# FINAL REPORT

PEOPLE
MARIE CURIE ACTIONS

**Marie Curie Intra-European Fellowships (IEF)**
**Call: FP7-PEOPLE-2013-IEF**

**Project acronym:** CLIMACOMM

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**Host organisation:** Bournemouth University, UK

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## Research background

The general consensus is that anthropogenic induced climate change is resulting in warming global air temperatures, with the rate of change progressing substantially faster than previous natural climate change events. The scale of subsequent air temperature increases will be dependent on emission levels, with higher emissions predicted to result in larger temperature increases. Irrespective, warming of up to 2$^{o}$C is now generally considered unavoidable ('unavoidable climate change') and political efforts are now focused on avoiding 'dangerous climate change' (e.g. +4$^{o}$C). Consequently, predicting, preventing and/ or ameliorating the consequences of climate change is a major strategic objective for the European Union, particularly in respect of ecology and biodiversity where adaptation measures to reduce the ecological impacts of unavoidable climate change feature strongly in the 'EU Biodiversity Strategy to 2020'.

Despite this clear strategic intent, ecologists have largely failed to generate comprehensive predictions of how climate change will impact biodiversity and ecosystem functioning, or provide clear suggestions for how impacts could be ameliorated. This is primarily due to the lack of a strong theoretical and empirical foundation for incorporating species interactions into predictions as the majority of work has focused primarily on predicting the consequences of warming at the individual species level. This means there is a very limited understanding of how these consequences manifest into community and ecosystem responses

## Project objectives

Consequently, the research objectives of this MC IEF project are to: (1) quantify the shifts in the climate envelope of native freshwater fishes in Great Britain under climate warming scenarios; (2) predict the influence of current and future temperatures on the somatic growth rates (as a surrogate of life history traits) of selected fish species; (3) determine the shifts in the symmetry of the competitive interactions between the model fishes arising from warming temperatures; and (4) using the selected fish species in experimental ponds, quantify the consequences of warming for the species, communities, food web structure and ecosystem functioning in temperate freshwaters.

## Research and training

Objective 1 saw climate envelope models developed for 12 freshwater fish species in Great Britain under a range of projected climate changes (low to high emissions). These models revealed that responses to climate change of the different freshwater fish species are species-specific but with some general patterns apparent at the family level. Salmonid fishes were predicted to have their climate envelopes constricted under warming scenarios, whereas cyprinid fishes were expected to generally have an increased climate envelope. Completion of this research also required completion of a large volume of training on climate envelope modelling.

Models completed in Objective 2 predicted that the somatic growth rates of the freshwater fishes will change markedly under climate change scenarios. For most (but not all) fishes, whilst there was a general shifts to populations comprising of faster growing individuals, this was likely to correspond with changes in their reproductive traits and life spans, and in some scenarios, shifts in their body sizes.

Completion of this objective also required completion of a large volume of training that was outlined in the training programme.

Work on Objective 3 revealed that experiments testing the effects of warming temperatures on freshwater fishes are species-specific and context-dependent, but with the competitive abilities of the fishes generally following hypotheses, i.e. fishes with physiological tolerances favouring higher water temperatures have greater competitive abilities as temperatures increase towards their thermal optima. This dovetailed with work completed in Objective 4 that revealed in small ponds, warmer water fishes such as carp *Cyprinus carpio* will grow faster in elevated temperatures provoked by climate change, although this will not necessarily be matched by changes in the size of their trophic niche size. Complementary experiments revealed that trophic niche size is influenced more by inter- and intra-specific competitive interactions that result from population densities.

A comprehensive training programme was also completed within the project, with the Fellow now being a highly competent user of predictive models for predicting climate change impacts on the distribution and life history traits of fishes, as well as in a wide range of professional and research competencies. The performance of the Fellow throughout the project was exceptional, resulting in a strong training and research programme and the publishing of, to date, three strong scientific papers (see below for details).

**Final results, potential impact and use**

The final results revealed that, in temperate regions of Europe, climate change will have considerable consequences for freshwater fish species, their populations, and the communities in which they reside. Impacts of climate change will not be easy to predict, with species responses not only shaped by their response to the changing climate, but also to how other species within the freshwater communities are also responding. Nevertheless, the results clearly indicated that shifts in the distribution and growth rates of freshwater fish can be expected, but with shifts in species' interactions (e.g. feeding interactions, trophic niche impacts) being more influenced by population abundances that drive intra- and inter-specific competition processes.

This work has the potential to substantially impact the manner in which climate change mitigation strategies are currently being operated, with governments, regulatory authorities and NGOs all able to utilise these outputs to mitigate against the adverse effects of rising air temperatures on water temperatures, and in doing so, protect vulnerable fish populations and communities from the adverse impacts of warming.

**Outputs**

To date, three papers in peer-reviewed journals have been published from the project:

Ruiz-Navarro, A., Gillingham, P.K. and Britton, J.R., 2016. Shifts in the climate space of temperate cyprinid fishes due to climate change are coupled with altered body sizes and growth rates. *Global Change Biology* 22: 3221-3232.

Ruiz-Navarro, A., Gillingham, P.K. and Britton, J.R., 2016. Predicting shifts in the climate space of freshwater fishes in Great Britain due to climate change. *Biological Conservation* 203: 33-42.

Britton, J.R., Ruiz-Navarro, A., Verreycken, H. and Amat-Trigo, F., 2017. Trophic consequences of introduced species: Comparative impacts of increased interspecific versus intraspecific competitive interactions. *Functional Ecology* https://doi.org/10.1111/1365-2435.12978.