



Australian Government

Commonwealth Environmental Water Office

Commonwealth Environmental Water Office
Long Term Intervention Monitoring Project
Murrumbidgee Selected Area

*Addendum to the Murrumbidgee Selected Area Monitoring and
Evaluation Plan, as of 24 August 2018*

Native and invasive fish dispersal, spawning and trophic dynamics during a managed river-floodplain connection

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Introduction

The Commonwealth Environmental Water Office, in conjunction with the NSW Office of Environment and Heritage, is proposing up to a 90GL environmental watering action for Yanga National Park in winter-spring 2018. This event will release environmental water from the IAS regulator over a period of several months to achieve a north-south overland flow aimed at supporting native fish populations and waterbirds, and provide a “top-up” of Yanga Lake for habitat protection for resident native fish, including the current population of golden perch.

Objective for the project

This program seeks to describe the responses of fish and waterbirds to the above environmental watering action aimed at supporting native fish populations in persistent floodplain lakes. The program seeks to evaluate key processes expected to occur in response to the proposed environmental watering action:

- Identify of fish movements during environmental water delivery
- Evaluate fish spawning outcomes and identify key food resources supporting larval growth and development
- Evaluate fish recruitment into adult populations (young of year)
- Evaluate the response of waterbirds to the environmental watering action and estimate the impact of fish-eating waterbirds on fish populations

It is expected that information from this study will be used to understand the importance of environmental flow-driven floodplain connections on providing food resources for fish spawning and recruitment and for waterbirds. This information will be used in adaptive management actions to guide the timing and magnitude of environmental watering actions which connect river channels environments and floodplains.

Background

Floodplains are critical habitats for native fish, providing highly productive nursery habitats (Beesley et al., 2014, Beesley et al., 2011, Lyon et al., 2010). Fish movement, spawning and recruitment in response to environmental watering has been studied extensively in river and creek systems during flow freshes and overbank flows (King et al., 2003, Rolls et al., 2013). However very few studies have investigated population dynamics of native fish occupying floodplain wetlands, creek lines and lakes, or their responses to environmental watering. In the Murrumbidgee River system, annual monitoring of larval fish has identified larval golden and silver perch and Murray cod with the probability of recording larval perch increasing with increasing temperature and lower discharge (Wassens et al., 2016). Despite clear evidence of spawning in the main river channel, survival rates of larval perch and cod are poorly known and few young of year individuals are collected during annual fish surveys (Wassens et al., 2016). One possible reason for apparent low recruitment of large bodied native fish into adult populations is reduced access to productive floodplain habitats (Humphries et al., 1999, Zampatti et al., 2015). That is, high discharge volumes, low productivity and the heavily incised channel structure of the Murrumbidgee River may contribute to reduce recruitment success, making the availability of persistent off-channel wetland habitats critically important.

Large bodied native fish are often managed as visitors to floodplain wetlands and lakes rather than residents. However we know from historical records that the large permanent lake systems in the Lowbidgee floodplain supported commercial cod, golden and silver perch fisheries until the 1950s (Brown, 1994). Indeed this loss of persistent floodplain habitat due to river regulation is associated with the loss of a number of native fish species, including the Murray hardyhead and olive perchlet (Wedderburn et al., 2007) and may be a key factor contributing to the lower recruitment levels among large bodied native fish populations (Humphries et al., 2008).

Linking floodplain productivity to larval fish recruitment and survival.

Floodplains are highly productive environments, and flow regimes drive energy production and influence how different sources of nutrients and carbon (basal resources) enter food webs and support larval fish growth and development (Humphries et al. 2014; Thorpe & Bowes 2017). River regulation has impacted both the diversity and availability of food resources as well as and their movement between floodplain and riverine ecosystems (figure 1). These changes act to simplify aquatic food webs, reducing the quality of available nutrients, altering the trophic niche of top predators and other consumers, and ultimately leading to effects on larval growth and survival. Understanding how particular watering strategies influence the availability of food resources and the stability of aquatic food webs is essential to the decision-making needed to support recruitment and larval fish survival, as well as supporting populations of higher vertebrates such as waterbirds.

The use of stable isotopes, fatty acids and otolith growth analyses provides information on the key sources of energy being utilised by fish at different ages. For larval fish, particularly perch which have a very small yolk sac, the availability of suitable food (prey) for their first feed is a critical factor that determines survival. As individuals grow and age their prey also changes, meaning that an individual fish might shift its prey preference multiple times in the first few months of life. In flow regulated systems food webs become simplified, and the diversity of food resources decreases, which decreases the likelihood that suitable prey will be available to meet the food needs of larval fishes at each stage of their development. From a management perspective, the timing and delivery methods employed to deliver environmental flows can influence the diversity of food resources and strengthen the relationship between larval fish and the availability of suitable prey. These food resources and other environmental factors combine to determine larval survival and ultimately recruitment to adult fish populations.

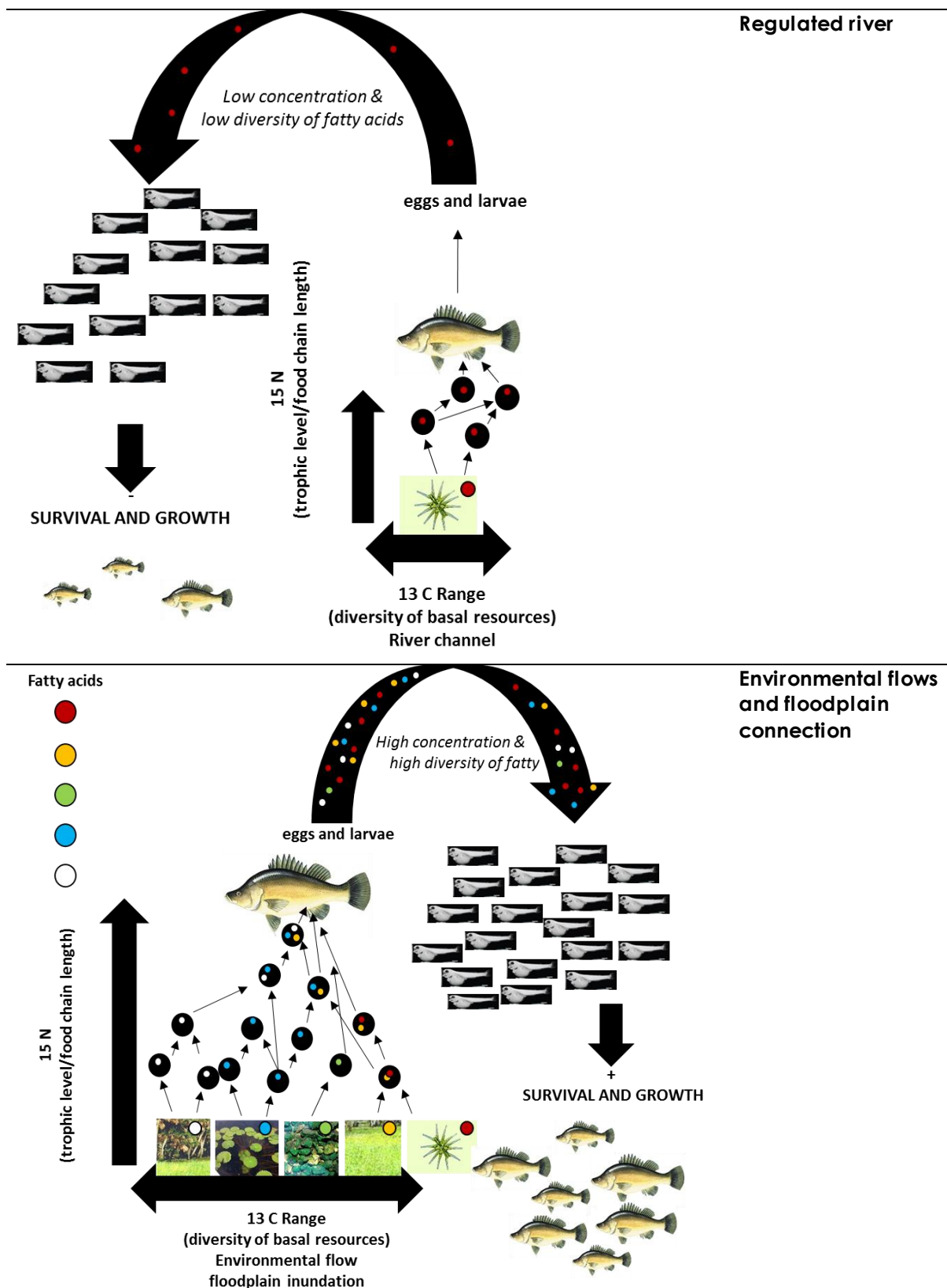


Figure 1. Conceptual model of the differences in food resource diversity and availability between regulated rivers and floodplain ecosystem- Isotopes and fatty acids can help us identify the origin of adult and larval fish, key food resources and provide cues to the causes of recruitment failures

Management of fish on floodplain wetlands is complex. Floodplain lakes, creeks and wetlands are orders of magnitude more productive than the Murrumbidgee river channel, and are therefore expected to support faster growth rates and improved fitness of floodplain fish. However wetland inundation can sometimes promote spawning and recruitment of introduced species, particularly common carp (Forsyth et al., 2013, Lyon et al., 2010). In addition the long-term contribution of wetlands to native fish populations is dependent on the maintenance of persistent habitat of suitable quality and opportunities for fish to move between the main river channel and the floodplain (Koster et al., 2014, Leigh and Zampatti, 2013). Floodplain habitat may also have significantly higher predation rates than channel habitats, with fish eating waterbirds often occurring in very high abundances.

The current situation in the Murrumbidgee

Large numbers of juvenile golden perch along with other important native fishes such as bony brim have been identified from persistent lakes through the lower Murrumbidgee. Environmental watering actions undertaken by the Commonwealth Environmental Water Holder and NSW in 2014-15 and 2017-18 appear to have assisted in the re-establishment of native species within Yanga and Tala lakes. However, there has been limited monitoring and evaluation of these watering actions on which to base recommendations for future environmental watering strategies and key questions regarding the population dynamics and food resources utilised by these populations remain unknown.

There are two potential pathways driving native fish spawning, recruitment and survival in the lower Murrumbidgee floodplain lake systems: (1) Larval fish may be spawned in the Murrumbidgee River and then may drift into the floodplain lakes via open regulator structures during environmental watering actions. (2) Flows to the lakes could be sufficient to trigger movement of adults from the lakes into connected creek lines (for example Woolshed, Devils Creek and Tala Creek) where spawning occurs after which larvae and juveniles are expected to drift downstream back into the lakes.

From an adaptive management perspective identifying the relative importance of these two processes has significant implications for long-term environmental water planning and management. There are two key management options available for the management of these populations:

- 1) Lake to River reconnection: Establishing riverine reconnections to facilitate movement of fish out of the lakes and into the main river channel via escape regulators (as was undertaken in August 2017)

- 2) Floodplain to lake reconnection: Supporting populations on the floodplain via environmental flows across the floodplain and into the lake systems as was undertaken in summer 2014-15 and is proposed as a priority watering action in spring 2018 (table 1).

Both watering actions have a range of potential benefits to these populations, however in years of low water availability, floodplain to lake actions as proposed for 2018-19 and described in table 1, may be desirable because they use significantly less water, have multiple benefits for other floodplain taxa, particularly waterbirds and may contribute to a higher diversity of basal food resources to support growth and recruitment of native fish. In some instances it may also be desirable for fish to remain on the more productive floodplain lake habitat because growth and development rates may be higher on floodplains due to greater food availability. Key risk of floodplain to lakes watering strategies is the potential to trigger breeding and recruitment of exotic fish species.

Table 1. Priority actions for the Lower Murrumbidgee floodplain 2018-19 to be addressed in the proposed Yanga watering event.

Priority watering actions	Primary BWS Objective	Primary ecological objectives and secondary objectives from annual plan	MDBA Priorities
B8: A2 event + Yanga full system to Yanga Lake for golden perch habitat. Possibility of return flows as water availability increases (Wet scenario)	Fish Waterbird	Primary: 8 (B8). Maintain Critical refuge habitats for native fish, frogs and turtles Secondary: 2 (B8). Improve or maintain the condition of floodplain habitat for populations of native fish, waterbirds and other aquatic species	8b. Lowbidgee floodplain - Basin-wide waterbird habitat and future population recovery; Improve the complexity and health of priority waterbird habitat to maintain species richness and aid future population recovery.
A2: Two bridges to Piggery (Including Mercedes)		Primary: 2. Improve or maintain the condition of floodplain habitat for populations of native fish, waterbirds and other aquatic species Secondary: 9. Improve or maintain the condition of habitat to enhance the resilience of populations of listed species (e.g. threatened species or migratory bird agreements)	

Evaluation questions

This study will address a range of environmental flow questions related to the importance of river-floodplain connections to supporting native fish and waterbird populations.

- What did environmental water contribute to native fish dispersal?
- Did environmental water stimulate target species to exhibit movement consistent with spawning behaviour?
- What did environmental water contribute to native fish reproduction?
- What did environmental water contribute to native fish recruitment?
- What did environmental water contribute to native larval and juvenile fish growth?
- What did environmental water contribute to the availability and diversity of basal food resources supporting fish spawning, growth and survival?
- What did environmental water contribute to waterbird species diversity within the system?

What did environmental water contribute to waterbird relative abundance in the system?

Methods

The methods and proposed evaluation framework are aligned with the CEWO outcomes framework and basin plan objectives related to biodiversity, resilience and ecosystem function (table 2).

Table 2 Alignment of monitoring activities with Basin Plan objectives and CEWO outcomes framework

Basin Plan Objective	CEWO environmental water outcomes framework*	Evaluation questions	Proposed evaluation activities
Biodiversity (Basin Plan S. 8.05)	<ul style="list-style-type: none"> Larval and juvenile recruitment (Fish Larval Growth and Survival) Condition (Fish condition) Larval abundance and survival Waterbird species richness and abundance 	What did environmental water contribute to native fish reproduction?	Flow cued movement
		What did environmental water contribute to native larval fish growth?	Larval surveys (Abundance, size structure and age structure)
		What did environmental water contribute to the availability and diversity of basal resources to support fish growth and survival	Stable isotopes and fatty Acid profile (larval and adult fish)
		What did environmental water contribute to waterbird species diversity?	Waterbird surveys
		What did environmental water contribute to waterbird abundance?	
Resilience (Basin Plan S. 8.07)	Individual survival and condition (population condition Individual refuges)	What did environmental water contribute to native fish populations?	Fish Community surveys Population structure within lake systems
Ecosystem Function (Basin Plan S. 8.06)	Connectivity Biotic dispersal and movement	What did environmental water contribute to native fish dispersal?	Flow cued movement Directional fyke netting
		Did environmental water stimulate target species to exhibit movement consistent with spawning behaviour?	Larval surveys

*(Commonwealth Environmental Water, 2013)

Survey areas

Evaluation will be carried out on the Lowbidgee floodplain (Redbank system) with a focus around Yanga and Tala Lakes and key floodplain and Lake inflow points: The IAS regulator which links the floodplain to the Murrumbidgee River at Redbank weir 1AS channel (inflow to floodplain), Tala Lake and Devils Creek upstream of Yanga Lake. Tala Creek (inflow to Tala upstream of Lake) and Devils Creek (Inflow to Yanga Lake) (figure 2). Three control sites will be included in the Murrumbidgee River to provide a baseline for the ecological responses occurring in the absence of targeted environmental flows.

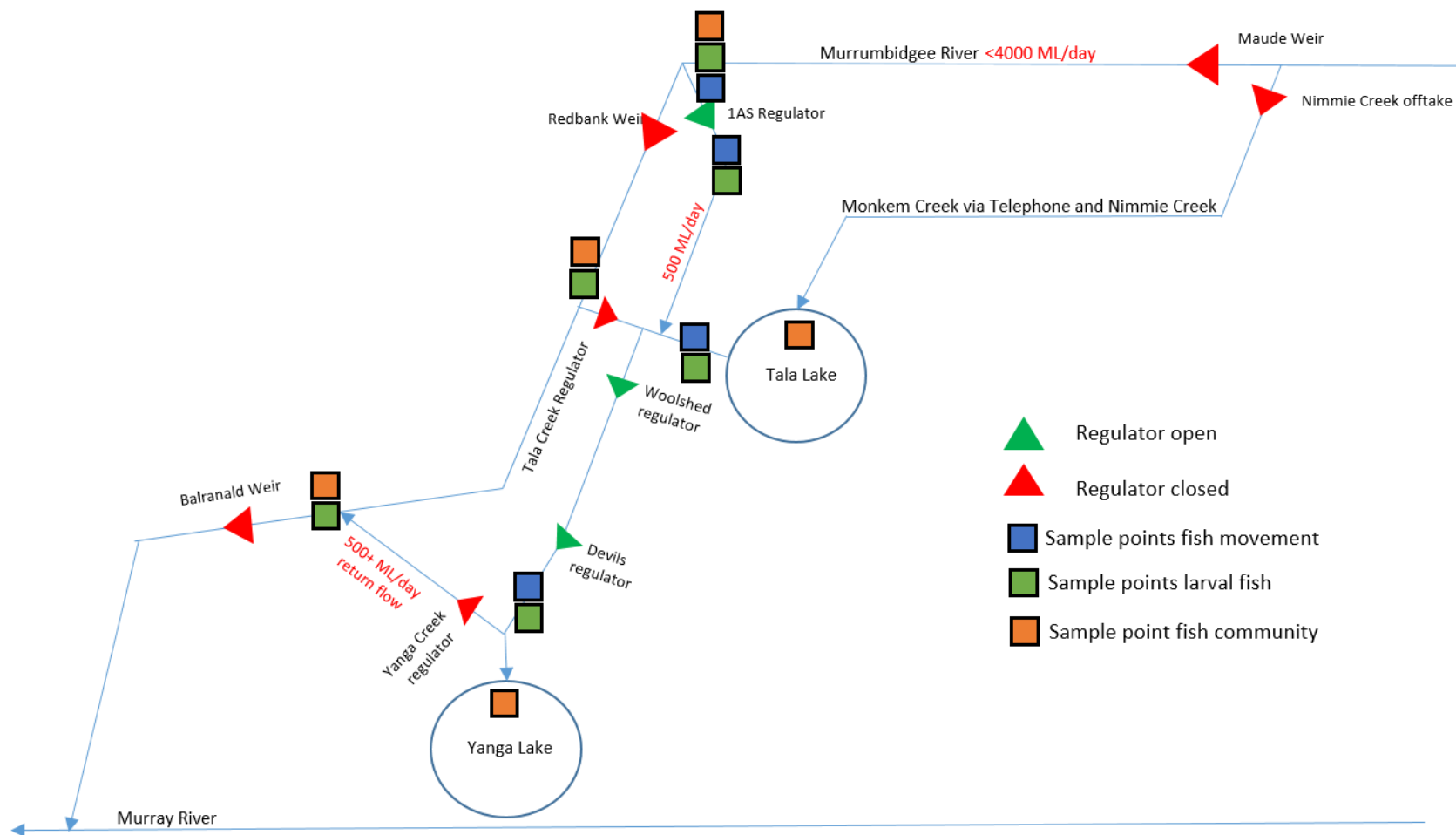


Figure 2 Conceptualisation of proposed regulated floodplain watering to create breeding opportunities and nursery habitat for native fish showing locations for fish community, movement and larval fish sampling.

Links to adaptive management

Understanding how environmental water influences the ecology of fish communities and waterbirds on river-floodplain connections will help inform management actions targeted at promoting spawning and the production of food resources necessary for successful recruitment of fishes and the long-term resilience of off-channel ecosystems.

Comparisons between the main river channel and the floodplain system will provide information on how off-channel environmental flows influence the diet, movement patterns, spawning, growth and recruitment of golden perch and other native and invasive fishes. Since the diet of fish (see figure 1) is reflected in isotope and fatty acid concentrations of their tissues, these data will facilitate adaptive environmental flow management to promote the necessary food resources to support fish reproduction, growth and recruitment in the lakes.

Understanding how the delivery of environmental water can be managed to facilitate native fish production also requires understanding how to minimize invasive species impacts on floodplains. Therefore, this project will also monitor the impacts of invasive fish to develop a better understanding of how environmental flows can be better managed to minimise common carp recruitment on floodplains.

From a management perspective, there are three potential scenarios that our monitoring program aims to address which will influence adaptive management outcomes for environmental flows and native fish.

Scenario 1

If native fish recruitment in the lakes is supported by larvae, juveniles and food resources derived from the main river channel, then environmental water delivery to the system may not require floodplain inundation to maintain populations. In this scenario, relatively small volumes of environmental water and regulatory structures would be used to ensure the free movement of adults, juveniles and larvae from the main river channel into the lakes.

Scenario 2

If native fish recruitment in the lakes is supported by floodplain re-connection and inundation, then the delivery of large over-bank environmental flows across the floodplain may be necessary to trigger adult movements, spawning and the production of food resources necessary to support populations. This scenario would provide strong justification for the delivery of sufficiently large volumes of environmental water to inundate floodplain habitats during spring in order to maintain viable fish populations in the lakes.

Scenario 3

Scenarios 1 and 2 are not mutually exclusive since fish populations in the lake may be sustained by both main river channel and floodplain derived sources of food, adults and recruits. In this case, small environmental flows would be used to consistently ensure the free movement of adults, juveniles and larvae from the main river channel into the lakes and in addition large volumes of environmental water would be delivered in other years to inundate floodplain habitat and promote recruitment.

In all scenarios, environmental water could be coupled with opportunistic high-flow periods in order to maximise fish recruitment outcomes in the lakes. Adaptive management actions should also be targeted at supporting other floodplain-specialist native fishes and their potential re-introduction back into floodplain ecosystems. Native fish populations in all of the aforementioned scenarios may be affected by invasive species and therefore common carp and other non-native fishes will also be examined in response to the river-floodplain connection. The results will be used to inform better management of environmental flows to benefit native fish populations and minimize recruitment of invasive common carp during managed river-floodplain connections.

Methods

Describe fish movement during floodplain–lake reconnection flow

- *What did environmental water contribute to native fish dispersal?*
- *Did environmental water stimulate target species to exhibit movement consistent with spawning behaviour?*

We predict that the flow of water into the lakes will trigger upstream movement out of the lakes and into floodplain creeks by adult fish, particularly golden and silver perch in preparation for spawning; and/or downstream movement of adult fish from the Murrumbidgee River onto the floodplain. The extent and direction of fish movement during environmental watering actions will be evaluated using directional fyke netting consisting of two pairs of large and small nets (1 pair upstream and 1 pair downstream) at four locations. Directional fyke netting can be carried on three occasions overlapping the environmental watering action (4 sites x 3 survey = 12 samples in total) and optimal water temperature for golden perch spawning. Nets will be set over night and cleared regularly to avoid debris build up, all fish collected will be enumerated, measured and weighed. Tissues (non-destructive caudal fin clip and muscle biopsy) from native and invasive fishes will be taken for stable isotope analyses which will provide information on the dominant food sources that

adult fish have been consuming and then using to produce eggs and larvae. The surveys will target golden and silver perch and other native species but common carp are likely to be present. Juvenile native and invasive fish (less than 75mm) will be collected to evaluate age structure. The net set arrangement and data collection matches those employed in the Murrumbidgee LTIM program ensuring that data collected is complementary with the broader program.

Spawning and Larval drift

- *What did environmental water contribute to native fish reproduction?*

Larval drift and tow nets will be deployed before, during and after the environmental watering action at the same four locations as the directional fyke netting (IAS, Tala Creek, Devils Creek and Woolshed Creek). Although the surveys will target golden and silver perch, the survey method is appropriate for a range of species and will provide important information on spawning activities occurring on the floodplain as well as larval drift onto the floodplain from the Murrumbidgee River. As perch are periodic spawners intensive (every 10 days over 60 days (6 sites x 6 surveys)) larval fish sampling is recommended given the short duration of spawning events by this species, as well as the rapid development from eggs (which are semi buoyant and contain an oil droplet) to larvae. Sampling will start prior to the environmental watering actions (if sufficient water is available) or immediately on the start of the environmental watering action.

Survey methods will be modified from those currently employed in the main river channel as part of the Murrumbidgee LTIM program to accommodate lower flow rates through floodplain creeks. Five drift nets per site will be possible assuming a moderate flow velocity with nets ideally set at least 100 m to each other. If a site does not contain suitable water for setting drift nets (too slow, wide, deep, etc.) then a boat will be used for taking larval trawls. Three replicate five-minute trawls at approximately $\frac{1}{2}$ m per second should be allocated to each site. The contents of two nets will be immediately frozen for stable isotope analysis while the other 3 nets will be stored in ethanol for larval fish community analysis.

Stable isotopes and fatty acids

- *What did environmental water contribute to the availability and diversity of food resources supporting fish spawning, growth and recruitment*

The aim of this component is to determine how environmental flows influence the food resources supporting native fishes and their reproduction, growth and recruitment. This component aligns with the Murray-Darling Basin Environmental Water Knowledge and Research (MDB EWKR) program. Age data can also be matched back to the environmental watering actions and to stable isotope and fatty acid data to evaluate the diversity of food resources which are contributing to fish spawning, growth and recruitment in the Lake systems. Stable isotope and fatty acid data will also be used to determine the trophic level of native and invasive fish and whether it is influenced by river-floodplain connections using environmental water.

Tissues from golden perch and other native and invasive fishes collected during surveys will be analysed for stable isotope and fatty acid concentrations. Fish tissues will be collected during directional fyke netting (3 sampling occasions x 20 samples x 3 species = 180), larval sampling (6 sampling occasions x 20 samples x 3 species = 360) and during fish community sampling in Tala and Yanga Lakes and the Murrumbidgee River (3 sampling occasions x 20 samples x 3 species = 180). Biological tissues including a muscle tissue biopsies (20 mg for stable isotope + 100 mg for fatty acid), a caudal fin-clip (15 mg wet weight /30 mm², stable isotope) and whole fish for individuals smaller than 150 mm total length (TL) will be collected during directional fyke netting and larval surveys. Biological tissues will be collected from larval fish, young of year; juveniles and adults. Whole fish (WF) should be euthanized for individuals less than 150 mm TL and in larger fish, a muscle biopsy (MB) and caudal fin-clip (FC) will be collected. All samples will be stored frozen.

Basal food resources including aquatic plants (macrophytes), biofilms (periphyton), suspended particulate matter (seston), terrestrial vascular plants, leaves and grasses will be collected from each site and sampled on three occasions (5 primary producers x 2 samples each x 3 sampling occasions x 6 sites). Periphyton will be brushed from rocks, macrophytes, and logs, pre-filtered through 250-µm mesh to remove large invertebrates, and then filtered onto precombusted Gellman A/E glass fiber filters (Pall Gelman Laboratory, Ann Arbor, Michigan). Seston will be collected from integrated epilimnetic water samples, pre-filtered through 250-µm mesh and then filtered onto pre-combusted Whatman A/E glass fiber filters. A minimum of three samples of each terrestrial and aquatic plant species present at each site will be cut-up (including stems, leaves and seeds) and placed into a zip-lock bag and frozen.

Fish community demographic structure

- *What did environmental water contribute to native larval fish growth?*
- What did environmental water contribute to native fish populations?

The aim of this component is to describe changes in demographic structure following floodplain watering actions in Tala and Yanga Lake and compare these to those of the main river channel (control). Data collected in 2019 will compliment data collected in 2018 by NSW OEH surveys and allow for evaluation of how demographic structure changes over time. Sampling will be undertaken on three occasions throughout the environmental flow delivery period. Sampling methods will align with the Murrumbidgee LTIM fish community protocols and will be carried out in April 2019 (as per the Murrumbidgee LTIM fish community sampling protocol). All fish collected will be enumerated, measured and weighed. Native and invasive fish tissue samples (non-destructive caudal fin clip) will be taken for stable isotope analysis which will provide information on the dominant food sources that adult fish have been consuming in the lake systems.

Size structure data will be complimented daily aging of 50 YOY individuals (less than 75mm in length) from each lake. The target sample size of 50 individuals from each Lake should be achievable and is not likely to have a significant impact of the population given the numbers reported during NSW OEH surveys. Conducting daily ageing on periodic species will enable us to link spawning events of these flow responders to specific stages of the environmental watering action. This information will be particularly useful to inform adaptive management.

Additionally, any potential young-of-year golden perch and other native or invasive species collected during this work will have a fin clip taken to be checked against the Murray-Darling Basin wide FishGEN database to ensure they are not of hatchery origin.

Waterbirds

- What did environmental water contribute to waterbird species diversity?
- What did environmental water contribute to waterbird relative abundance?

The aim of this component is to describe changes in waterbird populations following floodplain watering actions in Tala and Yanga Lakes and investigate links between waterbird abundance and fish communities. Data collected will compliment NSW Office of Environment and Heritage (OEH) annual spring surveys of the Lowbidgee floodplain (from 2008 onwards) with further data collection planned for October 2018. This data will be used to provide information on the relative importance of the lakes for fish-eating waterbirds in particular, with the boat-based surveys of the lakes providing further information on changes in waterbird abundance over time.

Boat-based surveys of waterbirds in Yanga Lake and Tala Lake will be done monthly by NSW OEH staff from September 2018 to April 2019. As the lakes are large, boat-based or aerial surveys are the most effective methods for completing total counts of the lakes (Kingsford 1999; Baldwin et al. 2005). Ground surveys can only provide an estimate for a smaller proportion of each lake. During the surveys the boat will circumnavigate each lake with two observers positioned one either side of the boat. Total counts of all waterbirds will be recorded by each observer using binoculars to aid species identification. The sampling units will be 200 m transects with one observer counting all birds on the water or in flight in a sampling window 100m either side, ahead and above the boat (Agler et al. 1999). The boat surveys will not be done during adverse weather conditions, including high winds or rain, as this will impact the detection of waterbird species.

Ground surveys of waterbirds will also be conducted at the 12 LTIM wetland survey sites spread across the mid-Murrumbidgee, Nimmie-Caira and Redbank zones (four sites per zone) as part of the LTIM program. Methods will follow those employed previously to survey waterbirds in the Murrumbidgee Catchment and are documented in Wassens *et al.* (2014).

Summary of Key activities

Activity	Location	Frequency	Key data collection	Associated data collection
Fish movement Directional fyke netting	1AS Tala Creek Devils Creek, River Channel at Redbank (Murrumbidgee River control x 3)	3 x surveys, beginning, middle and end of the spawning season (Sept-Dec)	Directional movement of native and invasive fish Size structure of moving individuals Condition and origin of individuals	Tissue sample for stable isotopes/fatty acids. Juvenile otoliths for aging
Fish spawning and larval drift and food resources		6 x Sept.-Dec. surveys	Abundance of native and invasive fish larvae Larval origin (floodplain/river) Larval food sources	Collection of individuals for otolith aging, stable isotopes/fatty acids
Fish community lake and river	Tala Lake, Yanga Lake, River Channel (control 3x)	3 x September- March-April 2019	Population demographics (size and age structure) Collect individuals for and daily aging	Tissue sample for stable isotopes/fatty acids. Juvenile otolith collection for aging
Waterbird community	Yanga Lake, Tala Lake	Monthly Sep 2018- Apr 2019	Abundance of each species (including total fish-eating waterbirds), total species richness	Complementary OEH spring surveys (multiple sites) and LTIM quarterly surveys (12 sites)

Note that survey days may be altered depending on the timing of flow delivery and local weather conditions

Budget

Omitted

Project timeline

[illegible]

F-Final Report ; DF-Draft Final report ; QR Quarterly Report ;. Note that survey days may be altered depending on the timing of flow delivery and local weather conditions.

Milestones

Milestone	Date	Total	GST	Total + GST
Quarterly report (Oct-Dec.)	31/12/2018			
Quarterly report (Jan-March)	31/03/2019			
Draft Final Report	31/08/2019			
Final Report	31/10/2019			

Links to complimentary projects

The proposed Commonwealth and NSW environmental flow will have multiple benefits for floodplain communities, with positive outcomes expected for frogs, turtles and aquatic vegetation. This proposed project will be managed independently of Long-term Intervention Monitoring (LTIM) in the Murrumbidgee but will complement the data collected at three wetland sites expected to be inundated by the proposed flow (Mercedes, Two Bridges and Piggery Lake). Data from these additional LTIM sites will be utilised to evaluate of the added ecological value derived from undertaking a larger volume top- to- bottom watering action.

The stable isotope methods applied here will be aligned with a basin-scale fish community trophic indicator project being led by R. Keller Kopf (CSU), funded by the Commonwealth Environmental Water and Knowledge Research project (EWKR-La Trobe), in collaboration with Long-term Intervention Monitoring (LTIM) of environmental water and New South Wales Fisheries DPI, Arthur Rylah Institute and the South Australian Research and Development Institute. The waterbird monitoring component is provided in-kind from NSW OEH and is complimented by UNSW annual aerial surveys of eastern Australian.

Reporting and communication

Progress will be reported within the Murrumbidgee LTIM quarterly reporting structure and timing (see project timeline). However, given the different timing, location and extent of data collected and monitoring proposed here, we propose to submit the draft and final reports separate to the Murrumbidgee LTIM project. The proposed project will compliment and cross-reference Murrumbidgee LTIM reporting and be administered a contract variation of the LTIM project. A draft final report for comment will be submitted and include the majority of data collected but will exclude fish recruit growth and stable isotope analyses that will be available for the final report. The final report will incorporate all comments and report on all data collected. At least one peer-reviewed publication is proposed to be written following the completion of this project and notable outcomes of interest to the public may be shared on social media and other online outlets, such as The Conversation.

This monitoring will depend on appropriate Animal Ethics and Exemptions approvals, in addition to scientific collection and national park's permits. If the environmental flow does not occur or permits are not approved then the CEWO will not incur the monitoring costs. Also, where samples or trips are unable to be conducted within the project, the CEWO will be notified in the progress, draft or final report and costs will not be incurred.

Personal and responsibilities

Personnel	Organisation	Role and responsibilities	Area of expertise
Dr R. Keller Kopf	Charles Sturt University	Project lead. Fish spawning, larval growth and development. Leader of trophic indicator project (EWKR-La Trobe)	Fish ecology, conservation and foodwebs
A Prof Skye Wassens	Charles Sturt University	Leader of the Murrumbidgee LTIM program, adaptive management and reporting	Floodplain ecology
Luke McPhan	Charles Sturt University	Field leader, fish movement and larval and growth, data management and reporting	Aquatic foodwebs, larval fish
Dr James Dyer	NSW OEH	Environmental water management	Fish ecology and water manager
James Maguire	NSW OEH	Environmental water management	Senior water manager Murrumbidgee
Dr Jennifer Spencer	NSW OEH	Waterbirds	Waterbird ecology and conservation
Dr Carmen Amos	NSW OEH	Waterbirds	Ecological monitoring- Waterbirds

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