ADAPTIVE MANAGEMENT IN ACTION – ENVIRONMENTAL FLOWS AND THE RESPONSE OF AUSTRALIAN GRAYLING

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The Australian grayling (*Prototroctes maraena*) is a nationally threatened diadromous fish that inhabits coastal rivers in south-eastern Australia. Increases in river flow are considered a key factor for spawning of Australian grayling. Consequently, the provision of environmental flows in regulated rivers may represent an important tool to support the reproductive requirements of Australian grayling. Notwithstanding, major gaps in our knowledge of reproductive behaviours of the species have limited the development of targeted and effective conservation management strategies. To improve understanding of Australian grayling reproductive ecology and to directly inform more effective delivery of environmental flows, we investigated spawning and/or movement of the species during autumn/winter between 2008 and 2015 in the Bunyip/Tarago and Yarra rivers in south-eastern Australia. Results showed that adult Australian grayling undertook rapid long distance downstream spawning migrations during elevated flows in mid-late autumn to lower river reaches, including in response to targeted environmental flow releases. Spawning activity of Australian grayling was also highest during increased river flows, including periods of targeted managed flows. The study demonstrates that the provision of environmental water can be effectively delivered to support the reproductive requirements of Australian grayling. This information can now be used to directly inform more effective and efficient delivery of environmental flows.

1 INTRODUCTION

Riverine fishes are among the most threatened fauna in the world, but many species remain poorly studied or are managed with little understanding of their ecological requirements. The Australian grayling (*Prototroctes maraena*) is a nationally threatened diadromous fish that inhabits coastal rivers in south-eastern Australia. Australian grayling has declined dramatically since European settlement, largely due to altered flow regimes and barriers to movement (Backhouse et al., 2008). Increases in river flow are considered are a key factor for spawning of Australian grayling. Maintaining or protecting key components of the natural flow regime, and the provision of environmental flows in regulated rivers, may therefore represent important tools to support the reproductive requirements of Australian grayling and potentially assist the recovery of the species.

In this study, we investigated spawning and/or movement of Australian grayling during autumn/winter between 2008 and 2015 in the Bunyip/Tarago and Yarra rivers in southeastern Australia. This included monitoring responses to targeted managed flows (within-channel pulses or ‘freshes) developed as part of seasonal watering plans by Melbourne Water and the Victorian Environmental Water Holder.

2 METHODS

2.1 Study area

The study was conducted in the Bunyip/Tarago and Yarra rivers in Victoria, south-eastern Australia. The upper reaches of the Bunyip/Tarago catchment are forested, while the mid to lower reaches consist predominantly of cleared agricultural land and small urban areas. The Tarago River is the main tributary of the Bunyip River and is regulated by the Tarago Reservoir. The upper reaches of the Yarra catchment are mostly forested, while the mid to lower reaches of the Yarra River flow through the Melbourne metropolitan area and is heavily urbanized. Flow in the Yarra River catchment is highly regulated by dams that supply water for Melbourne and agricultural irrigation.

2.2 Fish movement

Australian grayling were collected and tagged with acoustic transmitters in 2009, 2010 and 2015 from the Bunyip and/or Tarago rivers. An array of acoustic listening stations was deployed in the Bunyip River between Bunyip and Koo Wee Rup, and in the Tarago River between Fischer Road and the Bunyip River junction. The listening stations were deployed using a length of plastic-coated steel cable attached to star pickets as an anchor point. Data were downloaded from the listening stations every month throughout the study.

2.3 Fish spawning

Sampling for fish eggs and larvae was conducted in the lower reaches of the Bunyip and Yarra rivers using drift nets. Sampling was conducted about once per week from March – June in each year (except 2012) between 2008 and 2015. Drift nets were 1.5 m long, with a 0.5-m diameter mouth, consisted of 500-µm mesh, and had flow meters fitted to the mouth of the net to measure the volume of water filtered. Nets were set in late afternoon (1500–1700 hours) and retrieved the following morning (0800–1000 hours). Samples sorted in the laboratory under a dissecting microscope.

3 RESULTS

3.1 Fish movement

Tagged adult Australian grayling in the Bunyip and Tarago rivers undertook rapid downstream migrations over distances of up to 45 km to the lower reaches of the Bunyip River near Koo wee Rup from late March to late April (Figure 1). Downstream migrations coincided with natural flow increases driven by rainfall runoff as well as during a targeted managed flow release. Fish moved predominantly on positive flow changes, indicating that the rising limb of the hydrograph acts as a cue for downstream movement. Some fish ceased migration as flow decreased, then recommenced migration to the lower reaches during subsequent flow increases. The downstream migrations corresponded to the timing of spawning (Figure 2).

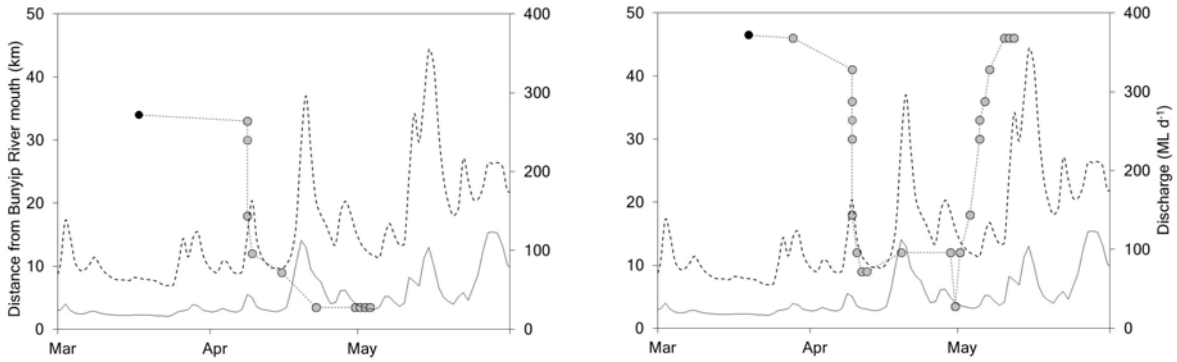

Figure 1. Examples of movement patterns of individual Australian grayling tagged in the Bunyip (left panel) and Tarago (right panel) rivers during 2015. Grey circles denote detection of a fish. Black circles denote fish release location and date. Black dashed line denotes daily discharge in Bunyip River at Iona. Solid black line denotes daily discharge in Tarago River at Drouin West.

3.2 Fish spawning

In total, 11918 eggs and 1314 larvae of Australian grayling were collected in the drift sampling (Table 1). Most eggs and larvae were collected from the Bunyip River (90%). Eggs and larvae were collected from April to June in the Bunyip River, with peak egg abundances collected between mid-April and mid-May, and in the Yarra River from May to June, with peak egg abundances collected between mid-May and mid-June.

Peak egg/larval abundances were collected coinciding with autumn within-channel flow pulses, including during periods of targeted managed flow releases (i.e. autumn 'freshes') (Figure 2). The highest concentrations of eggs typically occurred when flows in the week prior to sampling were higher than the median flow during the spawning period (April-May) for that year. This relationship began to fade at higher deviations of flow magnitude. Egg concentrations also exhibited multiple peaks in association with several flow pulses throughout the spawning season. Eggs were collected over a broad range of water temperatures (as high as 18 °C), with peak abundances at 10–15 °C.

Table 1. Number and density (number per 1000m^3) of Australian grayling eggs and larvae collected in drift samples from the Bunyip River at Koo Wee Rup and Yarra River at Collingwood (2008-2015).

			2008	2009	2010	2011	2013	2014	2015
Bunyip	Number	Egg Larvae	91 81	788 164	6336 89	1575 124	823 124	651 58	1447 670
	Density	Egg Larvae	6.3 5.6	96 19.9	429 6	99.8 7.9	69.4 10.5	80.5 7.2	115.6 53.5
Yarra	Number	Egg Larvae		78	1 4	4	4	116	1
	Density	Egg Larvae		5.7	<1 <1	<1	<1	<1	<1

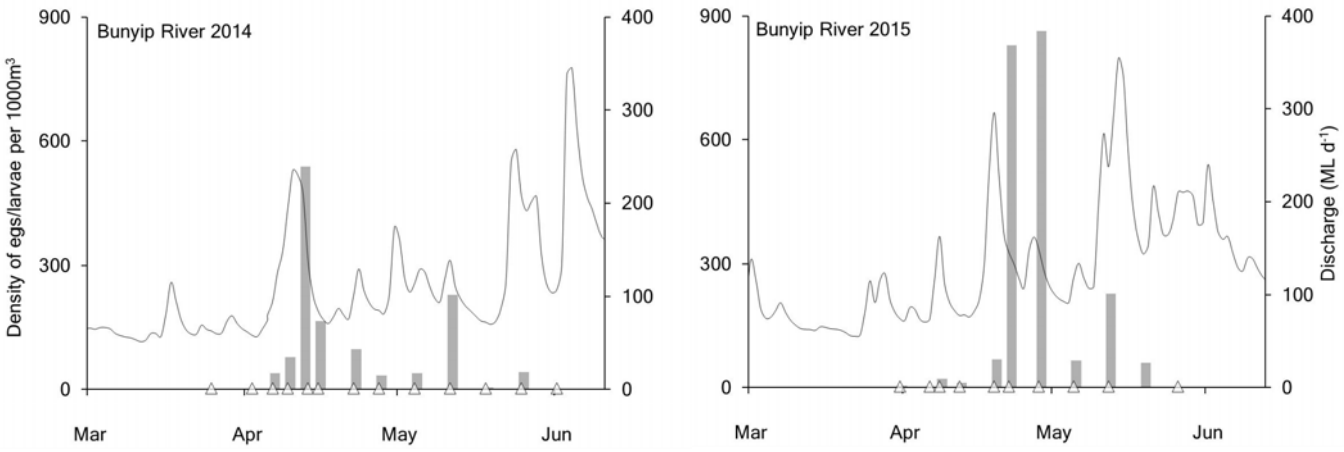

Figure 2. Examples of density of Australian grayling eggs/larvae (grey bars) collected in drift nets from the Bunyip River in 2014 and 2015. Black line denotes daily discharge in Bunyip River at Iona. White triangles denote sampling trips.

4 DISCUSSION

The results of the study have provided important new information on the ecology of Australian grayling, including specific information on links between downstream migration, spawning and river flows. The acoustic tracking of mature adults showed fish undertook downstream g migrations to lower river reaches in response to increased river flows in autumn, including environmental flow releases. Sampling of eggs and larvae confirmed that spawning occurred at the same time that migrations were detected. Spawning activity of Australian grayling was also highest during increased river flows, including during periods of targeted managed flows. These results demonstrate that environmental water allocation in regulated rivers can effectively enhance or trigger migration and spawning of this nationally threatened species.

For Australian grayling, recent environmental flow recommendations have focused primarily on short-lived flow events to trigger spawning, but not flows to allow for adult migration to spawning areas. The finding of a large-scale spawning migration by adult Australian grayling during periods of increased discharge in autumn demonstrates that existing flow recommendations are overly simplistic and insufficient to provide the environmental cues necessary to facilitate downstream migration and spawning. Environmental flow recommendations for Australian grayling need to include flow events of sufficient duration and magnitude to allow for adult migrations from habitat in the upper reaches to spawning areas in the lower reaches.

Our results also suggest that larger magnitude flows do not necessarily increase spawning activity of Australian grayling. While the highest concentrations of eggs typically occurred when flows in the week prior to sampling were higher than the median flow during the spawning period, this relationship began to fade at higher deviations of flow magnitude. This finding is an important consideration for environmental water management, as it suggests that providing appropriate smaller flow pulses of sufficient duration during the spawning period can stimulate spawning of Australian grayling, and thus the delivery of less water in a more strategic manner could achieve the same aims.

Australian grayling eggs have consistently been collected in much higher numbers in the Bunyip River compared to the Yarra River throughout this study. The lower abundance of eggs in the Yarra River is likely related to the low abundances of adult Australian grayling in this river, whereas the Bunyip River supports a more abundant Australian grayling population. The Dights Falls barrier on the lower Yarra River has significantly reduced the range and abundance of Australian grayling in this system (Zampatti et al., 2003). However, the recent vertical slot fishway does pass juvenile upstream migrants of Australian grayling, and consequently future spawning success in this river could be expected to increase.

For Australian grayling, we have found substantial numbers of eggs throughout this study at water temperatures as high as 16-18 °C, and hence a decrease to 10–12 °C is not crucial to trigger spawning as previously suggested (Berra, 1982; Hall and Harrington, 1989). For water managers, this provides some flexibility in the timing of flows to trigger spawning.

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