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Editorial

Adaptive management in action: using chemical marking to advance fish recovery programs in the Murray–Darling Basin

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Abstract. Being able to tell the difference between stocked and wild fish is essential to understand the overall success of hatchery programs. It is a substantial issue to address, especially considering that over 60 million fish have been stocked into Australian inland waters over the past 30 years. A trial into permanently marking live fish, with fluorescent chemicals, has demonstrated substantial promise. Having been cleared by food safety authorities, and validated by targeted research, it is presently being rolled out on a large scale in the Murray–Darling Basin.

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Introduction

Artificial stock enhancement is widely accepted as an important requisite for any fisheries managers' toolbox (Molony *et al.* 2003). Ascertaining whether stock enhancement activities are establishing productive fisheries, recovering species under threat, and are generating good value for money must be critical requirements of any successful program (Caddy 2014). Stock enhancement has been undertaken in the Murray–Darling Basin region of Australia for over 100 years (Barwick *et al.* 2014); an area where native fish species are estimated at less than 10% of pre-European levels (Koehn *et al.* 2014). Some species have declined further, many unsighted for almost 40 years in areas where they were historically abundant (Baumgartner *et al.* 2014). Originating as a simple trap and relocation program (Anderson 1915), the stock enhancement program is now coordinated by individual state agencies across the entire catchment in collaboration with government, anglers and private hatcheries. Over 60 million fish were liberated into the basin over the past 30 years and in many cases have helped to reverse declines and increase distributional ranges (Barwick *et al.* 2014).

Hatcheries allow spawning and recruitment to occur under controlled conditions and avoid the high larval mortality rates experienced in the wild. It is financially inefficient and logistically difficult to develop hatchery rearing programs for all native species. Efforts are subsequently focussed mainly on species of recreational importance (Allen *et al.* 2009). Other management interventions are implemented to help these and other species. In fact, 13 separate interventions have been identified as needed to help recover fish within the Murray–Darling Basin (Koehn and Lintermans 2012) because many stressors are adversely affecting fish simultaneously. The resultant situation is a mosaic of different management interventions being applied across an extremely large scale with very few programs actively quantifying success. The lack of intervention-specific monitoring programs, and an *ad hoc* approach to implementation, makes it difficult to determine the relative success of each action in isolation from others. Thus, where fish communities are deemed to be improving, or continuing to decline, it is impossible to link cause with effect to a single factor.

Confusion 'rains'

The Australian government has embarked on an ambitious program to deliver environmental flows to recover declining aquatic ecosystems. The Murray–Darling Basin plan was developed following an act of parliament (*Water Act (Clth)* 2007, see https://www.comlaw.gov.au/Series/C2007A00137, accessed 6 October 2015) that recognised that action was needed to save a major national resource (MDBA 2011). The approach was conceptually simple. Water would be recovered from licenced users through a buy-back scheme and delivered for environmental purposes. Concurrent research and monitoring programs would be established to justify whether environmental water was making a positive difference.

Fish are a major beneficiary of environmental water and thus are an excellent indicator to monitor (Marchetti and Moyle 2001). Water delivery can provide cues for fish to spawn, govern metabolic activity, as well as providing habitat and food (Rose 2000). Environmental water monitoring programs subsequently include some measurement of these metrics. The general assumption is that any positive response is associated

with watering events. Fisheries and conservation managers are, however, presently implementing a range of different intervention activities across the basin. The benefits from environmental watering programs could be therefore confounded by the cumulative benefits provided by these actions such as stock enhancement.

A reductionist research and monitoring approach is the only way to link specific interventions to outcomes in a multi-activity environment. It requires a combination of larger scale monitoring to report on broad trends and be complemented by intervention-specific research to help understand recovery trajectories. For example, if techniques were available to distinguish between stocked and wild fish, the relative contribution from stock enhancement could be isolated from, say, environmental watering interventions. The outcomes of such research are the focus of this exciting research front.

To stock or not to stock

Recognising that stock enhancement has been undertaken on such a large scale for many decades, it is impossible to determine natural recruitment trends across the Murray–Darling Basin; at least for stocked species. Stock enhancement has occurred in virtually every single sub-catchment (Rourke *et al.* 2011). Any large scale fish monitoring programs are therefore confounded by stocking because there was no mechanism to discriminate hatchery and wild fish. Teasing out environmental watering effects, and those of any other management interventions, from stock enhancement was therefore impossible.

Recognising this difficult situation, researchers embarked upon a proof-of-concept approach. The aim was to determine whether batch identification techniques, which had been successfully applied elsewhere to discriminate different sources of fish, could be applied to Murray–Darling species. Pilot studies assessed a range of techniques, and chemical batch marking quickly became the most cost-effective and useful tool (Crook *et al.* 2009). Although the chemical batch marking trials were promising, there were some caveats requiring further developmental work. For instance, it became apparent that to provide the most benefit, chemical marks must be (i) easily detectible, (ii) not adversely affect the individual, (iii) be permanent and ideally (iv) non-lethal (Crook *et al.* 2012; Baumgartner *et al.* 2013). Initial work focussed primarily on technique refinement and then gaining approval for use by the relevant authorities (Sanger and Crook 2007).

Positive policy change

Longer term trials have now validated chemical marking as a useful technique (Crook *et al.* 2016; Forbes *et al.* 2016). Initiating a broad-scale, coordinated tagging program was the next logical step to ensure the benefits from stock enhancement activities could be discriminated from wild recruits. New South Wales Department of Primary Industries has, following a period of constructive consultation, has agreed to lead and implement the first ever coordinated batch marking program. Over the next 5 years, all Murray cod and golden perch released by both government and commercial hatcheries will be chemically marked using the techniques described in this edition (Crook *et al.* 2016; Forbes *et al.* 2016). The decision will complement a series of broader projects that currently seek to determine fish recruitment outcomes from environmental water delivery and other habitat rehabilitation initiatives. There was concern among researchers and water managers that any stocking conducted in watering zones could mask any natural recruitment. The statewide commitment to chemically mark fish will eliminate this ambiguity. In this instance researchers worked closely with managers to develop and implement solutions that will improve data integrity and allow future decisions to be based on robust science. It is a clear example of adaptive management in action. Considering that environmental watering programs are now being coordinated across five separate jurisdictions in the Murray–Darling Basin, expanding the marking program to include other states and territories would be a productive next step.

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