakes (Fig. 4). Fossorial macroinvertebrates, which were unaffected or favored by the presence of brook trout, do not show any clear trend (Fig. 4). These results show that eradication is **a feasible conservation measure** and that the invertebrate fauna of alpine lakes have **high resilience potential** after fish eradication, encouraging management and conservation authorities to undertake new eradication projects.

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