Fish movement in response to environmental watering of Potterwalkagee Creek, Vic.

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Final report prepared for the Mallee CMA by The Murray–Darling Freshwater Research Centre.

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Cover Image: Stoney Creek, which feeds Potterwalkagee Creek from the Murray River.

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1 Introduction

Off-channel floodplain habitats are amongst the most productive of environments, providing essential breeding and foraging habitat for a variety of organisms. In particular, floodplains are important for many fish populations because of the increased habitat diversity, offering heightened survival, feeding and reproduction opportunities (Jones & Stuart 2008; Junk *et al.* 1989; King *et al.* 2003; King *et al.* 2009).

Many floodplain rehabilitation programs, which involve the operation of regulators to restore wetting and drying cycles, are undertaken to improve habitat quality. Managed hydrological regimes (filling and/or draining) of floodplain habitats can elicit a range of lateral movement responses by fish (both passive and active), providing opportunities for native (and pest) fish dispersal into important habitats required for recruitment (Ellis & Pyke 2011; Nichols & Gilligan 2003). Through better understanding of fish movement responses to managed interventions, future events can be timed and operated to enhance the dispersal and recruitment of native fish, and potentially contribute to the control of non-native species (Ellis *et al.* 2014). For example, timing environmental watering events to coincide with main river channel spawning events provides an important opportunity for the transfer of juvenile native fish into productive off-channel floodplain habitats (Ellis *et al.* 2014).

Mulcra Island is part of the Chowilla Floodplain and Lindsay–Wallpolla Islands Living Murray icon site. Mulcra Island operations (MCMA 2012) were first conducted between August and October 2013 to inundate the icon site floodplain and increase flows down Potterwalkagee Creek. The present project examined the lateral movements of large-bodied fish species in response to a second environmental watering of Mulcra Island via Potterwalkagee Creek in September 2014. We also assessed movement of drifting stages of fish (i.e. eggs and larvae) into the Mulcra Island system during the watering event, with a particular focus on the key large-bodied species Golden perch, Silver perch, Murray cod and Common carp. The project will improve our ability to achieve substantial ecological benefits for native fish in future hydraulic management of Mulcra Island.

The study aims are:

I. To determine if lateral movement of large-bodied fish occurs between the Murray River and Potterwalkagee Creek during filling and drawdown hydraulic phases.

II. To determine whether environmental regulator operation facilitates the transport of drifting larval and juvenile stages of native and non-native fish into Potterwalkagee Creek via the Upper Potterwalkagee Creek and Stoney Crossing inlets during filling and drawdown hydraulic phases.

2 Site information

Mulcra Island is bordered to its north by the Murray River and to the south by the Potterwalkagee Creek anabranch. Lock 8 is situated on the Murray River at the east–west midpoint of the island (Figure 1). The position of Lock 8 allows for raising or lowering of the Lock 8 weir pool to augment flows through the Potterwalkagee Creek system. Engineering works recently completed at Mulcra Island as part of The Living Murray are designed to be used in conjunction with Lock 8 to restore a more natural hydrological regime (MCMA 2012). The system of works consist of a large earthen embankment and regulator on Lower Potterwalkagee Creek effluence (Lower PCR), a pipe and spillway to transfer water to Mulcra Horseshoe Billabong, regulators on the inlet of Upper Potterwalkagee Creek and at Stoney Crossing and a series of containment regulators and embankments (Henderson *et al.* 2014).

This survey was conducted during a floodplain inundation operation, which involves the raising of the Lock 8 weir pool to increase flow through the regulators at Upper Potterwalkagee Creek and

Stoney Crossing. Lower PCR is raised with stop-logs to push water back up onto the adjacent floodplain and wetland habitat. A subsequent drawdown of Potterwalkagee Creek through Lower PCR occurs towards the end of the operation. It is noted that the raising of Lock 8 during a floodplain inundation operation may reduce the effectiveness of the Lock 8 fishway. Given that upstream fish passage though Lower PCR during floodplain inundation operations is prevented as the Lower PCR is closed; this has implications for upstream fish movements between the Lock 7 weir pool and the Lock 8 weir pool (MCMA 2012).

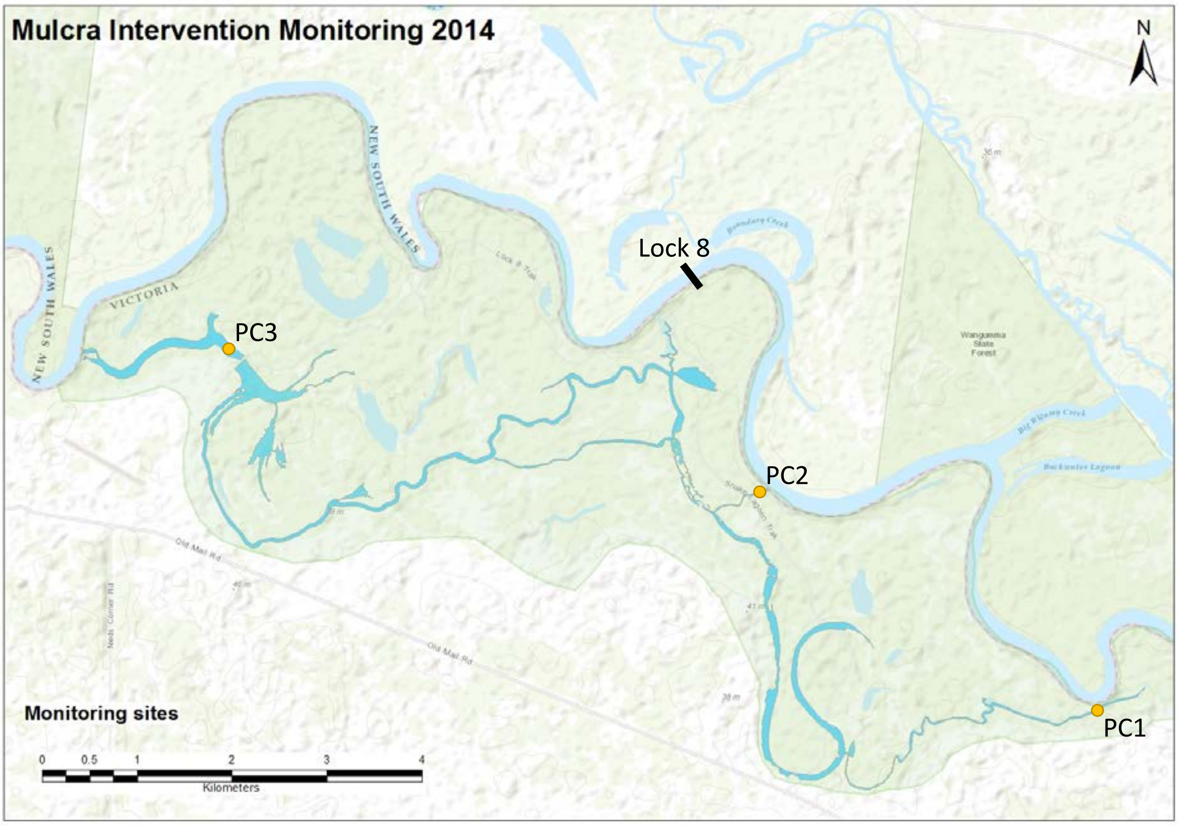

Figure 1. Map of Mulcra Island and Potterwalkagee Creek with approximate location of directional netting sites indicated by yellow circles.

3 Methods

To examine the lateral movement of large-bodied fish between the Murray River and Potterwalkagee Creek monitoring sites were established at two upstream effluent points and the downstream confluence point with the Murray River. These sites were PC1 (Upper Potterwalkagee Creek), PC2 (Stoney Crossing) and PC3 (immediately below the Lower PCR) (Figure 1). Fish were sampled using directional dual-wing large-mesh fyke nets and larval drift nets set overnight. Although not a project requirement, small-mesh fyke nets were also deployed on each sampling event to identify the presence and general directional movements of small-bodied species (and juveniles of larger species) present in Potterwalkagee Creek.

Directional fyke nets (DWFN) have dual wings (each 8 m x 1.5 m) attached to the first supporting hoop (∅ = 0.55 m) with a 32-cm stretched entry. These were set to block the entire creek channel. Each DWFN has a stretched mesh size of 28 mm.

Larval drift nets (DN) were deployed at PC1 and PC2 (one at each location) overnight during each survey event to identify immigration to Potterwalkagee Creek by drifting larval fish. One larval drift net was deployed overnight during each survey event at PC3 to identify emigration of larval fish spawned within the system. Drift nets are 1-m long conical nets with a circular opening (Ø = 0.5 m) and a mesh size of 0.52 mm. Mean flow rates (m/s) through each drift net were derived by averaging flow rates immediately upstream of the net at deployment and retrieval (measured with a *HACH FH 950* handheld meter). Drift samples were preserved and processed (larval identification) at the laboratory.

Small fyke nets (SFN) have dual wings (each 2.5 m x 1.2 m), with a first supporting hoop (∅ = 0.4 m) fitted with a square entry (0.15 m x 0.15 m) covered by a plastic grid with rigid square openings (0.05 m x 0.05 m). Each SFN had a stretched mesh size of 2 mm.

3.1 Sampling design and effort

3.1.1 Spatial structure

The spatial structure of the sampling design was as follows:

- Three sites were established within Potterwalkagee Creek: PC1 (Upper Potterwalkagee Creek inlet); PC2 (Stoney Crossing inlet); and PC3 (immediately below the Lower PCR) (Figure 1).
- Each site was sampled with two DWFNs and two SFNs; one of each net type was set facing in each direction (upstream or downstream) to capture fish moving both into and out of Potterwalkagee Creek.
- A larval drift net was deployed at each site (where flow was sufficient to suspend the net) to sample drifting larval fish/eggs.

3.1.2 Temporal structure

The temporal structure of the sampling design was as follows:

- Each site was originally intended to be sampled weekly for four weeks during filling of the system, once during a cease-to-flow (stable) period, and weekly for three weeks during a drawdown event (see Proposed hydrology; Figure 2).
- In response to altered timing in the management schedule (primarily an extended filling period), seven weekly sampling trips were conducted during the filling phase from September to mid-October, with the final (eighth) trip conducted during drawdown on the 20 November 2014 (see Actual hydrology; Figure 2).
- Nets were set in the afternoon and retrieved the following morning.
- Set and retrieve times and instantaneous flow rates at the mouth of drift nets at the time of setting and retrieval were recorded.

3.1.3 Sample processing

Samples were processed as follows:

- Upon retrieval, the fish caught in each DWFN and SFN were identified to species and enumerated, with the length (standard and total) and weight of the first 20 fish of each species recorded.
- Drift samples were preserved in 70% ethanol and were later processed with larval identification and enumeration at the laboratory.

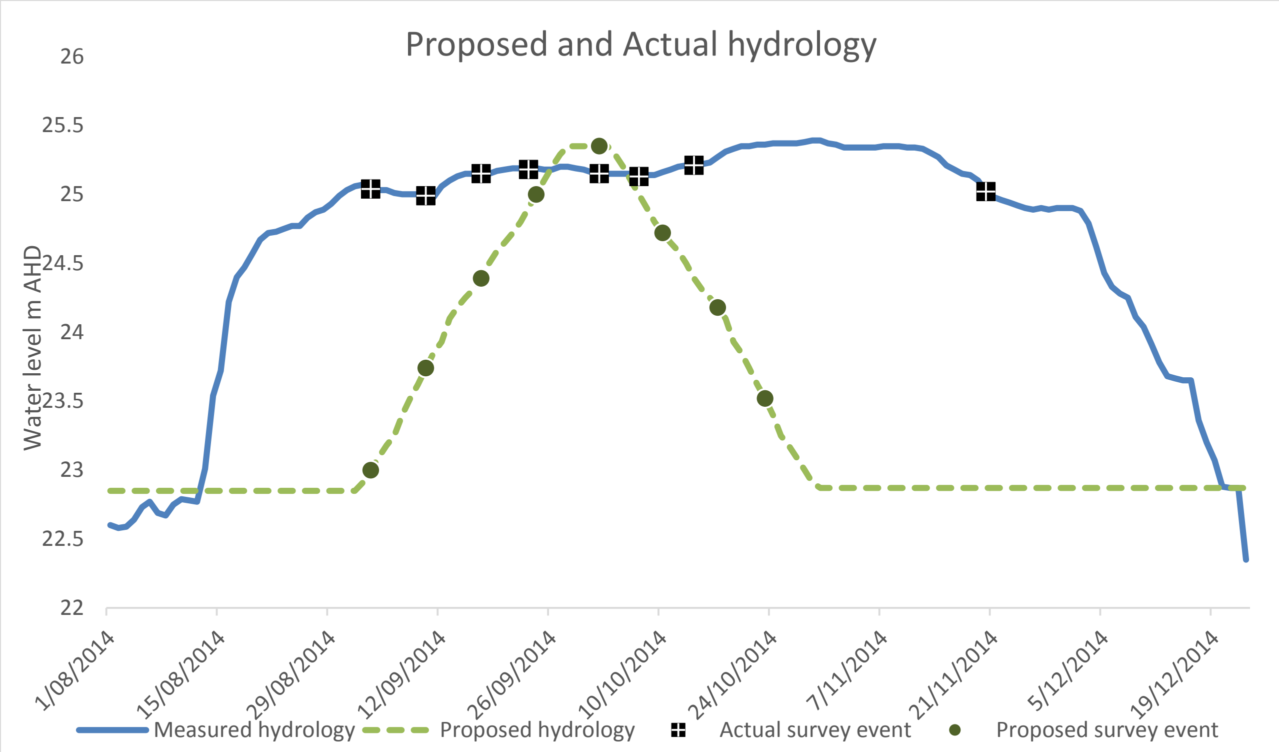

Figure 2. Proposed and actual hydrology and sampling schedules. Measured hydrology displayed as water level (m AHD) at Lower Potterwalkagee Creek regulator (unpublished data: Andrew Keogh, MDBA). Proposed hydrology displayed as modelled water level at Lower PCR.

4 Results

4.1 Murray River flows

Actual flow data for the relevant river section is not currently available. However, Figure 3 shows the water level at Lock 9, as a surrogate for demonstrating the hydrological conditions in the Lock 8 weir pool section of the river.

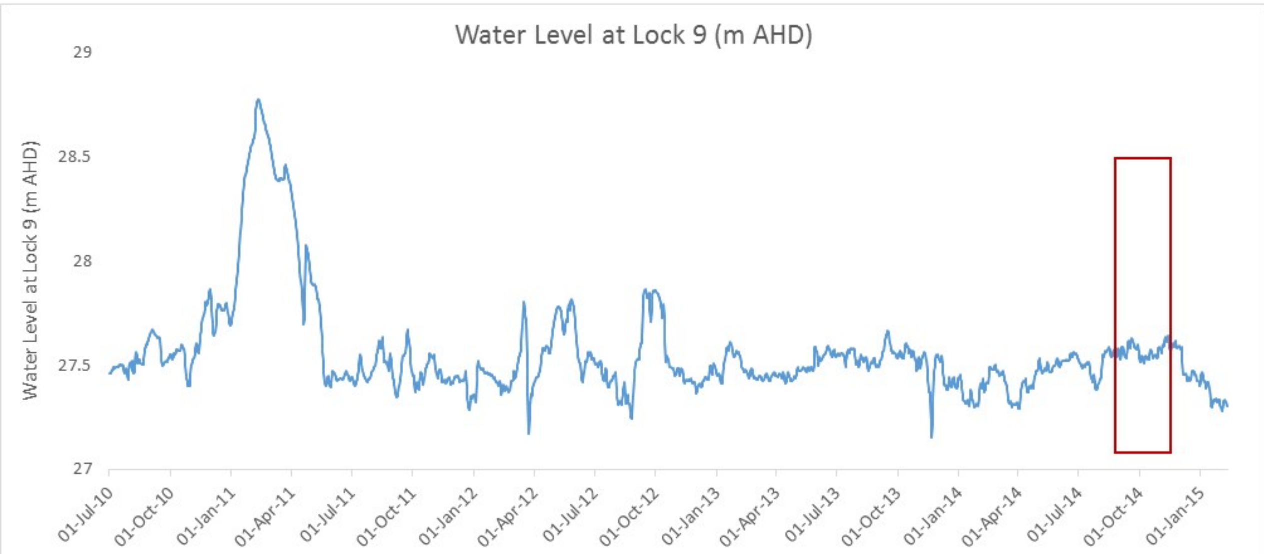

Figure 3. Water level at Lock 9 in the lower Murray River adjacent to Mulcra Island. This provides an indication of river hydrology in the Lock 8 weir pool. The survey period 3 September to 20 November 2014 is highlighted by a red rectangle.

4.2 Larval fish and eggs

4.2.1 Filling

During the seven-week filling phase, 429 larval fish from two native species (n = 425) and two non-native species (n = 4) were recorded at PC1, PC2 and PC3 in Potterwalkagee Creek. A further 130 unidentified fish eggs were also detected exiting Potterwalkagee Creek in drift material during the filling phase at PC3 (Table 1). Australian smelt and Carp gudgeon were the most abundant larval species detected drifting into Potterwalkagee Creek throughout the filling period (Table 1). Larvae of two non-native species, Common carp and Eastern mosquitofish, were detected in low numbers.

4.2.2 Drawdown

During the one-week drawdown phase, larvae from three native species (n = 1248) and two non-native species (n = 98): all were sampled exiting Potterwalkagee Creek at PC3 with the exception of six fish detected entering PC2 (Table 2).

Flathead gudgeon (n = 1218) and Common carp (n = 93) were the most abundant larval species detected exiting Potterwalkagee Creek during the drawdown phase (Table 2). Most Flathead gudgeon were estimated to be 10–20-day-old flexion larvae or meta-larva (Serafini & Humphries 2004). This estimation was based on studies of sympatric gudgeon species (McCasker *et al.* 2014).

Table 1. Larval fish and eggs transported downstream in Potterwalkagee Creek during filling. Values are total numbers sampled within drift nets at PC1, PC2 and PC3 over seven weekly sampling events.

Species	In	Out
PC1		
Native		
Small-bodied		
Australian smelt	76	n/a
Carp gudgeon	23	n/a
PC2		
Native		
Small-bodied		
Australian smelt	265	n/a
Carp gudgeon	29	n/a
Non-native		
Small-bodied		
Eastern mosquitofish	1	n/a
PC3		
Native		
Small-bodied		
Australian smelt	n/a	25
Carp gudgeon	n/a	7
Non-native		
Large-bodied		
Common carp	n/a	3
Fish Eggs		
Fish Eggs	n/a	130

Table 2. Larval fish and eggs transported downstream in Potterwalkagee Creek during drawdown. Values are total numbers sampled within drift nets at PC1, PC2 and PC3 during drawdown (one week event).

Species	In	Out
PC1		
No Fish	0	n/a
PC2		
Native		
Large-bodied		
Bony herring	1	n/a
Small-bodied		
Flathead gudgeon	5	n/a
PC3		
Native		
Large-bodied		
Bony herring	n/a	1
Small-bodied		
Carp gudgeon	n/a	23
Flathead gudgeon	n/a	1218
Non-native		
Large-bodied		
Common carp	n/a	93
Goldfish	n/a	5

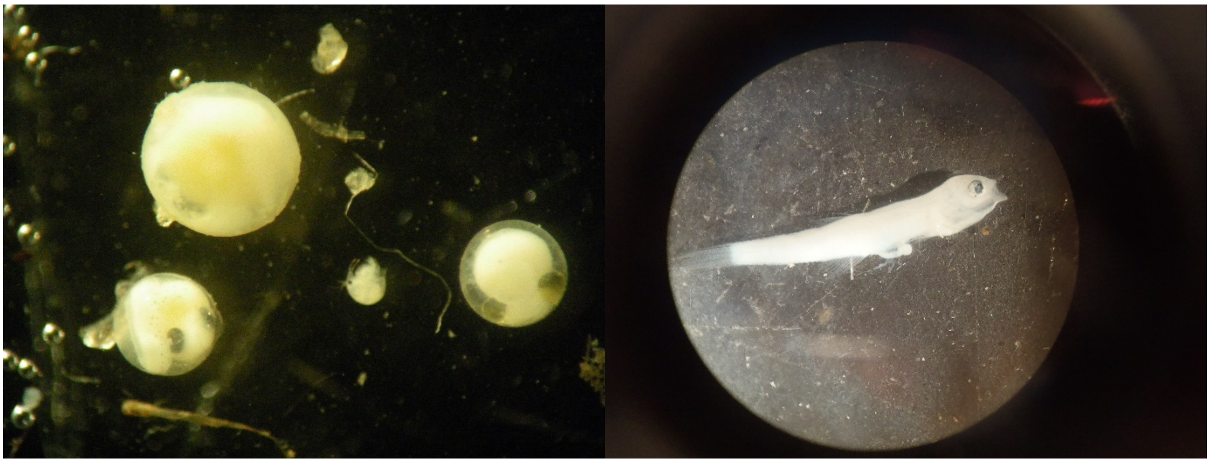

Figure 4. Two different size classes of eggs detected exiting PC3 during filling (left) and an example of a larval stage of fish (Carp gudgeon) detected throughout the survey period (right).

4.3 Adult and juvenile fish

4.3.1 Filling

A total of 5370 native fish (from eight species) and 2606 non-native fish (from four species) were sampled in fyke nets during the seven weekly trips conducted during the filling event (Table 4).During the filling period, Bony herring were the most abundant large-bodied species detected in directional DWFN. These exhibited bidirectional movement at each site. Golden perch were detected moving predominantly upstream, exiting the system during filling, most often at PC1 (Table 3). A single Murray cod was captured moving upstream (exiting the system) during the filling period.

In week six and seven of the filling period a juvenile cohort of Common carp (10–25 mm) was detected in SFN moving downstream at PC3 (exiting Potterwalkagee Creek) (Figure 5, Table 3). This is consistent with the same juvenile cohort detected in drift nets (Table 3) exhibiting the same response during drawdown.

Australian smelt and Carp gudgeon were the most abundant small-bodied species captured throughout the seven week filling period; each exhibiting bidirectional movement throughout the survey period (Table 3). Low numbers of other small-bodied species were detected with no discernible directional movement patterns.

4.3.2 Drawdown

During the single drawdown event 655 native fish (from six species) and 185 non-native fish (from two species) were sampled in fyke nets. (Table 4). Bony herring and Golden perch demonstrated similar movement patterns to that identified during filling (i.e. bidirectional movement by Bony herring, and predominantly upstream movement out of the system by Golden perch) (Table 4). During drawdown Carp gudgeon were the most abundant, exhibiting bidirectional movement with a preference for exiting the Potterwalkagee Creek system (Table 4).

Although not represented in the data, turtles were detected throughout the survey period and included representatives from all three species known to occur throughout the Murray–Darling Basin, as were numerous freshwater shrimp and yabbies.

Figure 5**.** Juvenile Common carp detected exiting Potterwalkagee Creek at site PC3 (left) and an example of a Golden perch detected exiting PC1 (right).

Table 3. Large- and small-bodied fish sampled in Potterwalkagee Creek during the seven weekly sampling events conducted during filling.

Species	Downstream DWFN	Downstream SFN	Upstream DWFN	Upstream SFN
PC1				
Native				
Large-bodied				
Bony herring	22		18	
Golden perch			8	
Small-bodied				
Australian smelt		55		33
Carp gudgeon		372		309
Dwarf flathead gudgeon		1		
Un-specked hardyhead		2		
Non-native				
Large-bodied				
Common carp			4	
Goldfish			13	
Small-bodied				
Eastern mosquitofish				1
PC2				
Native				
Large-bodied				
Bony herring	26	1	29	
Golden perch		2		
Murray cod			1	
Small-bodied				
Australian smelt		339		240
Carp gudgeon		269		180
Dwarf flathead gudgeon		1		7
Un-specked hardyhead		2		
Non-native				
Large-bodied				
Common carp	6	1	1	
Goldfish	1			
Small-bodied				
Eastern mosquitofish		1		1
PC3				
Native				
Large-bodied				
Bony herring	41	2	73	
Golden perch			1	
Small-bodied				
Australian smelt		100		135
Carp gudgeon		245		67
Flathead gudgeon		3		2
Non-native				
Large-bodied				
Common carp	2	2700	4	47
Goldfish	1			
Oriental weatherloach		1		

Table 4. Large- and small-bodied fish sampled in Potterwalkagee Creek during the single drawdown sampling event.

Species	Downstream		Upstream	
	DWFN	SFN	DWFN	SFN
PC1				
Native				
Large-bodied				
Bony herring	28		1	
Golden perch			16	
Small-bodied				
Carp gudgeon		221		49
Non-native				
Large-bodied				
Common carp			15	
Small-bodied				
Eastern mosquitofish				1
PC2				
Native				
Large-bodied				
Bony herring	5		4	
Small-bodied				
Australian smelt		30		
Carp gudgeon		80		80
Dwarf flathead gudgeon		40		15
Non-native				
Large-bodied				
Common carp		20		
PC3				
Native				
Large-bodied				
Bony herring	18		20	6
Golden perch			1	
Small-bodied				
Carp gudgeon		30		9
Flathead gudgeon		2		
Non-native				
Large-bodied				
Common carp		30	1	119

5 Discussion

5.1 Larval fish and eggs

During the filling period for this project no significant increases in water level at Lock 9 (and thus no flow pulses) were experienced in the adjacent Murray River (see Figure 3). Golden perch and Silver perch are considered flow-dependent specialists based on their tendency to spawn in response to elevated flows (during spring/summer) (Baumgartner *et al.* 2014; Humphries *et al.* 1999; Sharpe 2011). An absence of larvae from these species in drift sampling in the upper Potterwalkagee Creek (sites PC1 and PC2) is likely to reflect an absence of concurrent in-channel spawning by Golden perch and Silver perch. In contrast, Murray cod are thought to spawn annually in spring regardless of flow conditions (Baumgartner *et al.* 2014; Humphries *et al.* 1999) however, no Murray cod larvae were detected during sampling. This suggests that sampling during the filling event may have occurred prior to Murray cod larval drift.

We recommend that the transfer of larvae/juveniles of key native large-bodied species into floodplain wetlands may best be facilitated by timing environmental watering events to occur during elevated river flow levels in spring and summer (breeding season) or when Murray cod larvae are likely to be drifting (November) (Ellis *et al.* 2009). Larval drift monitoring conducted in the adjacent Murray River channel to identify in-stream spawning could serve to trigger managed wetland filling events.

Although no key large-bodied species were detected, the larvae of several native small-bodied species, including Australian smelt, Carp gudgeon and Flathead gudgeon, were detected drifting into and out of the system. Australian smelt and Carp gudgeon were most abundant at the two effluents of Potterwalkagee Creek (PC1 and PC2) during the filling phase, and hence were likely to have been spawned in the main river channel and passively entered Potterwalkagee Creek, given the proximity of the sampling sites to the Murray River water source. Flathead gudgeon and Common carp larvae were most abundant during drawdown at PC3. Flathead gudgeon were estimated to be 10–20-day-old flexion larvae or meta-larva (Serafini & Humphries 2004). Consequently, we suggest that these larvae were spawned within the Mulcra Island and Potterwalkagee Creek floodplain system during the spring watering event, and transferred back to the main river channel during the drawdown phase. Common carp were also sampled as juveniles in SFNs and are discussed further below.

Fish eggs were not detected entering the Potterwalkagee Creek system. However, they were detected exiting at the downstream site (PC3), suggesting they were spawned within the Mulcra Island floodplain system. Although eggs are difficult to identify, the majority of fish eggs (n = 114) detected in drift samples exiting the Mulcra Island floodplain at PC3 are considered to be native Australian smelt or Bony herring due to their size (Puckridge & Walker 1990) with several larger eggs (n = 16) considered to be non-native Common carp or Goldfish (see Figure 4).

5.2 Adult and juvenile fish

5.2.1 Native species

Lateral movement of large-bodied fish between the Murray River and Potterwalkagee Creek was identified during both the filling and drawdown periods of this watering event at Mulcra Island. Bony herring were the most abundant large-bodied species detected. They exhibited bidirectional movement, which may represent haphazard bidirectional movements of fish searching for food or refuge habitat (Conallin *et al.* 2010). Bony herring are considered one of the most widespread Australian native fish species and form the diet of key native fish species such as Murray cod and Golden perch (Lintermans 2007) and piscivorous birds (Winfield 1990).

Twenty-six of the twenty-eight Golden perch captured were adult fish moving upstream at PC1 and PC2. As the Lower PCR remained closed to upstream movement and hence acted as a barrier to fish passage during this floodplain inundation event, the Golden perch detected here exiting at the upstream sites were most likely to have originated from within Potterwalkagee Creek prior to commencement of the filling event.

This is consistent with other directional netting surveys by MDFRC at additional regulated wetlands in the Mallee (e.g. Margooya Lagoon, Butlers Creek), in which managed inflows to floodplain habitats were found to cue upstream movement by Golden perch (and Silver perch), whereby they exit wetlands and return to the riverine habitat(Ellis *et al.* 2014; Ellis & Pyke 2011). Elevated river flows are reported to be associated with upstream movement and spawning by adults of several large-bodied native fish including Golden perch and Silver perch (King *et al.* 2009; Mallen-Cooper & Stuart 2003). These results also suggest that managed attractant flows may provide suitable cues to encourage certain key native fish to move out of wetlands to avoid stranding prior to a drying event (Nichols & Gilligan 2003).

5.2.2 Non-native species

A recently spawned juvenile cohort of Common carp (10–25 mm) was detected exiting Potterwalkagee Creek at the Lower PCR during the last two weeks of filling (7 October to 14 October). This juvenile cohort was also detected exiting via PC3 during the single drawdown survey event. Whilst the Lower PCR acted as barrier to upstream movement, it still allowed for fish to pass downstream over the stop-logs, and out of the system. It should be noted that some fish may have been trapped between the regulator and the nets as they were set each time, which may have slightly influenced the catch sampled 'moving out'. The juvenile cohort is estimated to be between 20–30 days old, which suggests that the timing of the managed filling event coincided with the spawning season of Common carp within the Potterwalkagee Creek system. Consideration of strategies to minimise return of these fish to the Murray River channel is recommended (Smith 2005).

5.2.3 By-catch

Approximately 70% of shrimp detected during this survey were captured exiting Potterwalkagee Creek to the Murray River during the filling period. This highlights the secondary production potential of floodplain habitats, in terms of the potential prey for large-bodied native fish and waterbirds that can be returned to main river channel habitats during managed watering events.

6 Recommendations

The timing of the managed inundation of Potterwalkagee Creek was not favourable for meeting native fish or invasive fish species objectives. The operation was too early to entrain drifting Murray cod larvae and did not match flow peaks in the Murray River that may have contained Golden or Silver perch eggs or larvae. The timing also matched the preferred spawning season of Common carp and created a substantial area of high-value Common carp spawning and rearing habitat.

Whilst we recognise that there are limitations around the timing and availability of environmental water, future filling events could be timed to coincide with flow increases in the main channel or could be timed to match the predictable Murray cod larval drift in November. This would increase the potential for eggs and/or larvae of key native species to be transferred into Potterwalkagee Creek, thus contributing to the greater recruitment of native fishes.

Watering events in spring and summer, such as the one studied here, risk promoting Common carp spawning events. When the intention is to water for floodplain vegetation and/or waterbirds, we recommend trialling watering events earlier in the year to avoid the potential for promotion of Common carp spawning.

It is noted that the raising of Lock 8 during a floodplain inundation operation may reduce the effectiveness of the Lock 8 fishway (MCMA 2012). Given that upstream fish passage through Lower PCR during floodplain inundation operations is prevented, this has implications for upstream fish movements between the Lock 7 weir pool and the Lock 8 weir pool (MCMA 2012).

A modification to the Lock 8 fishway was fitted prior to this watering event, which raises the height of the fishway walls with a metal ‘barrier’ (see Figure 6). This modification has the potential to alter the hydraulics within the fishway itself and may restrict fish passage (MCMA 2012).

Future studies at Mulcra Island should assess the impact of this modification on the effectiveness of the fishway during weir pool manipulations. Future studies should also assess movement of fish through Potterwalkagee Creek during flows where Lower PCR is open. This information would inform decisions regarding watering events for Mulcra Island with regard to maintaining fish passage during peak fish migration periods.

Figure 6. Fishway ‘barrier’ (indicated by yellow arrows) at Lock 8, which runs the perimeter of the fishway structure and extends into the rock levee bank at the far left (photo: Karl Pomorin).

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