An assessment of fish spawning and early life-history in the Lindsay Island anabranch system 2018

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Front cover photo: Clockwise from top left: Lindsday River, larval Murray cod, Mullaroo Creek and a mixture of small-bodied native fish sampled with a light trap (S. Raymond).

An assessment of fish spawning and early life-history in the Lindsay Island anabranch system 2018

Scott Raymond, Graeme Hackett and Zeb Tonkin

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Department of Environment, Land, Water and Planning

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Contents

Tables

Figures

Summary

Despite major historical alterations to the flow regime in the lower Murray River, the Lindsay Island anabranch system maintains a native fish community of high conservation significance. Of particular note, is the importance of the anabranch system in providing critical habitat such as feeding areas and spawning, for native fish due to its unique hydrological regimes and high density and complexity of instream habitat. In recent years, the system has been subject to the construction of a regulating structure on the upper Mullaroo Creek and subsequent alteration to flows in the anabranch; as well as two major blackwater events which resulted in the death or emigration of a large proportion of Murray cod. As a result, waterway managers were interested in assessing whether the Lindsay Island anabranch system still provided an important spawning area for native fish, particularly large-bodied species such as Murray cod, *Maccullochella peelii*. This study provides an assessment of the early life-stages of large- and small-bodied fish species within three reaches of the Lindsay Island anabranch system during spring 2018. The results are used to explore how spawning may be influenced by habitat types and hydraulic attributes (including environmental flows) through these anabranches.

Early life-stages (eggs, larvae and juveniles) of fish were captured from three reaches of the Lindsay Island anabranch system, each relatively unique in terms of hydraulic diversity. The presence of, and temporal transition in, early life-stages is used to highlight potential preferences by early life-stages of several fish species for distinct reaches. Species-specific life-history strategies are discussed in relation to regions of hydraulic diversity and management.

Sampling was conducted from mid-October – late November 2018 in the Mullaroo Creek, lower Lindsay River and upper Lindsay River. This is the core reproductive period for species of conservation and recreational significance (Murray cod, golden perch, silver perch and freshwater catfish) and therefore a priority for waterway managers. A total of 10 702 fish or eggs were recorded, representing seven native and two alien fish species. Murray cod and freshwater catfish larvae were only detected in the the Mullaroo Creek, the reach which exhibited the greatest hydraulic diversity. No golden or silver perch eggs or larvae were collected during the study. Carp gudgeon and Australian smelt dominated the fish count and were predominantly sampled from the slow flowing and comparatively (to the Mullaroo Creek) uniform hydraulics of the upper Lindsay River.

These findings highlight the importance of a hydraulically diverse anabranch system that meets the requirements of all fish species. While Murray cod continue to spawn in the Mullaroo Creek, numbers were low and recovery from recent hypoxic blackwater impacts is slow and remain cause for concern. Further, the loss of hydraulic diversity throughout the Murray-Darling Basin may negatively impact available spawning habitats for species of conservation concern.

To facilitate the recovery and maintenance of Murray cod and other native fish species within the Lindsay Island anabranch system we provide the following recommendations;

- Determine suitable baseflows and spring rises through the Mullaroo Creek to support spawning of target fish species and functional populations. Discharge rates will continue to be refined with improved knowledge and understanding associated with ongoing monitoring.
- Monitor the recovery of Murray cod over a 10-year period.

1 Introduction

Global regulation of rivers has resulted in increasing threats to freshwater biota through habitat degradation, barriers to movement and altered flow regimes (Dudgeon et al. 2006; Vorosmarty et al. 2010). The installation of weirs and locks across the Lower Murray River, Australia, has created a series of deep, slow-flowing ‘weir-pools’ with a relatively constant water level and uniform hydraulic conditions in the main channel (Vilizzi et al. 2007; Mallen-Cooper and Zampatti 2018). This regulation has potential impacts (positive or negative) for fish, vegetation and birds. Understanding the relationship between fish and hydraulics provides waterway managers with tools to facilitate positive ecological outcomes for fish.

Australian freshwater systems are amongst the most temporally variable in the world (Maheshwari 1995) and contain fish species well adapted to these conditions (Harris and Gehrke 1994). The large variability in hydraulic conditions has facilitated a broad array of reproductive strategies amongst native fish that exhibit a range of spawning behaviours, timing and habitat preferences. As such, maintaining this hydrologically diverse riverine environment appears to be critical.

The Murray-Darling Basin Authority (MDBA), Victorian, New South Wales and South Australian state governments and the Mallee Catchment Management Authority (MCMA) collaborate in the management of water through the Lindsay Island anabranch system, a system that maintains a native fish community of high conservation significance. The anabranch system, unlike much of the surrounding Murray River, provides critical habitat for native fish due to its unique hydrological regime and high density and complexity of instream habitat. As such it is the focus of a long-term monitoring program on the movement patterns of adult large-bodied fish (Saddlier and O’Mahony 2009; Tonkin et al. 2018). Regulating structures and operational procedures within the Lindsay Island anabranch system enable managers to implement optimal surface water management actions to facilitate ecological objectives through defining how and when water is delivered (ARI 2018).

The combination of recent changes in infrastructure, refining water operations and blackwater-induced fish-kills (Tonkin et al. 2017; ARI 2018) within and surrounding the Lindsay Island anabranch system along with a decline in abundance of mature Murray cod (*Maccullochella peelii*) from Mullaroo Creek (Tonkin et al. 2018) is concerning and facilitated an investigation into the species’ spawning within the system. The objective of the current investigation was to assess spawning of *M. peelii* within the Lindsay Island anabranch system in spring 2018 and to provide contemporary information on links between hydraulically diverse habitats and early life-stages (egg/larvae/juveniles) of fishes within the system that may help guide the management of water to facilitate positive outcomes for native fish in the region.

2 Methods

2.1 Study site

Early life-stages of fish were sampled within three reaches of the Lindsay Island anabranch system (Figure 1). The three reaches were chosen to represent three hydraulically variable areas (Appendix A) within the anabranch network, all of which are influenced by water management (Vilizzi et al. 2007; ARI 2018). Specifically:

1. Mullaroo Creek (high hydraulic diversity)
2. Lower Lindsay River (LLR; medium hydraulic diversity)
3. Upper Lindsay River (ULR; low hydraulic diversity)

It is important to note that these reaches and associated hydraulic conditions were reflective of the low flow conditions forecast for Spring 2018. Furthermore, under high river flow conditions and the lowering/raising of Weir 7 in the Murray River, the ULR for example, is likely to exhibit similar hydraulics to the Mullaroo Creek given its instream woody habitat density and channel form.

Sample locations were based on those used by Vilizzi et al. (2007). Flow discharge through the Mullaroo Creek covering the duration of sampling were obtained from Gauging station number 414211, http://data.water.vic.gov.au/monitoring.htm. At the time of sampling, water flow through the ULR was variable and low (<70 ML/d) while flows in the LLR were low/moderate and consisted of discharge from the Mullaroo Creek and ULR. The relatively narrow width (10 m) of the Mullaroo Creek sample site facilitates the passage of higher velocity water compared with the Upper (20-30 m wide) and Lower (20-40 m wide) Lindsay River sample sites.

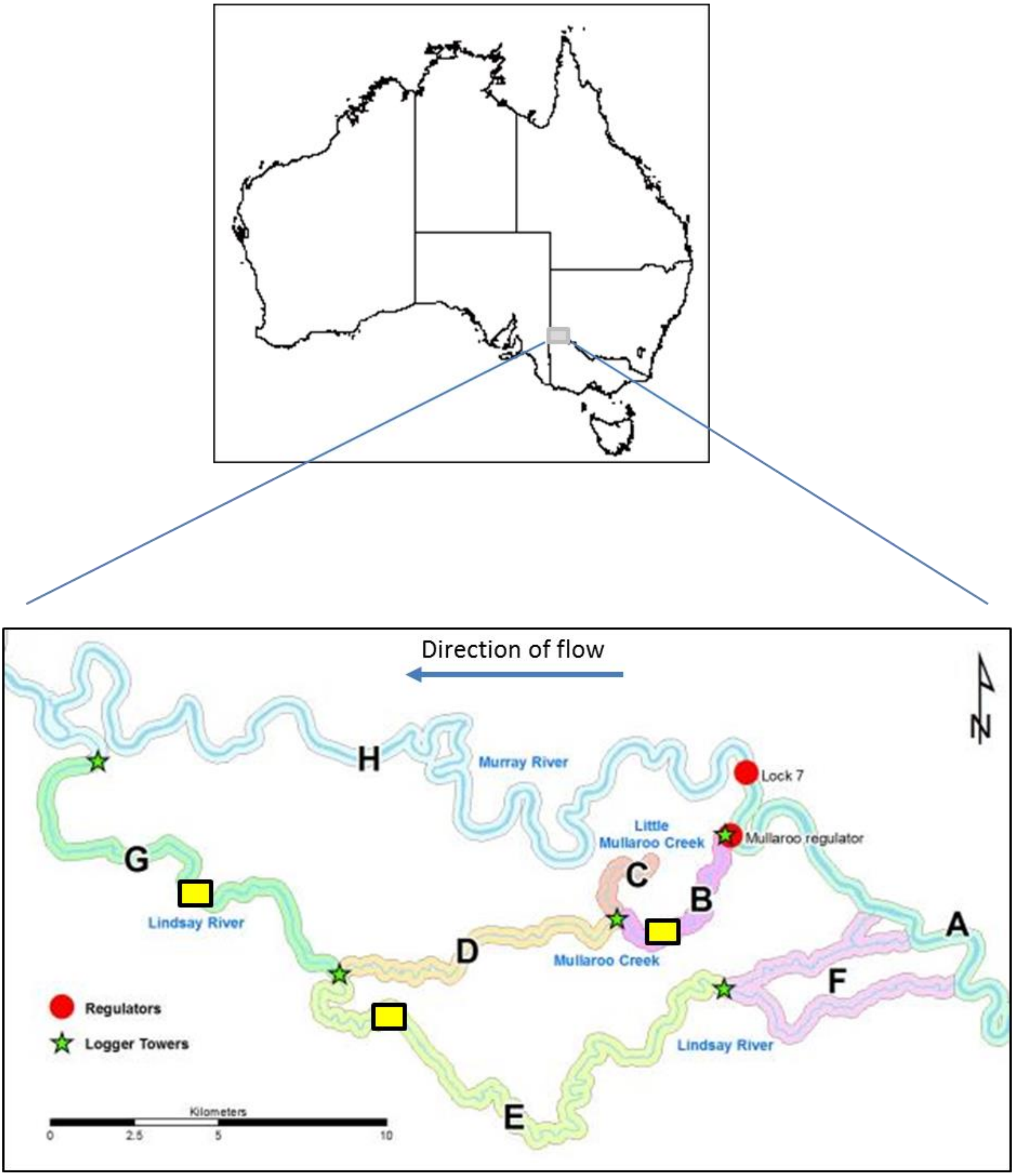

Figure 1. Sampling locations (yellow squares) within the lower Lindsay River, Upper Lindsay River and Mullaroo Creek 2018. Map borrowed from Tonkin et al. (2018).

2.2 Survey methods

Sampling the Lindsay Island anabranch system for early life-history stage fish and small-bodied fish was undertaken using a combination of larval drift nets, trawls and light traps (Figures 2 and 3) as per Vilizzi et al. (2007). Fortnightly sampling was undertaken during four overnight trips from mid-October to the end of November 2018. Five light traps and either three drift nets or three trawls were undertaken at each site for each sample event. Fish species collected for each gear type is presented in Appendix B.

In the faster-flowing waters of Mullaroo Creek, three larval drift nets were set across the creek during each sampling event, left overnight (12 – 14 hrs) and retrieved the following morning. In addition, five modified quarterfoil light traps (Secor et al. 1992) were set amongst slower flowing habitats such as slackwaters, approximately 10cm below the water surface, set overnight (12 – 14 hrs) and retrieved the following morning. A Yellow Cyalume® 12h light-stick was placed within the core Perspex™ tube of each light trap. In the slower/no flow regions of the Upper and Lower Lindsay River, larval drift nets were trawled rather than set. Three replicate, five minute trawls were undertaken at each sample site for each of the four sample events and conducted after sunset. Larval fish and stages (Figure 4) were identified using fish keys in Serafini and Humphries (2004).

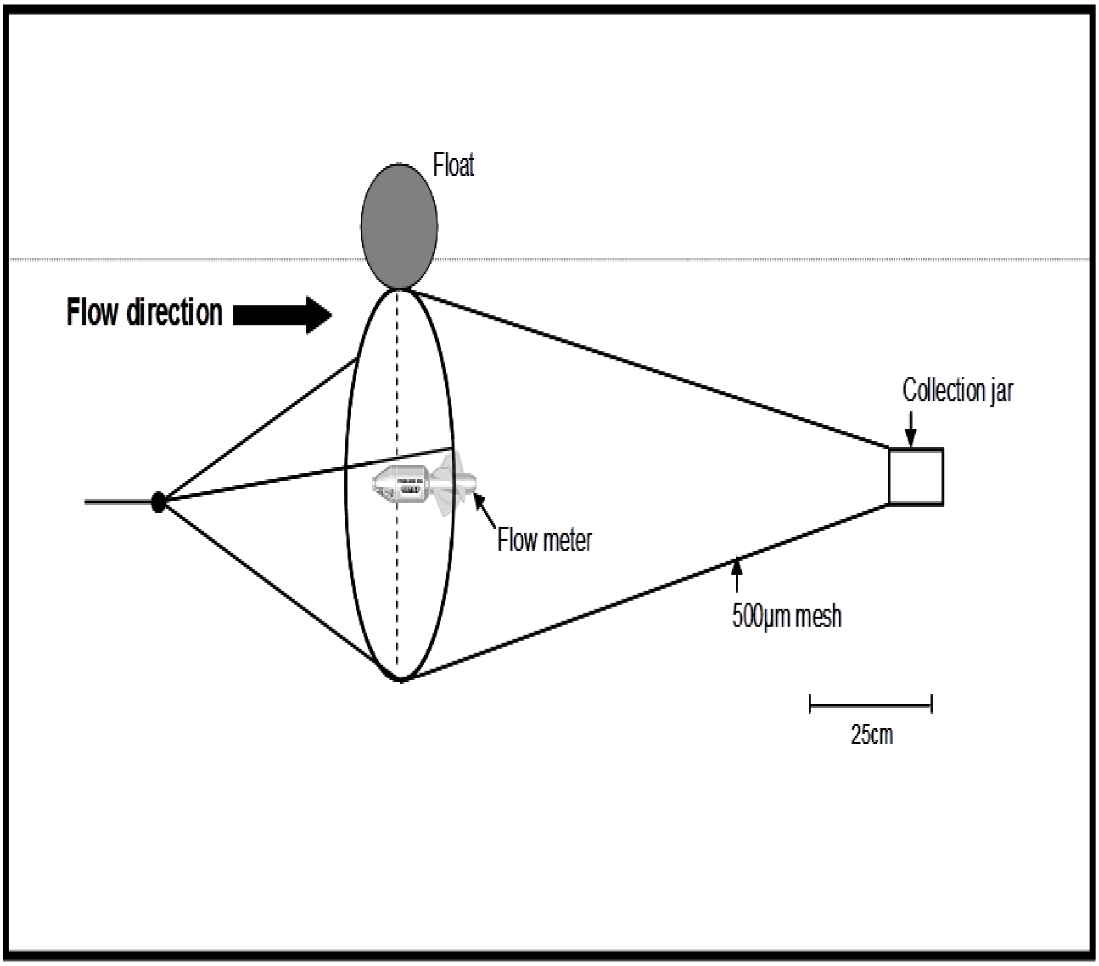

Figure 2. Larval drift net

Figure 3. Light trap.

Figure 4. A mixture of fish from a single larval trawl (top) in the upper Lindsay River and individual carp gudgeon sorted to different developmental stages (bottom).

3 Results

Hydrology

The Lindsay Island anabranch system provides regions with a diversity of managed flows, velocities and hydraulic habitats. Water flow through Mullaroo Creek was variable over the duration of sampling, with comparatively higher flows in the last two sampling events (Figure 5). A minor flow peak (~ 1 000ML/d) was recorded in early spring followed by a peak in discharge (1 282 ML/d) in late spring, coinciding with the known spawning and drifting phases of many native fish eggs and larvae. Comparatively greater numbers of larval Murray cod were sampled in early November, following an increase in discharge from 600 to 1 000 ML/d (Figure 5). In contrast with the highly variable flows and water velocities of Mullaroo Creek, the ULR was defined by considerably lower and more stable (<70 Ml/d) flowing habitat (Figure 6). The LLR provides intermediate flowing habitat, with flows largely dependent on those through the Mullaroo Creek and ULR.

Figure 5. Mullaroo Creek hydrograph and raw abundance of drifting Murray cod (orange triangles) and freshwater catfish (black square) for each sample trip 2018.

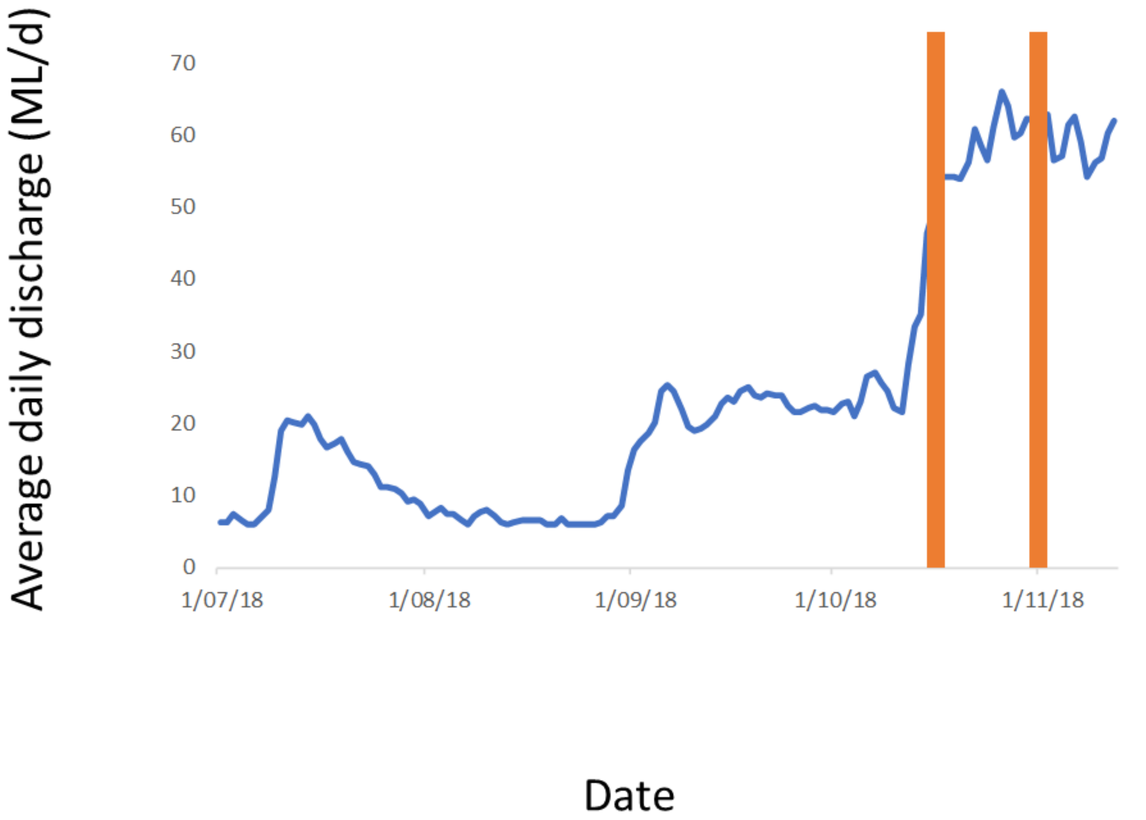

Figure 6. Upper Lindsay River hydrograph for sample trips 1 and 2, 2018. Data for the last two sample trips is unavailable. Gauge 414212 data kindly supplied by MCMA.

Fish catch

Abundance and diversity

A total of 9 502 fish were recorded from the three reaches and four sampling trips in spring 2018, comprising eight native and two alien species (Table 1). Carp gudgeon (*Hypseleotris spp*.) and Australian smelt were the dominant species. Murray cod (n=14), freshwater catfish (*Tandanus tandanus*) (n=3) and bony herring (*Nematalosa erebi*) (n=2) were recorded in low abundance, Unspecked hardyhead (*Craterocephalus stercusmuscarum*) and adult Australian smelt showed a preference for the faster flowing waters of Mullaroo Creek. In addition, 1 204 native Australian smelt (*Retropinna semoni*) eggs were recorded (Table 2).

Table 1. Summary and location of total fish sampled during the 2018 Lindsay Island anabranch survey. Egg numbers are presented in parentheses.

Fish type	Species common name	Mullaroo Creek	Upper Lindsay River	Lower Lindsay River	Total
Native	Murray cod	14	0	0	14
	freshwater catfish	3	0	0	3
	carp gudgeon	330	7 168	493	7 991
	Australian smelt	98 (1 191)	1 071	259 (13)	1 428
	flathead gudgeon	2	9	4	15
	unspecked hardyhead	23	13	2	38
	Murray River rainbowfish	3	1	2	6
	Bony herring	0	2	0	2
Alien	common carp	0	0	4	4
	Eastern gambusia	1	0	0	1
Total		474	8 262	764	**9 502**

Table 2. Abundance of life-history stages at each sample location. Egg numbers are presented in parentheses.

Fish type	Species common name	Mullaroo Creek			Upper Lindsay River			Lower Lindsay River		
Native		Adult	Juvenile	Larvae	Adult	Juvenile	larvae	Adult	Juvenile	Larvae
	Murray cod*	0	0	14	0	0	0	0	0	0
	freshwater catfish*	0	0	3	0	0	0	0	0	0
	carp gudgeon	265	65	0	999	2 866	3 303	287	127	79
	Australian smelt	78	10	20 (1 191)	34	875	909	69	153	190 (13)
	flathead gudgeon	0	2	0	0	9	0	0	4	0
	unspecked hardyhead	19	7	0	1	1	0	11	2	0
	Murray River rainbowfish	2	1	0	1	0	0	1	1	0
	Bony herring	0	0	0	0	2	0	0	0	0
Alien	common carp*	0	0	0	0	0	0	0	0	4
	Eastern gambusia	0	0	1	0	0	0	0	0	0

* Sampling of adults of these species was not undertaken

Murray cod were sampled during each sample trip, at a mean (+/- S.E.) abundance of 3.5 (+/- 1.3) larvae per trip. Freshwater catfish were only collected from a single sample trip in mid-November. No golden perch (*Macquaria ambigua*) or silver perch (*Bidyanus bidyanus*) eggs or larvae were detected during the survey..

Distribution

Species were unevenly distributed across sample sites (Table 1). Murray cod and freshwater catfish were only collected in Mullaroo Creek (Figure 5). Carp gudgeon and Australian smelt were predominantly (90%) recorded from the ULR with two juvenile bony herring sampled only from this reach. In contrast, unspecked hardyhead and Murray River rainbowfish were collected as adults or juveniles from Mullaroo Creek and the LLR. A small number (n=4) of introduced larval carp (*Cyprinus carpio*) were collected from the LLR while a single introduced Eastern gambusia (*Gambusia holbrooki*) was collected from Mullaroo Creek.

Temporal trends

Species and developmental stages of fish recorded varied between sites and trips (Table 2, Figures 6 and 7, Appendix C). Murray cod (n=14), freshwater catfish (n=3), common carp (n=4) and eastern gambusia (n=1) were only sampled as larvae. Flathead gudgeon (*Philynodon grandiceps*) were only detected as juveniles, with the majority collected during the third trip, in mid-November. Murray cod larvae were collected during each sample trip, with a peak in larval abundance in early-November. Freshwater catfish (*Tandanus tandanus*) larvae and bony herring juveniles were only collected from the last sampling trip. Adult and larval Murray River rainbowfish (n=6) and adult and juvenile unspecked hardyhead (n=38) were sampled, with higher numbers collected in the second half of sampling. In contrast, all three stages (adult, juvenile and larvae/egg) of carp gudgeon and four stages (including eggs) of Australian smelt were sampled across all sample trips.

Higher numbers of carp gudgeon were sampled from the ULR, compared with the LLR and Mullaroo Creek. Gudgeon captured in the Mullaroo Creek and LLR were dominated by adults, while gudgeon in the ULR were dominated by juvenile and larval fish in the last three sample trips (Figure 7).

Higher abundances of adult Australian smelt were recorded from Mullaroo Creek in mid-October (trip 1) while greater abundances of juvenile smelt were collected in the ULR (Figure 8). Australian smelt eggs were only collected from Mullaroo Creek in late-October (trip 2) to late-November (trips 3 and 4), with a peak in mid-November.

A proliferation of zooplankton was observed in samples during the first two survey trips from the Lindsay River, predominantly from the ULR.

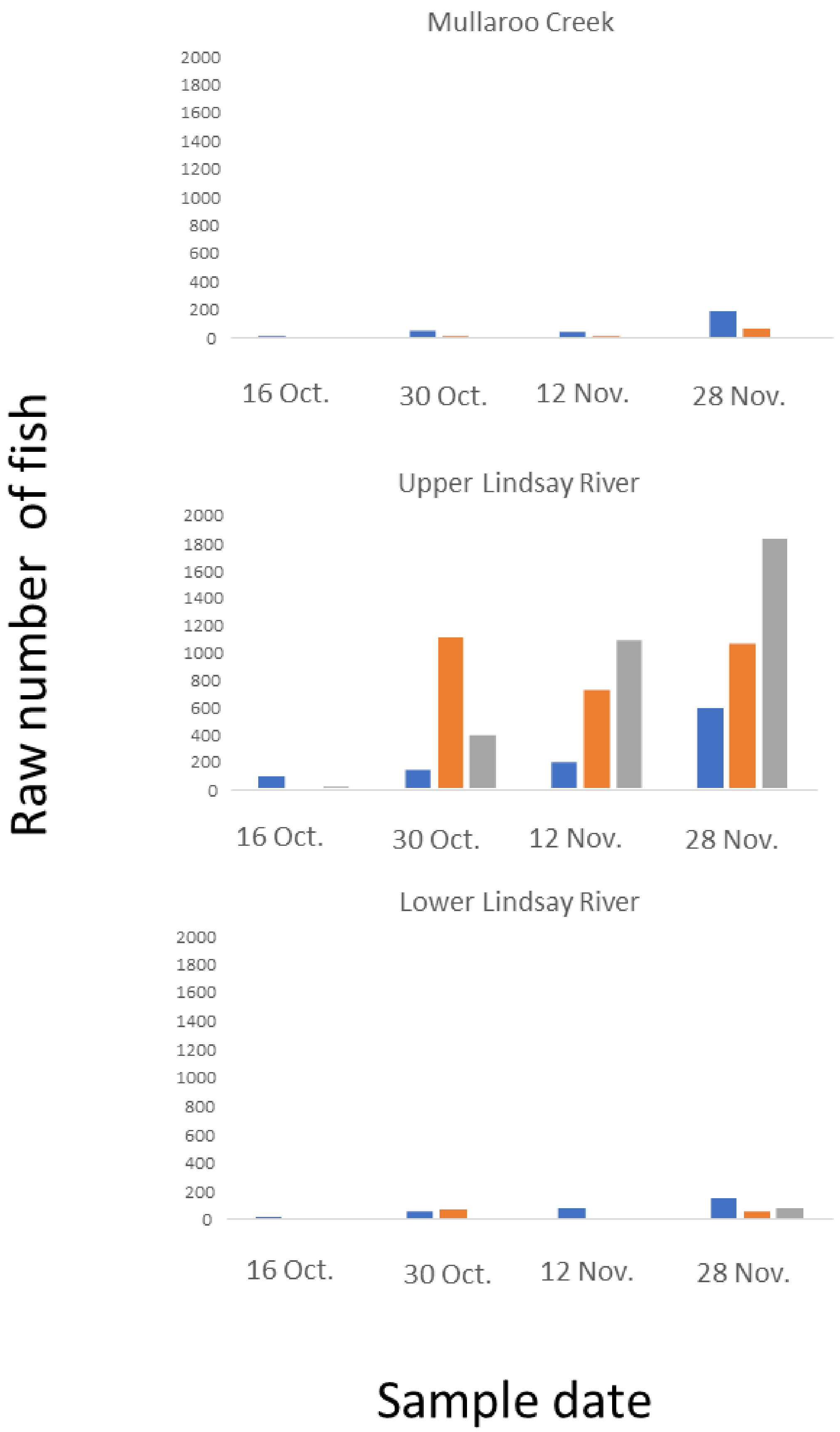

Figure 7. Spatio-temporal abundance of carp gudgeon adults (blue), juveniles (orange) and larvae (grey) sampled in October and November 2018.

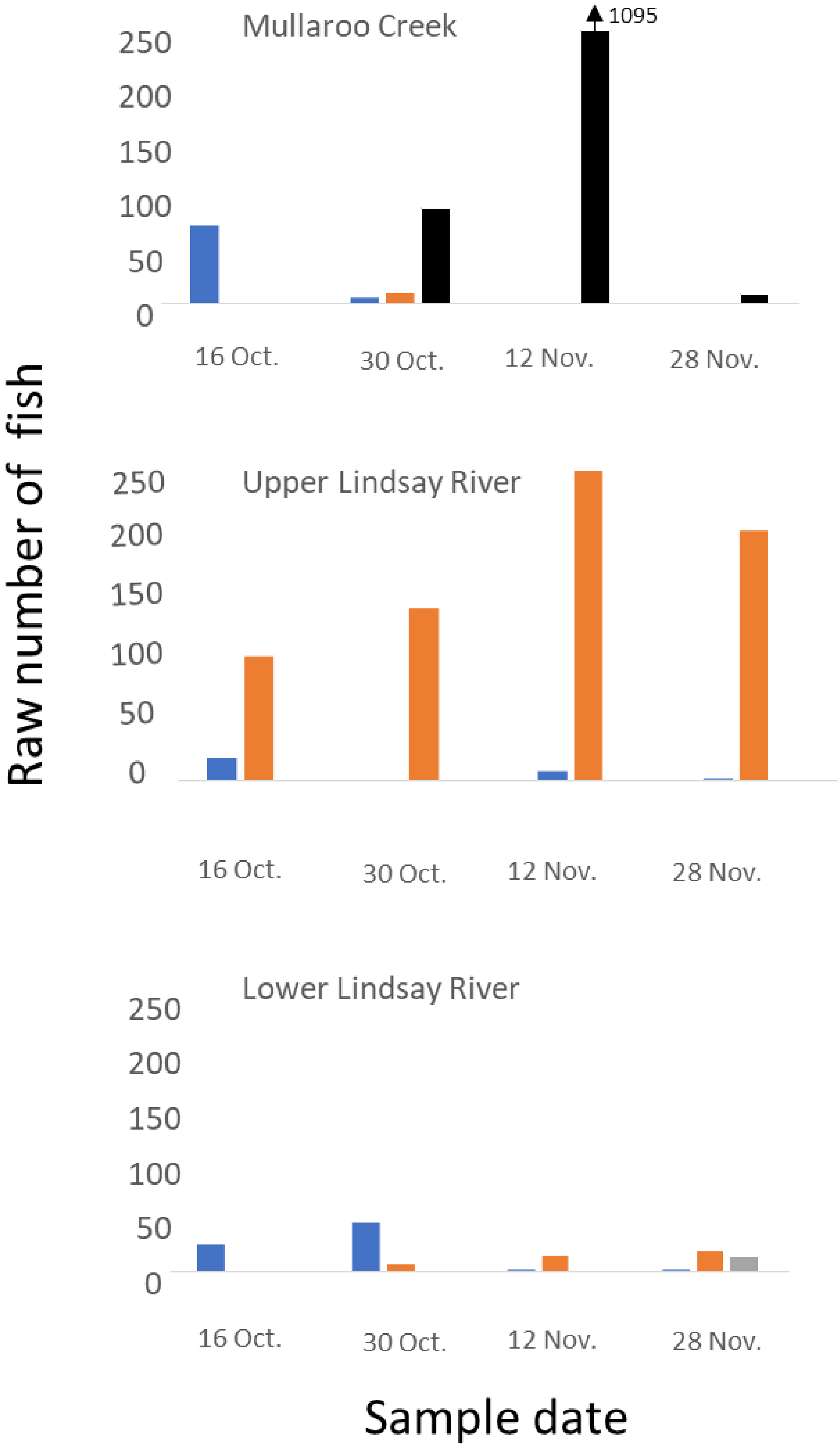

Figure 8. Spatio-temporal patterns in raw abundance of Australian smelt adults (blue), juveniles (orange), larvae (grey) and eggs (black) sampled in October and November 2018.

4 Discussion

The results of our study reinforce the concept that maintaining a diverse array of hydraulic habitats is critical to meet the variety of life-history requirements of the native fish community in lowland riverine ecosystems (Vilizzi et al. 2007; Cheshire 2010; ARI 2018). Of the three hydraulically variable habitats studied, Mullaroo Creek had the greatest diversity of speciesand the ULR supported high abundances of small-bodied species with broad and changing developmental stages throughout the study. The unique characteristics of the three regions and the distribution of different species, abundances and/or developmental stages reflects the diverse hydraulic characteristics of the system. Consequently, management of the Lindsay Island anabranch system should focus on maintaining the diversity of hydraulic habitats within the system to facilitate its unique fish fauna.

The presence of larval Murray cod and freshwater catfish from Mullaroo Creek indicates that both species have successfully spawned within the system and that adults showed a preference for reaches with a diversity of flowing water in which to spawn, consistent with differences in adult catch rates between Mullaroo Creek and Lindsay River (Saddlier and O'Mahony 2009). Low numbers of drifting larvae of Murray cod support the reduced catch of adults sampled from the creek in recent years (Tonkin et al. 2018) and highlights the need to provide suitable flows to attract mature Murray cod back into the system. The absence of golden perch and silver perch eggs in our samples suggests conditions, likely flow, were insufficient for these species to spawn in the Lower Murray River system over the 2018 study period (Sharpe 2011).

While the focus of the study was to provide contemporary early life-history data on target fish species (Murray cod, golden perch, silver perch and freshwater catfish) to complement an investigation of fish movement patterns within the system (Tonkin et al. 2018), detailed spatio-temporal differences amongst species was evident. The 2018 catch was dominated by small-bodied native carp gudgeon and Australian smelt, that were most abundant in the ULR reach, consistent with the findings of Vilizzi et al. (2007). Differences in hydrology, presence of and transition between fish life-history stages and species habitat preferences may explain the patterns in distribution across the system. The sampling of fish using a variety of methods was found to reduce inherent bias in single gear fish assessment.

The presence of adult Australian smelt and the subsequent collection of eggs indicate that adults may also prefer hydraulically diverse reaches for spawning. Similarly, larger numbers of adult and juvenile unspecked hardyhead suggest a preference for this habitat type over the more uniform and reduced flow conditions in the other study reaches. The high flow variability within the Mullaroo Creek and comparatively greater species abundance supports the notion that environments with variable flows are important in maintaining healthy fish communities (Bunn and Arthington 2002).

While the diverse hydraulic conditions in Mullaroo Creek are indicative of preferred spawning habitat for some large-bodied native fish species and small-bodied adult Australian smelt, large abundances of other generalist small-bodied native fish sampled from the Upper and Lower reaches of the Lindsay River suggest a preference for lower flow velocities, particularly those of the ULR. All life-history stages (adult, juvenile and larvae) of carp gudgeon and juvenile Australian smelt were most prolific in the ULR, indicating a preference of life-stages of these species for riverine regions with lower hydraulic diversity, particularly those associated with low flow conditions.

The raw abundance of carp gudgeon and juvenile smelt generally increased with sample trip. The huge increase in carp gudgeon, a species reported to prefer slow-flowing habitats (Allen et al. 2002), throughout the study was due to an increase in juvenile and larval fish, restricted to the ULR sites. In contrast, the increase in Australian smelt (ULR), was restricted to juveniles. The lack of larval smelt was most likely due to their reported earlier spawning in August/September. Consistently high and increasing abundances of juvenile and larval carp gudgeons, respectively, collected from the ULR highlight the importance of slow/no flow habitats for spawning and recruitment of the species. In general, the large increase in these species from the slower flowing regions of the ULR align with the low flow recruitment hypothesis whereby slow flowing areas such as slackwaters, and in this case weir pools, are favoured by the early life-history stages of many generalist species such as carp gudgeons, smelt and rainbowfish.

The increase in fish abundance followed an observed increase in the abundance of zooplankton, particularly calanoid copepods. The 'boom and bust' nature of many small-bodied fish (r-strategists) is widely recognised and often linked with food availability and enhanced survival (Harris and Gehrke 1994; Humphries 1999; Cheshire 2010).

We also highlight that our findings are limited to a five-week period, which does not cover the entire known spawning period of all native fish species in the region (e.g. Murray River rainbowfish, unspecked hardyhead and bony bream; (Vilizzi et al. 2007). As such, additional information on spawning and early life-history requirements of all species requires broader sampling over a period of four to five months.

The findings from this study have shown the importance of hydraulically diverse habitats in lowland floodplain ecosystems. The Lindsay Island anabranch system is one such example. Large bodied species of conservation significance such as Murray cod and freshwater catfish were only detected from the most variable hydrological environments while the expanse of slow flowing water in the ULR was more favoured by early life stages of small-bodied generalist fish species such as carp gudgeons and Australian smelt.

This information adds weight to the importance of hydrologically diverse habitats supporting a more diverse range of native fishes and may be used to guide flows through this managed system, particularly flows targeted at providing positive outcomes for native fish. Flow conditions that facilitate the movement and spawning of Murray cod, freshwater catfish and other target-species are required to sustain existing populations and to contribute to populations further afield. Similarly, regions of slow/no flows such as those reported in the ULR support small-bodied native fish species and likely provide benefits to downstream fish communities through increased food availability.

Recommendations

To facilitate the recovery and maintenance of Murray cod and other native fish species within the Lindsay Island anabranch system we provide the following recommendations;

- Determine suitable baseflows and spring rises through the Mullaroo Creek to support spawning of target fish species and functional populations. Discharge rates will continue to be refined with improved knowledge and understanding associated with ongoing monitoring.
- Monitor the recovery of Murray cod over a 10-year period.

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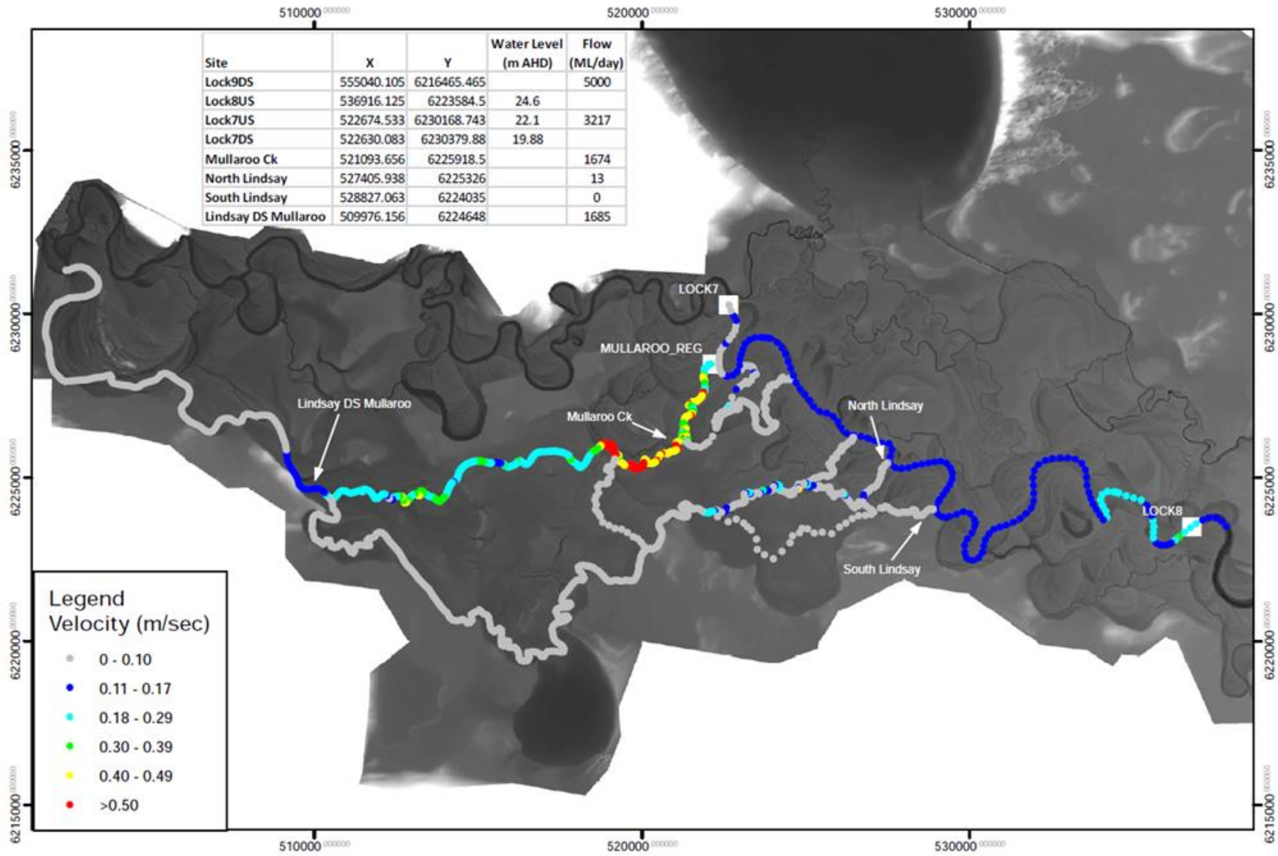
Appendix A



Site	X	Y	Water Level (m AHD)	Flow (ML/day)
Lock9DS	555040.105	6216465.465		5000
Lock8US	536916.125	6223584.5	24.6	
Lock7US	522674.533	6230168.743	22.1	3217
Lock7DS	522630.083	6230379.88	19.88	
Mullaroo Ck	521093.656	6225918.5		1674
North Lindsay	527405.938	6225326		13
South Lindsay	528827.063	6224035		0
Lindsay DS Mullaroo	509976.156	6224648		1685

Modelled Lock7 Velocity 22.1m AHD (FSL) 5,000 ML/d River Murray Flow

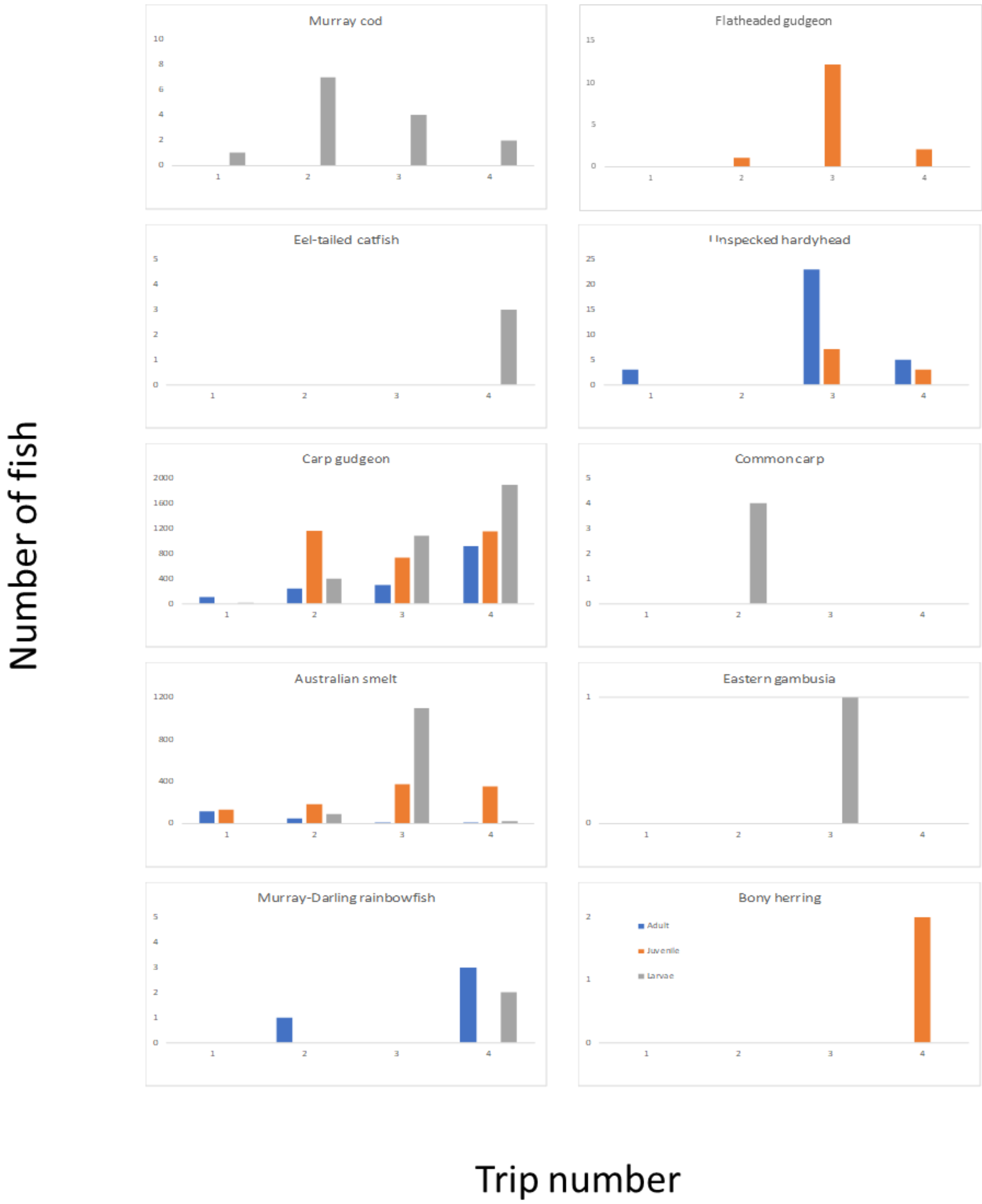
Modelled flow velocities through the Lindsay Island anabranch system under 5000 ML/d flow down the Murray River. Data kindly provided by the MCMA.

Appendix B

Summary of fish species sampled during spring 2018 in the Lindsay/Mullaroo anabranch system, separated by gear type and location.

	Mullaroo Creek		Upper Lindsay River		Lower Lindsay River		
Species common name	Drift net	Light trap	Light trap	Trawl	Light trap	Trawl	Total
Murray cod	14	0	0	0	0	0	14
Carp gudgeon	3	327	812	6 356	422	71	7 991
Australian smelt	4	94	197	874	145	114	1 429
Australian smelt eggs	1 191	0	0	0	0	13	1 204
Flathead gudgeon	1	1	1	8	2	2	15
Freshwater catfish	3	0	0	0	0	0	3
Unspecked hardyhead	26	0	2	0	13	0	41
Murray-River rainbowfish	0	1	0	0	1	0	2
Bony herring	0	0	0	2	0	0	2
Common carp	0	0	0	0	0	4	4
Eastern gambusia	2	0	0	0	0	0	2
Totals	**1 244**	**423**	**1 012**	**7 240**	**583**	**204**	**10 706**

Appendix C



Temporal abundance and developmental stage of fish (adults in blue, juveniles in orange, and larvae in grey) sampled from the Lindsay Island anabranch system, October to November 2018.