Inland Waters & Catchment Ecology

Monitoring temporal changes in the species composition and lateral movement patterns of small-bodied fishes within the inlet and outlet creeks to Banrock Station wetland.

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Fredberg, J., Smith, B., Thwaites, L., Conallin, A. and Fleer, D.

SARDI Aquatics Sciences,
PO Box 120, Henley Beach, SA 5022

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South Australian Research and Development Institute

SARDI Aquatic Sciences,
PO Box 120,
HENLEY BEACH, SA 5022.

Telephone: 8207 5400
Facsimile: 8207 5481

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Author(s):	Fredberg, J., Smith, B., Thwaites, L., Conallin, A. and Fleer, D.
Reviewers:	Marsland, K. and Leigh, S. (SARDI Aquatic Sciences) and Hollis, B. (SA MDB NRM Board)
Approved by:	Dr. Qifeng Ye
Signed:	
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Executive Summary

The lateral movement patterns of small-bodied (<150 mm at maturity) fishes was assessed by sampling the number of fish entering the inlet and outlet channels at Banrock Station wetland, South Australia, during 2nd June to 1st October 2008. Sampling occurred once per week over 16 weeks, using single and double-winged fyke nets set overnight near the inlet and outlet flow control structures. In total 27,327 fish (inlet, 11,719 fish; outlet, 15,608 fish) from 12 species, including 9 native and 3 exotic were captured. The catch included one fish species of conservation significance (freshwater catfish, *Tandanus tandanus*; 'Protected' in South Australia under the *Fisheries Management Act* 2007) as well as a 'Rare' turtle species (the broad-shelled turtle, *Chelodina expansa*). Temporal patterns suggest that the peak migration period for small-bodied native fishes overlaps with that of common carp. Hence, common carp management strategies need to closely consider the passage requirements of native fish.

Introduction

Banrock Station RAMSAR wetland is a managed wetland with flow control structures at its inlet and outlet (box and pipe culverts, respectively). It bypasses Lock and Weir 3 on the River Murray near Overland Corner, and there is a 3 m head difference in water levels from upstream to downstream- creating the capacity to operate as a flow-through wetland. As per all managed wetlands in South Australia, Banrock Station wetland was forcibly closed (disconnected from the river) under ministerial order in January 2007, as a water savings measure to minimise evaporative losses.

During the summer of 2007/2008, it was observed that the 'health' of the wetland was in severe deterioration, indicated by the intrusion of saline groundwater, dying red gums and the presence of acid-sulphate soils. As such, 215 ML of water was purchased by Banrock Station and a further 617 ML of water was secured by the South Australian River Murray Environmental Manager to refill the wetland. Filling commenced on the 2nd June 2008 and by the 19th of June the wetland was completely filled (0.86 AHD) and began operating as a flow-through system regulated by stop-boards at both the inlet and outlet flow control structures.

Since the onset of filling, lateral fish movement patterns were evaluated on a weekly basis by sampling fish moving into the wetland via the inlet and outlet channels (i.e. movement with- and against the flow, respectively). The main focus of fish sampling was to trial new jumping/pushing traps for carp; however as part of this project, rigorous/quantitative opportunistic sampling of small-bodied fish also occurred. This report describes the temporal changes in the species composition and lateral movement patterns of small-bodied fishes (not larvae) that were collected from 2nd June until 1st October 2008. The temporal pattern in the catch of carp in the downstream outlet cage, where 99.9 % of carp (n = 4702) were captured, is also shown in Appendix A.

Methods

Small body fish monitoring

To evaluate the spatial and temporal variation in the pattern of small-bodied fish (<150 mm at maturity) movements, both the inlet and outlet creeks were sampled on a weekly basis. On each sampling occasion, one double wing small-mesh fyke net was set at the inlet channel and two single wing small-mesh fyke nets were set at the outlet channel (Figure 1). On each occasion, nets were set for approximately 24 hr.

All fish were processed immediately after capture. The first 30 fish of each species were measured (TL, mm) and weighed (for biomass estimates) and returned to the water. Remaining fish of each species were counted and weighed. However, as fyke nets can sometimes catch several hundred fish per sample, sub-sampling and extrapolation was required on some occasions to minimise the stress on captured fish and to ensure the timely completion of sample processing. If sub-sampling was required, the catch was divided into halves (or thirds). One half (or third) of the total catch was processed as normal, whilst the other was inspected for rare species and returned to the water. With the exception of exotic fish, all fish were released.

The duration of sampling varied between the inlet and outlet creeks because it took 17 days for the water coming in the inlet to fill the wetland to the required depth (0.86 AHD) before the outlet could be opened. Furthermore, the small-bodied fish catch includes some juveniles of large-bodied native species, and large-bodied fishes that bypassed the carp traps and entered the fyke nets.

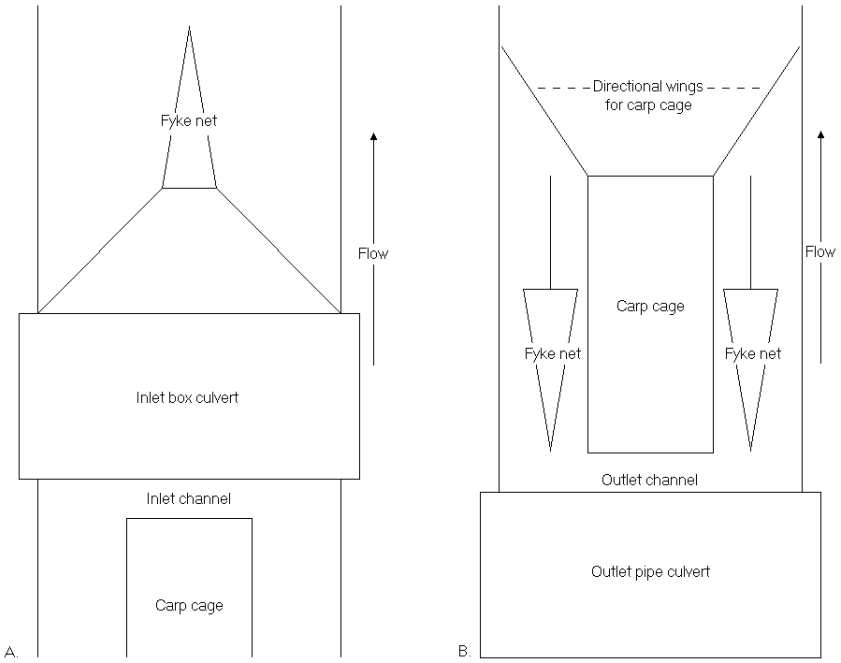

Figure 1: Fyke net sampling strategy for small-bodied fish monitoring at Banrock station wetland inlet (A- movement with the flow) and outlet (B- movement against the flow) channels. The location of the inlet and outlet carp separation cages in relation to the fyke nets is also shown.

Monitoring the lateral migration patterns of carp

The temporal trend in the lateral migration pattern and catch rate of carp at the outlet cage (Figure 1-B) was assessed on a weekly basis. On each sampling occasion, the total number of carp trapped inside of the cage was recorded and the first 30 were measured (length, width, depth, mm; weight, g). Similarly, all carp within 50 m directly downstream (weir pool and outlet creek) of the cage were captured using a backpack electro-fisher, counted and the first 30 measured.

Water Quality

To investigate the relationship between fish movement and water temperature, temperature (°C) was continuously recorded at both the inlet and outlet for the duration of the study on pre-calibrated loggers (TPS-90C). The average temperature for each sampling period is reported.

Results

Catch summary

In total 27,327 fish (inlet, 11,719 fish; outlet, 15,608 fish) from 12 species, including 9 native species and 3 alien invasive species were captured, along with 33 eastern long-necked turtles (*Chelodina longicolis*), two broad-shelled turtles (*Chelodina expana;* listed as 'Rare' in South Australia), and many yabbies (*Cherax destructor*; *n* estimate = >200). Table 1 provides information about the fish and turtle species captured (common and species names) within the inlet and outlet channels, their total and relative abundances, and length data.

Native fish species represented 94.7 % of the catch; 93.8 % were small-bodied native fishes and 0.9 % were either juveniles of large-bodied fishes or large-bodied fish that had bypassed the carp cages (burrowing under cage 'wings' or passing whilst cages were lifted). Only one individual of one threatened fish species (freshwater catfish, *Tandanus tandanus*; Protected in South Australia under the *Fisheries Management Act* 2007) was captured.

The most abundant fish taxa was Australian smelt (*Retropinna semoni*), followed by the carp gudgeons (a species complex of uncertain taxonomy, see Bertozzi *et al*. 2000) and unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*) (Table 1). Together these three species comprised 89 % of the total catch. Lesser abundant species included flat-headed gudgeons (*Philypnodon grandiceps*), dwarf flat-headed gudgeons (*Philypnodon macrostomus*) and juvenile bony herring (*Nematalosa erebi*). The least abundant species included Murray River rainbowfish (*Melanotaenia fluviatilis*), and juveniles of freshwater catfish and golden perch (*Macquaria ambigua*). The most abundant invasive alien fish species captured was goldfish (*Carrasius auratus*), with significantly fewer eastern gambusia (*Gambusia holbrooki*) and carp (*Cyprinus carpio;* includes juvenile carp, as well as some adult fish that bypassed the cages).

Table 1. Summary statistics for small-bodied fish monitoring conducted at the inlet and outlet channel of Banrock Station wetland from the 2nd June until 1st October 2008. Note: Juvenile large-bodied native fish, common carp and other fauna captured in the small mesh fyke nets are also reported.

Common name (Species name)	INLET CHANNEL				OUTLET CHANNEL			
	Abundance	Abundance as % of total fish catch	Length Mean ± S.D. (mm)	Length Range (mm)	Abundance	Abundance as % of total fish catch	Length Mean ± S.D. (mm)	Length Range (mm)
Small-bodied native fish (<150 mm at maturity)								
Australian smelt (*Retropinna semoni*)	6810	58.11	44.7 ± 6.3	25 - 67	11862	76	47.6 ± 5.2	35 - 63
carp gudgeons (*Hypseleotris* spp.)	2297	19.6	34.9 ± 5.7	13 - 77	1532	9.82	39.9 ± 4.3	30 - 52
un-specked hardyhead (*Craterocephalus stercusmuscarum fulvus*)	1800	15.36	33.1 ± 7.4	19 - 65	7	0.04	39.0 ± 5.3	33 - 43
dwarf flat-headed gudgeon (*Philypnodon macrostomus*)	191	1.63	34.7 ± 4.9	23 - 50	2	0.01	33.5 ± 2.1	32 - 35
flat-headed gudgeon (Philypnodon grandiceps)	46	0.39	56.5 ± 17.1	23 - 85	1070	6.86	50.1 ± 6.6	35 - 80
Murray river rainbowfish (*Melanotaenia fluviatilis*)	23	0.2	42.4 ± 10.1	30 - 65	1	0.01	62	62
Juveniles of large-bodied (>150 mm at maturity) native fish								
bony herring (*Nematalosa erebi*)	236	2.01	52.0 ± 20.0	23 - 194	0	0	0	N/A
freshwater catfish (*Tandanus tandanus*)	1	0.01	67	67	0	0	0	N/A
golden perch (*Macquaria ambigua*)	0	0	0	N/A	2	0.01	295	295
Alien invasive Fish Species								
goldfish (*Carassius auratus*)	230	1.96	64.9 ± 12.5	45 - 125	1114	7.14	118.0 ± 29.7	52 - 230
eastern gambusia (*Gambusia holbrooki*)	85	0.73	31.8 ± 4.4	24 - 43	18	0.12	31.3 ± 1.2	30 - 33
common carp (*Cyprinus carpio*)	2	0.02	482.5 ± 3.5	480 - 485	19	0.12	274.4 ±	104 - 517
Catch at Inlet	**11,719**							
Catch at Outlet	**15,608**							
Total Catch	**27,327**							
Total Species	**12**							
Other fauna - freshwater turtles								
eastern long-necked tortoise (*Chelodina longicollis*)	3		210.0 ± 22.9	185-230	30		207.8 ± 19.9	150-240
broad-shelled river turtle (*Chelodina expansa*)	0		0	N/A	2		255.0 ± 14.1	245-265

Temporal trends in catches

The graphs below (Figures 2-7) show temporal trends in the species composition and lateral movement patterns of small-bodied fish species (not larvae) and the incidental by-catch of large-bodied natives and invasive alien species that have been collected from 2nd June until 1st October 2008. Inlet and outlet graphs are grouped into three species categories- small-bodied native species (Figures 2 & 3), large-bodied native species (Figures 4 & 5), and invasive alien species (Figures 6 & 7).

Note: Week 2 (10/06/08) and week 10 (7/08/08) are omitted from the inlet channel graphs due to unreliable data resulting from net malfunctions.

Small-bodied native fishes

Inlet

Over the duration of sampling, the total abundance of smelt (*Retropinna semoni*), unspecked hardyheads (*Craterocephalus stercusmuscarum fulvus*) and carp gudgeons (*Hypseleotris spp*) increased, with peak abundance for these three native fish species occurring with rising water temperature between the sample weeks of the 9/09/08 and 16/09/08 (Figure 2). Dwarf flat-headed gudgeons (*Philypnodon macrostomus*), flat-headed gudgeons (*Philypnodon grandiceps*) and Murray River rainbowfish (*Melanotaenia fluviatilis*) were captured in low abundance over the entire sampling period within the inlet channel (Figure 2).

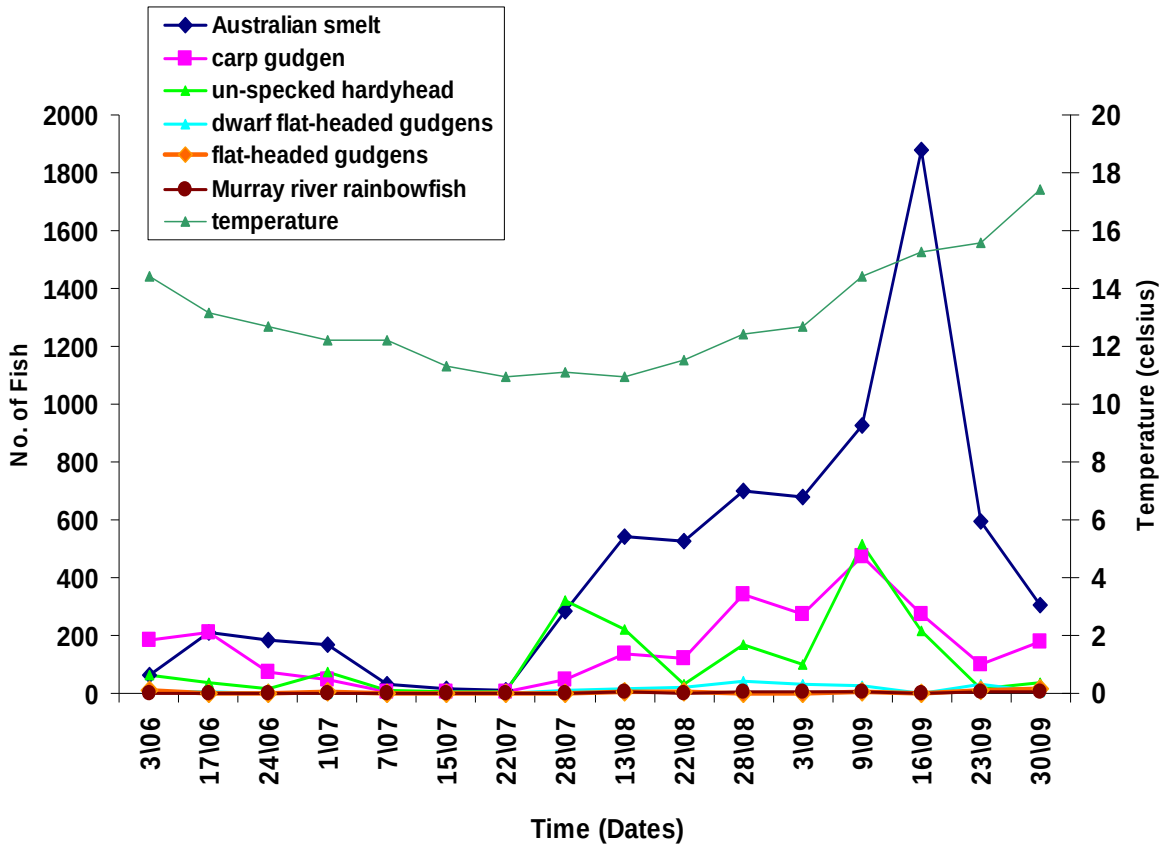

Figure 2. The total abundance of small-bodied native fish species captured at the inlet channel from the 03/06/08 to 30/09/08 plotted with temperature.

Outlet

Within the outlet channel, the total abundance of smelt (*Retropinna semoni*) peaked in week one (1/07/08) while water temperatures were relatively low. A smaller peak was observed in early and mid September (9/09/08 & 16/09/08) as water temperatures were rising (Figure 3). The total abundance of carp gudgeons (*Hypseleotris spp*) and flat-headed gudgeons (*Philypnodon grandiceps*) peaked in the final week of sampling (30/09/08), when water temperature was highest (Figure 3). Unspecked hardyheads (*Craterocephalus stercusmuscarum fulvus*), dwarf flat-headed gudgeons (*Philypnodon macrostomus*) and Murray River rainbowfish (*Melanotaenia fluviatilis*) were all found in low abundance over the entire sampling period for the outlet channel (Figure 3).

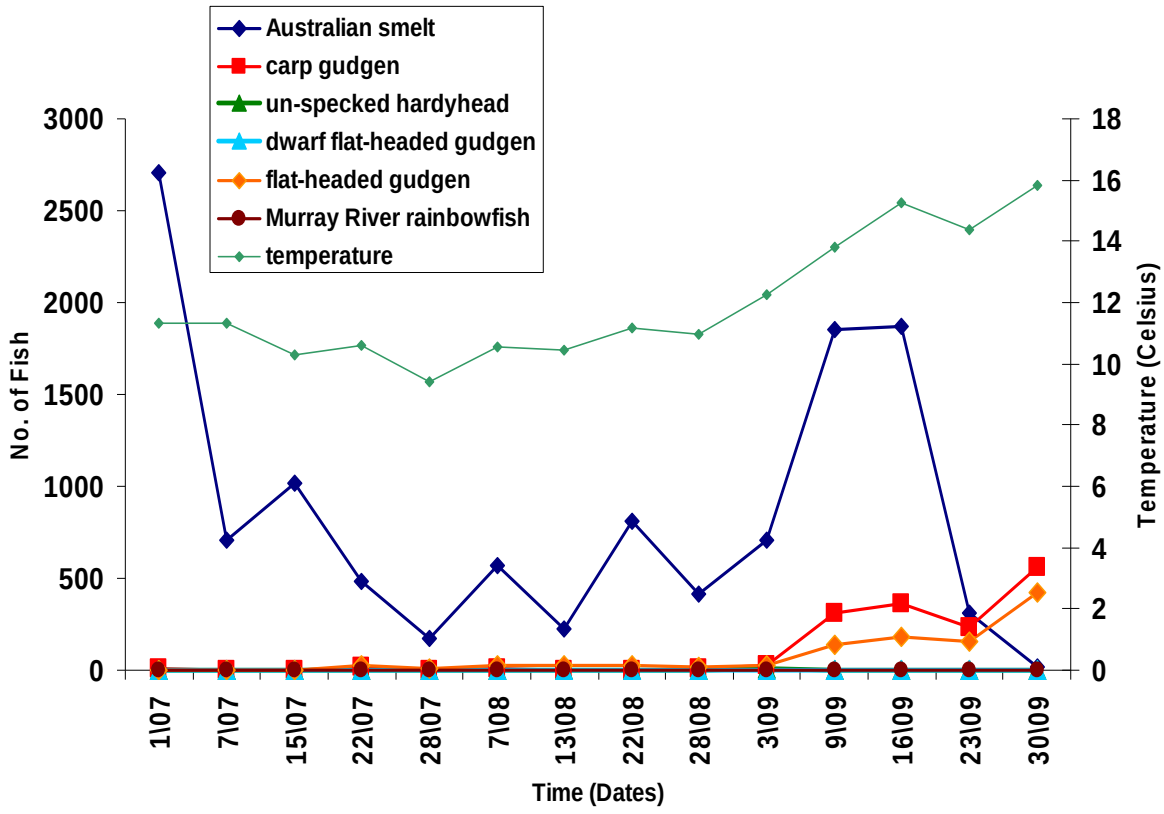

Figure 3. The total abundance of small-bodied native fish species captured at the outlet channel from the 01/07/08 to 30/09/08 plotted with temperature.

Large-bodied native fishes

Inlet

The total abundance of bony herring (*Nematalosa erebi*) fluctuated over the entire sampling period, with peak abundance occurring in mid August (13/08/08) when water temperature was low (Figure 4). One freshwater catfish was captured moving into Banrock wetland in late August (28/08/08) (Figure 4).

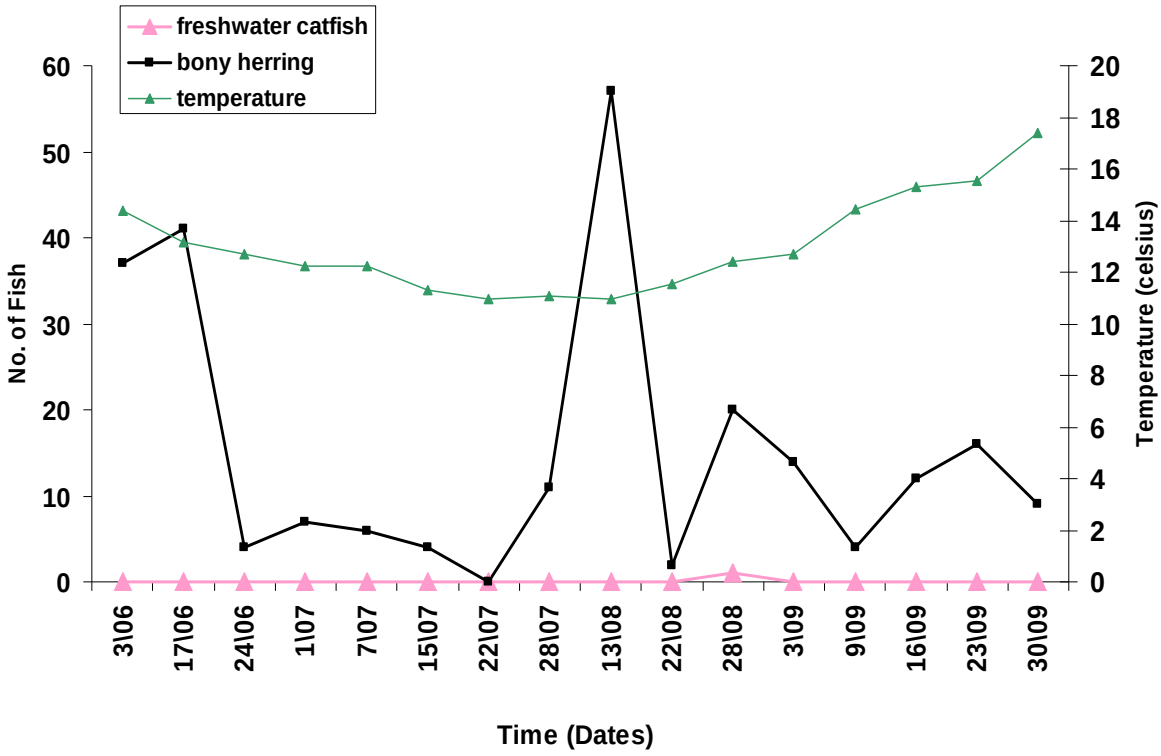

Figure 4. The total abundance of large-bodied native fish species captured at the inlet channel from the 03/06/08 to 30/09/08 plotted with temperature. *(Note: Majority of fish were juvenile, with the exceptions of a few individuals which by-passed the carp separation cage either by swimming under the attaching wings, which directs the fish into the cage or when the separation cage was removed for processing).

Outlet

Golden perch (*Macquaria ambigua*) was the only large-bodied native fish captured moving into Banrock wetland via the outlet channel with only two juveniles captured in early September (3/09/08 and 9/09/08) (Figure 5).

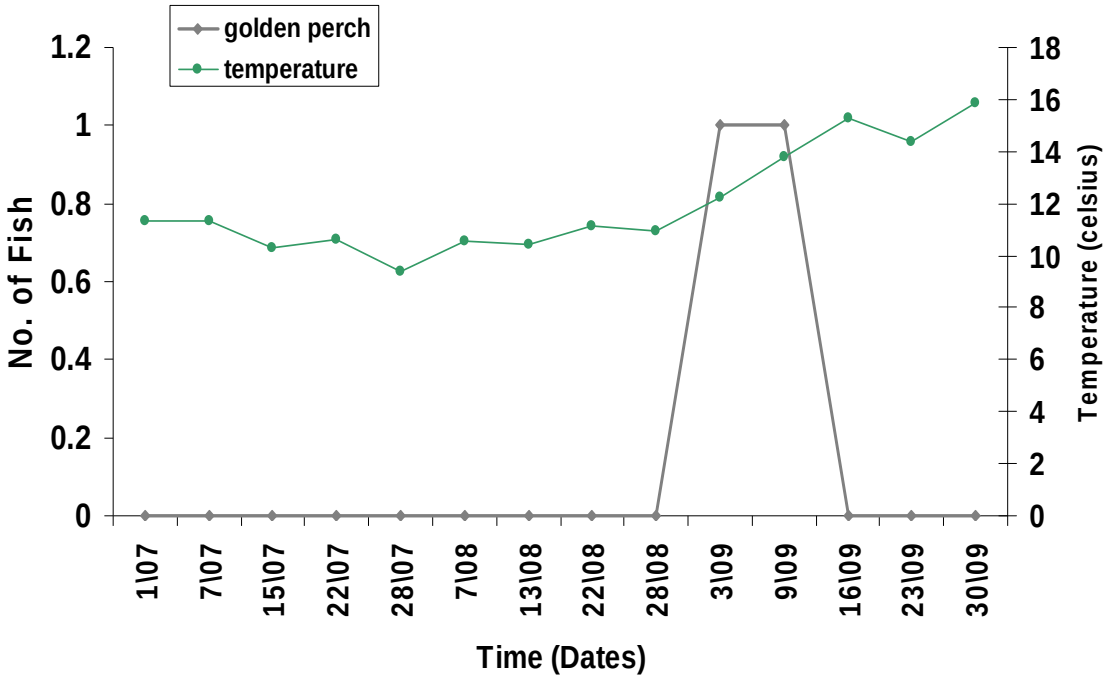

Figure 5. The total abundance of large-bodied native fish species captured at the outlet channel from the 01/07/08 to 30/09/08 plotted with temperature. *(Note: Individuals e.g. golden perch by-passed the carp separation cage either by swimming under the attaching wings, which directs the fish into the cage, or when the separation cage was removed for processing).

Invasive alien fishes

Inlet

Goldfish (*Carrasius auratus*) had the highest total abundance of the invasive alien species captured at the inlet, with peak abundance occurring in the first week of sampling (3/06/08) (Figure 6). The total abundance of eastern gambusia (*Gambusia holbrooki*) peaked in late September (23/09/08) as water temperature was increasing (Figure 6). Common carp, (*Cyprinus carpio*), were in low abundance over the entire sampling period at the inlet channel (Figure 6).

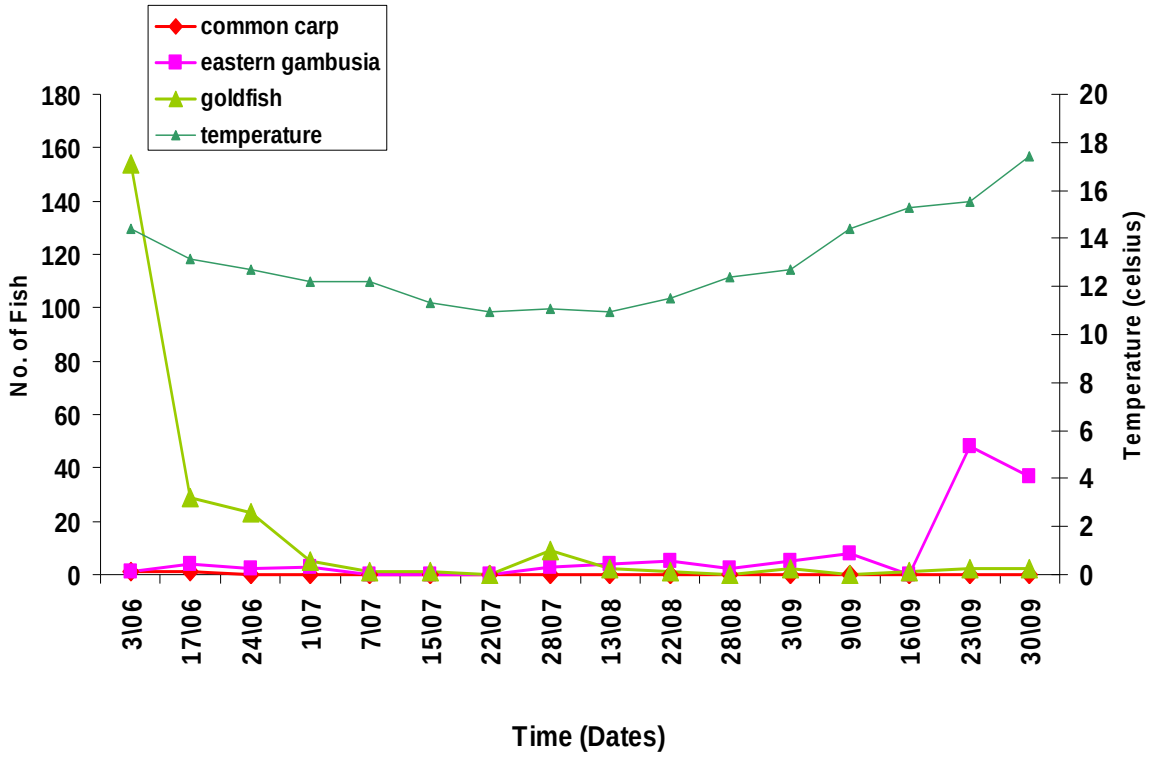

Figure 6. The total abundance of invasive alien fish species captured at the inlet channel from the 03/06/08 to 30/09/08 plotted with temperature. *(Note: The large-bodied fish e.g. common carp, goldfish by-passed the carp separation cage either by swimming under the attaching wings, which directs the fish into the cage, or when the separation cage was removed for processing).

Outlet

The total abundance of goldfish (*Carrasius auratus*) increased as water temperature increased, with peak abundance recorded in early September (9/09/08). Both eastern gambusia (*Gambusia holbrooki*) and common carp (*Cyprinus carpio*) were recorded in low abundance in the outlet channel over the entire sampling period (Figure 7).

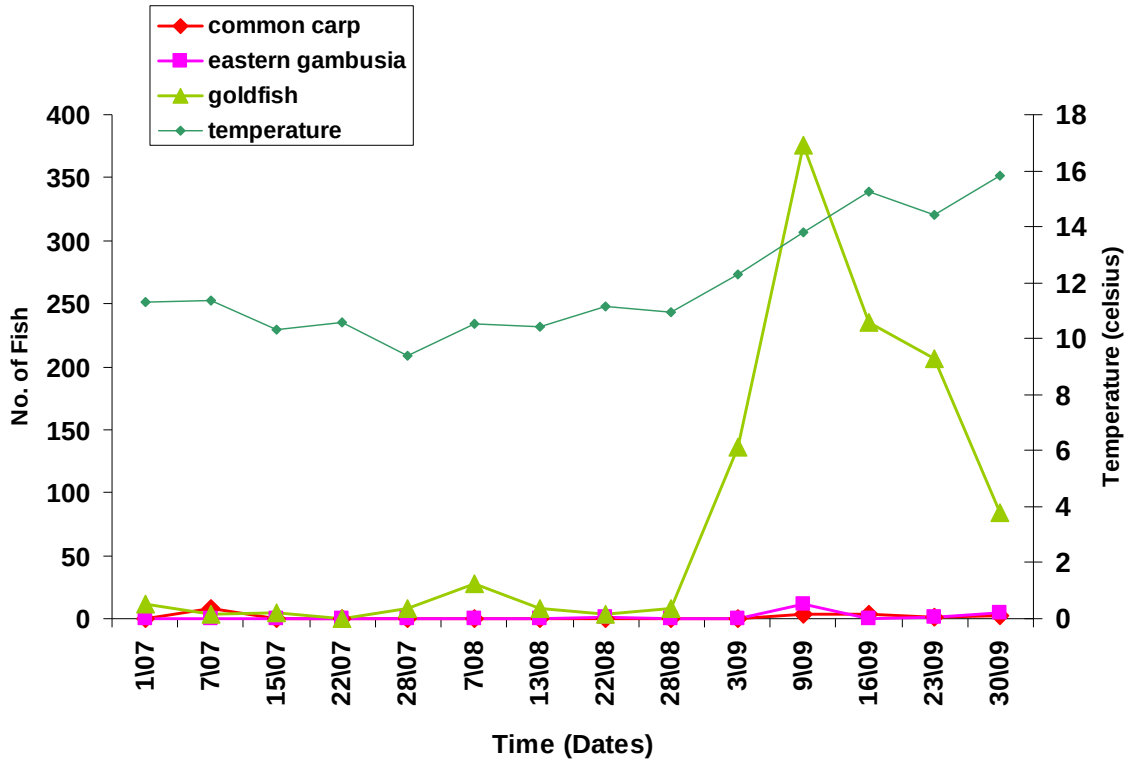

Figure 7. The total abundance of invasive alien fish species captured at the outlet channel from the 01/07/08 to 30/09/08 plotted with temperature. *(Note: The large-bodied fish e.g. common carp, goldfish by-passed the carp separation cage either by swimming under the attaching wings, which directs the fish into the cage, or when the separation cage was removed for processing).

Discussion

The catch of 12 fish species recorded from Banrock Station wetland compares with fourteen fish species recorded previously from wetlands in the same (Riverland) region during the 2004-7 River Murray Wetlands Baseline Surveys (see further, Holt et al. 2004; Smith 2006; Smith et al. 2007; Smith and Fleer 2007). The only species not captured attempting to enter Banrock Station wetland, via the inlet or outlet channels, includes one large-bodied native species (silver perch, *Bidyanus bidyanus*) and one large-bodied alien invasive species (redfin perch, *Perca fluviatilis*). The absence of silver perch in this study may result from the species preference of deeper habitats. Typically, silver perch are confined to the main river channel and are only occasionally captured in wetland/anabranch systems that are deeper than approximately 1.5 m; Banrock Station wetland has an average depth of just 0.5 m (SARDI Aquatic Sciences, Unpublished Data). The absence of redfin perch is difficult to explain and warrants further investigation as the species has been recorded at >54 % of the 24 wetlands previously surveyed in the Riverland region. Otherwise, apart from freshwater catfish, every fish species captured at Banrock Station wetland has previously been found to be common within wetlands of the Riverland region (see further, Holt et al. 2004; Smith 2006; Smith et al. 2007; Smith and Fleer 2007).

Overall, it is clear that a majority of mature large-bodied carp, which are most destructive in wetlands, attempted to migrate into Banrock Station wetland at approximately the same time as the many small-bodied native fishes (mid-September; see Appendix A for the temporal trend in carp catch). Thus, carp management options need to closely consider the passage requirements of native fishes. Designs for optimized carp exclusion screens and carp jumping/pushing traps are available via discussions with staff in the Invasive Species Sub-Program at SARDI Aquatic Sciences.

Acknowledgements

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Appendix A.

Temporal pattern in the catch of carp attempting to enter Banrock Station wetland via the outlet channel (24 June to 16 Dec 2008)

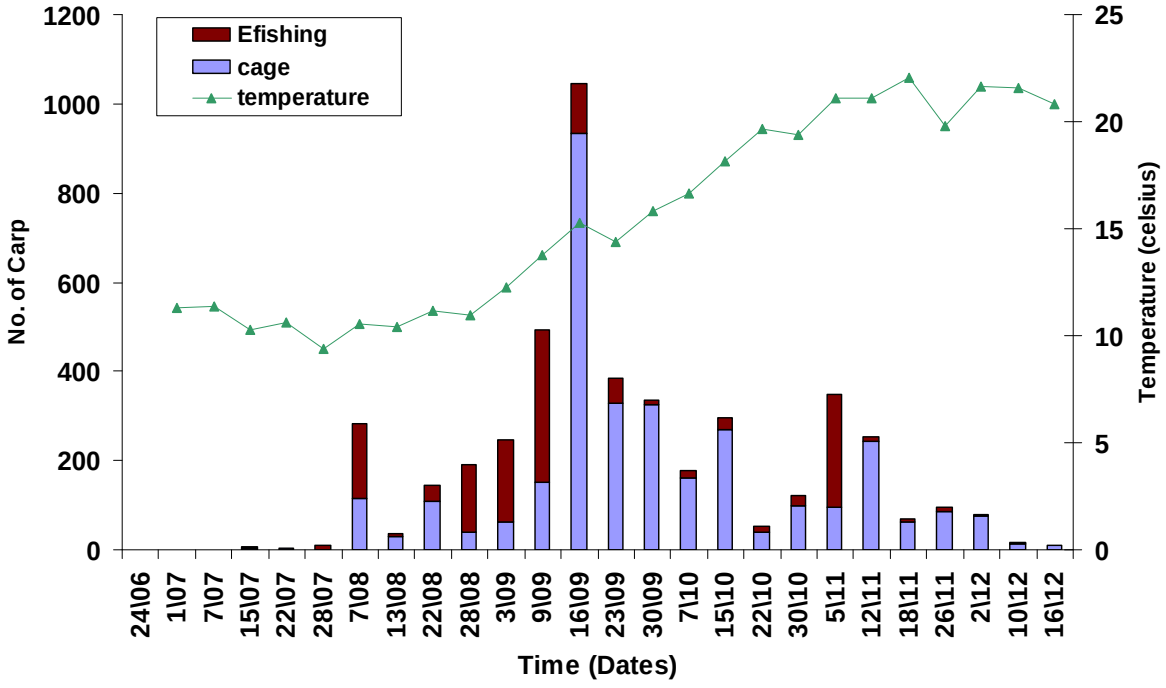

Figure 8. Total abundance of carp moving into the Banrock Station wetland via the outlet channel from the 24/06/08 to 16/12/08 plotted with water temperature.