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Introduction

Recovering threatened freshwater fish in Australia

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General introduction

Concern over the decline of freshwater ecosystems has grown dramatically in recent decades, with major threats of habitat loss or modification, altered flow regimes, changed water quality, barriers to dispersal and migration of biota, and impacts of alien species (Malmqvist and Rundle 2002; Dudgeon *et al.* 2006). Fishes are a key concern for all of these threats; populations and species are declining globally, with additional threats to fish generated by inappropriate translocation and stocking, and over-exploitation. The number of threatened freshwater fish taxa on the IUCN Redlist listed as critically endangered, endangered or vulnerable has increased from 741 in 1996–98 to 2041 in 2012 (version 2012.1; IUCN 2012).

Australia has a comparatively small freshwater fish fauna of 256 currently recognised species, of which 74 % are endemic (Unmack 2013). However, this species diversity is expected to rise significantly as there are increasing numbers of undescribed and/or cryptic taxa being uncovered through genetic investigations (e.g. Hammer *et al.* 2007; Raadik 2011). As new species are described, it is increasingly the case that many are already threatened, particularly in southern Australia, where they are often relictual populations with small geographic distributions (e.g. Raadik 2011). The first national list of Australian threatened species in 1980 recognised only 3 freshwater fish species but this has rapidly grown to the 74 species currently on national state or territory listings (Lintermans 2013*a*).

Considerable effort and resources are devoted to recovery of threatened fish species in Australia. Of the 36 freshwater fish listed as nationally threatened, 21 species have national recovery plans, with several additional species having recovery plans in preparation, or covered under recovery plans for threatened ecological communities. To facilitate improvement in the management of recovery programs, review of past and current efforts is essential, but this has not yet occurred for freshwater fish in Australia.

Introduction to the Special Issue

This Special Issue synthesises the diverse recovery approaches, and uses a series of case studies to review progress, success and failure of recovery efforts, for a selection of individual freshwater fish species across Australia. Although most of the case studies are from southern Australia, where most threatened freshwater fish are located (Lintermans 2013*a*, 2013*c*), the described recovery approaches are applicable more broadly, both nationally and internationally. Ten papers in this Special Issue outline the recovery efforts for a range of fish species, with an array of management interventions employed across a diversity of habitat types from sub-alpine lakes to semi-arid springs.

Lintermans (2013*c*) sets the scene by reviewing the diversity of on-ground recovery actions available to managers, synthesising the what, how and why these recovery actions have been deployed. The most commonly utilised recovery actions were harvest control, translocation, habitat enhancement and stock enhancement. While the majority of recovery actions reported that there was associated monitoring, insufficient detail was provided on the type or design of monitoring employed, and high levels of success claimed may be unrealistic. Few or no recovery actions were reported for many nationally and state-listed species. While recovery plans were identified as important drivers of management action, climatic extremes over the ‘Millennium Drought’ (1997–2010) highlighted deficiencies in existing plans, with planning for extreme events such as drought and blackwater events obviously lacking.

Emergency responses associated with prolonged drought were critical components for several species, with desiccation and/or declining water quality the key drivers of emergency recovery activities (Ellis *et al.* 2013; Hammer *et al.* 2013). For Murray hardyhead, *Craterocephalus fluviatilis*, which largely rely on off-channel habitats for persistence, recovery activities initially revolved around delivery of water to such habitats to prevent desiccation and manage water quality issues such as increasing salinity (Ellis *et al.* 2013). However, during prolonged drought, competing demands for water jeopardised environmental water delivery, with fish rescues, captive maintenance programs and translocation of both wild and captive-bred fish becoming the mainstay of conservation efforts (Ellis *et al.* 2013). The study highlights the difficulty in conserving short-lived species in off-channel habitats in agricultural landscapes during drought.

Emergency responses were also pivotal in the conservation of small-bodied fishes in the lower Murray River basin, with several species or populations facing imminent local extinction as a result of declining water levels during drought (Hammer *et al.* 2013). Initial rescues from wild habitats and the establishment of captive-breeding programs in makeshift facilities saved two species (southern purple-spotted gudgeon (*Mogurnda adspersa*) and Yarra pygmy perch (*Nannoperca obscura*)) from regional extinction, and prevented the loss of local populations in three other species (Hammer *et al.* 2013). The subsequent development of a multi-agency drought action plan that drove a

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mix of *in situ* and *ex situ* conservation management measures demonstrates the importance of coordinated management action, and highlights the need for threatened species and ecological community recovery plans to consider extreme climatic events.

It is now almost 30 years since the first national recovery plan for an Australian freshwater fish (trout cod, *Maccullochella macquariensis*), was published, with this species now demonstrating some recovery through the expansion of existing populations and evidence of recruitment in some stocked populations (Koehn *et al.* 2013). The considerable and continuing research activity into this species has been a key factor in recovery efforts, and demonstrates the importance of partnerships between management and researchers. This case study also highlights the value of using population models, coupled with ongoing monitoring of stocking efforts, in delivering an improved and successful reintroduction program (Koehn *et al.* 2013).

The difficulty in assessing the success of recovery actions is highlighted by Lintermans (2013*b*), who outlines the results from a 30-year monitoring program of a translocation of Macquarie perch (*Macquaria australasica*). Four years after, the translocation was considered a failure, but a decade later the translocation was thought to be successful, with a self-sustaining population established. However the Millennium Drought is thought to have led to a cessation of recruitment, with the population now undetectable. The existence of a long-term monitoring program was critical in determining the fate of this recovery attempt.

Addressing the threat from alien fish has been central to several recovery programs. Kerezsy and Fensham's (2013) description of the efforts to conserve the red-finned blue-eye, *Scaturiginichthys vermeilipinnis*, in the face of invasion by eastern gambusia, *Gambusia holbrooki*, demonstrates the difficulties of alien fish control in shallow, low-relief, semi-arid spring habitats. The complexity of control efforts was significantly increased by the presence of a range of threatened taxa. This study demonstrates the significant contribution to conservation by non-government organisations, with a mix of *in situ* chemical gambusia control combined with local-scale translocation of red-finned blue-eye within the spring complex trialled. These combined approaches appear to be the likely conservation pathway for this species (Kerezsy and Fensham 2013).

In contrast, the battle to save the Pedder galaxais, *Galaxias pedderensis*, could not be fought *in situ*, as control of salmonid populations in Lake Pedder was not possible in the required timeframe (Chilcott *et al.* 2013). Attempts at captive breeding were largely unsuccessful, and a last-chance translocation to a small isolated lake outside the species' natural range ultimately saved the Pedder galaxias from extinction. Chilcott *et al.* (2013) demonstrate the long-term commitment required for species recovery, including ongoing monitoring programs, and also provide a reminder of the need to consider non-routine monitoring methods (e.g. remote operated vehicle and underwater cameras, night snorkelling) to evaluate population status when individuals are scarce.

The existence of a national recovery plan does not necessarily enhance recovery outcomes. Saddlier *et al.* (2013) review the recovery of two pygmy perch species and find that few recovery actions have been completed and the status of many populations is unknown following the recent Millenium Drought. The lack of significant progress with recovery actions is attributed in part to the small body size, lack of commercial value, cryptic nature and non-charismatic status of pygmy perch, with less funding available and lower public awareness than for larger, iconic species with recreational angling potential (Saddlier *et al.* 2013).

Reservoirs or impounded waters can provide essential habitat for threatened freshwater species, but this is almost never their primary purpose. Consequently, there are often competing management demands in such environments between managing for anthropogenic water uses and conservation requirements. Hardie (2013) demonstrates the value of trialling specific water management regimes to assist recovery of lacustrine populations of golden galaxias, *Galaxias auratus*, in both drought and non-drought years. Golden galaxias spawning and recruitment was enhanced in the receiving water, without impacting the species in the donor lake, demonstrating the value of targeted science in meeting multipurpose water management objectives.

The response of Macquarie perch to construction of a purpose-built rock-ramp fishway for the species is reviewed by Broadhurst *et al.* (2013), who note the delays before a population response could be detected. This highlights a perennial issue of working with rare or threatened species, where detection power may be low, and for long-lived species, where response to management interventions may not be immediate. The study provides a useful example of where remediation of a single stressor or impact (restricted migration) at the site scale may result in broader benefits for a threatened species.

What have we learned?

Assessments of the success of recovery actions can be ephemeral, with a commitment to long-term monitoring programs required (Lintermans 2013*b*). Similarly, assessments of the outcome of the Pedder galaxias translocation success and the benefits of a fishway in expanding the range of Macquarie perch required several years before success could be evaluated (Broadhurst *et al.* 2013; Chilcott *et al.* 2013). The high reported success rate in the national review of recovery actions (Lintermans 2013*c*) is difficult to critically evaluate and likely represents early assessments that may ultimately turn out to be less successful than initially claimed.

The importance of a translocation as recovery action is evident for several species, particularly small-bodied species whose reproductive ecology was poorly known, where captive breeding facilities were unavailable, or where natural habitats had been rendered uninhabitable (Chilcott *et al.* 2013; Ellis *et al.* 2013; Hammer *et al.* 2013; Kerezsy and Fensham 2013). The popularity of translocation as a freshwater recovery action in recent years is apparent for other freshwater species both nationally and internationally (e.g. Ayres *et al.* 2011; Soorae 2011; Lintermans 2013*c*), and holds much promise for recovery of species outside of hatchery programs.

A reliance on *ex situ* actions such as captive breeding programs to sustain or recover threatened fish was evident in several of the case studies reported in this Special Issue (Ellis *et al.* 2013, Hammer *et al.* 2013, Koehn *et al.* 2013). Such breeding programs are often driven by a mix of the inability or unwillingness to invest in costly *in situ* actions (see Ellis *et al.* 2013), a last-chance emergency action to prevent imminent extinction (see Hammer *et al.* 2013) or long-standing fisheries interest for those species with historic recreational value (see Koehn *et al.* 2013). Whatever the driver, reliance on captive breeding programs for species recovery is problematic, with such programs often an easier option than efforts to restore habitat, eradicate alien species or counter other large-scale threats (Philippart 1995). Further, there are a variety of concerns for hatchery programs around domestication and genetic integrity (Brown and Day 2002; Nock *et al.* 2011). While captive husbandry has a significant role in the management of many threatened species, and if well managed can produce positive results (see Lyon *et al.* 2012; Koehn *et al.* 2013), it must be viewed as only one component of a broader recovery program, with *in situ* responses preferred (Lintermans 2013*a*).

Ingredients for success

The collection of case studies in this Special Issue highlights several important issues that are seldom appreciated or addressed in recovery programs:

- **Timeframe for recovery:** Most species by the time of listing have been in decline for decades, facing multiple and pervasive threats. It is unlikely that species will dramatically recover in just a few generations, and recovery may mirror or exceed the time period of decline.
- **Scale:** There is often a mismatch in scale, with most recovery actions being small-scale (temporal and spatial) in response to lengthy and widespread declines.
- **Planning for extreme events:** There is a deficiency in recovery planning for infrequent and extreme climatic events such as drought, bushfire and flooding. Consequently, when such events inevitably occur, *ad hoc* and crisis management dominates, and the lessons learned are then forgotten when the next extreme event (usually of a different kind) occurs.
- **Monitoring:** Although monitoring is widely acknowledged as essential, much of it is poorly resourced, short-term (in ecological timeframes), and suffers from a very limited focus.
- **Status and trend:** Many species suffer from a basic lack of current knowledge about population status or trajectory. Regular audits of trajectory, as required under the *US Threatened Species Act* (see Male and Bean 2005 and references therein) would be of significant benefit in assessing progress towards recovery.
- **Public engagement:** The support by human communities for recovery actions becomes critical when times are tough and there are competing demands for limited resources (water, dollars, time) (see Ellis *et al.* 2013). Improved mechanisms and effort for capturing public interest in small, often drab, species with no commercial or recreational interest is essential.
- **Recovery coordinators:** Threatened species management is usually multi-jurisdictional, with a range of political, agency, and public/private issues involved. To drive coordinated cross-boundary management, a dedicated recovery team or coordinator is required, with documented benefits accruing from such an approach (Lundquist *et al.* 2002).

The number of threatened freshwater fishes continues to grow worldwide, and so does the requirement for strategic and coordinated management of these species. Unless we learn from previous recovery successes and failures, we are doomed to repeat the mistakes of the past. The papers in this Special Issue provide invaluable information to inform future recovery actions.

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