KNOWLEDGE EXCHANGE FOR EFFICIENT PASSAGE OF FISH IN THE SOUTHERN HEMISPHERE (KEEPFISH)

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The decline of freshwater fish biodiversity is proceeding at an alarming and persistent rate. Given that most fish must undertake some form of migration in order to complete their life-cycle, of particular concern is the proliferation of hydropower schemes that block migration routes, as well as a variety of other barriers such as weirs and culverts. Several locations in the southern hemisphere are among the major global hotspots of hydropower development. Mitigation measures for fish passage have traditionally relied on designs developed for strong swimming, generally salmonid species of the northern hemisphere. These designs are ineffective for smaller, relatively weak swimming 'non-sport' fish, such as those found in temperate regions of the southern hemisphere, but there is no detailed understanding of the mechanisms involved. This paper introduces an

innovative EU-funded project, KEEPFISH, that aims to address gaps in the knowledge of passage requirements for non-sport fish of the temperate south. The project, beginning in 2016, represents the first systematic attempt to bring together world-leading practitioners in an effort to exchange knowledge and construct a shared vision for fish passage science and policy. This will be achieved through systematic review, expert consultation, ecological modelling, postgraduate training programmes, networking and stakeholder engagement using a novel combination of approaches.

1 INTRODUCTION

Fish communities in temperate zones of the southern hemisphere typically have low species richness but high levels of genetic diversity and endemism [1-5]. These communities are indicated by the presence of the catadromous common jollytail or 'inanga' (*Galaxias maculatus*) and the anadromous pouched lamprey (*Geotria australis*), whose extant distributions encompass southern Australia, New Zealand and Patagonian South America. The galaxiids and related taxa are the dominant groups in these locations, comprised of over 50 species from the families Leptogalaxiidae (Australia), Retropinnidae (Australia and New Zealand) and Galaxiidae (whole range). These populations are experiencing a major decline due to the effects of habitat deterioration, overexploitation and displacement by introduced species [6-7].

With relatively weak swimming abilities, the so-called 'non-sport' fish that characterise freshwaters in the temperate south are particularly vulnerable to habitat fragmentation, yet facilities installed to aid fish passage have largely relied on designs suitable only for strong-swimming, generally salmonid species of the northern hemisphere. The high degree of diadromy in non-sport fish communities, and the fact that most upstream migrations occur during juvenile life stages, further exacerbates the problem. This is important because many of these species have high conservation value. The majority of species native to Chile and 74% of New Zealand's species are threatened or at risk [8-9]. Their ranges are also hotspots for the construction of hydropower facilities, often with scant regard for the migratory needs of fish [e.g. 10-11]. Chile, for example, is one of the world's hotspots for hydropower development [12-13].

If native fish fauna in the temperate south is to be adequately protected we must ensure provision of effective fish passage facilities ('fishways'), in both upstream and downstream directions, at existing and future barriers. This involves the synthesis of existing knowledge and the production of new knowledge on affected species [8, 14], as well as innovation in order to adapt research methodologies to the characteristics of non-sport fish (see Franklin & Baker in this session). Action is urgently required, necessitating the systematisation of research efforts [14-15]. The education of a range of stakeholders will be central to ensuring that the resulting management recommendations are implemented and the proposed solutions are sustainable [1, 12]. Immediate progress hinges on the synthesis of valid transferable knowledge from fish passage research elsewhere in the world, particularly in northern temperate and South American neotropical systems, with new and existing knowledge on non-sport fish of the temperate south.

This paper introduces the EU-funded KEEPFISH project, briefly outlines the state-of-the-art in fish passage research and reviews existing knowledge on the relevant aspects of species native to the temperate south in order to justify the following project objectives:

- Gather and synthesise generic transferable knowledge, specific empirical data and expert judgement to predict passage probabilities for non-sport fish of the temperate south
- Identify key uncertainties and knowledge gaps
- Train biologists, engineers and interdisciplinary workers in state-of-the-art methods, and develop new innovative approaches to research on non-sport fish
- In consultation with stakeholders, agree and begin to action a systematic research strategy for fish passage research in the temperate south
- Disseminate findings, raise public awareness and influence research and policy

2 STATE-OF-THE-ART IN FISH PASSAGE RESEARCH

A variety of experimental and field-based methods have emerged to quantify fishway effectiveness and inform optimal fishway design, few of which have been applied to a limited number of non-sport species in the

temperate south. The most robust field methods for quantifying effectiveness metrics and identifying passage success and failure mechanisms at a sufficient resolution involve the use of Passive Integrated Transponder (PIT), radio or acoustic tags [16-19]. Methods employing eclectromyography or accelerometry have also helped to reveal passage success or failure mechanisms in the northern hemisphere [10-23]. Such methods are, however, unsuitable for the vast majority of non-sport species whose small body size precludes the use of currently available tags and sensors.

3 CURRENT STATE OF KNOWLEDGE ON FISH PASSAGE IN THE TEMPERATE SOUTH

Of primary importance for fish passage research is knowledge on the life-histories and swimming abilities of native species. Miles *et al*. [24] review knowledge on the life-history of 33 diadromous species native to Australia and find that only 9% of them have been studied at all life stages, whilst 30% are largely unknown. Even for the more 'well known' species, such as *G. Australis*, major knowledge gaps exist on passage abilities at migratory barriers. In particular, very few species of the temperate south have been the subject of experimental assessment of swimming performance and behaviour in response to stimuli. A review of fish passage research by Roscoe and Hinch [25] shows that less than 5% of published fishway evaluations are performed in temperate zones of the southern hemisphere. The lack of studies investigating passage failure mechanisms is a particular deficiency of work in these locations [25]. Not a single study from the southern hemisphere met the criteria for inclusion in Bunt *et al*'s [26] meta-analysis. No separate measures of attraction and entrance efficiency are available for the temperate south, despite the fact that this is where fishways elsewhere in the world often fail [14, 26]. Furthermore, no assessments of downstream passage have been performed.

4 INTRODUCING THE KEEPFISH PROJECT

Over a period of four years, the KEEPFISH project aims to address gaps in the knowledge of passage requirements for species native to the temperate south. Systematic review of data contained in published, unpublished and grey sources will be used alongside expert elicitation to model fish passage probabilities for native species given a range of fishway designs. The model will also highlight key research priorities. In parallel with this, postgraduate students will be trained in state-of-the-art methodologies in order to build capacity and develop innovative approaches to non-sport fish passage research. Networking and stakeholder engagement activities occurring throughout the project will result in a shared vision for fish passage science and policy in the temperate south, ensuring an enduring legacy of the project through a long-term programme of funded research directly linked to policy-making. The approach taken and the results obtained will also be relevant to other areas of the world where intense hydropower development is threatening local fish populations.

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