
Restoring large bodied fish populations at Millewa Forest

Project status and summary report

Clayton Sharpe



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Contact us

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NSW National Parks and Wildlife Service
23 Neil St, Moama
03 5483 9100

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Introduction

Background

Barmah-Millewa Forest (B-MF) is a vast (66, 615ha), highly complex floodplain wetland ecosystem of the mid-Murray River. B-MF has international significance under the Ramsar Convention (Ward 2005) and is one of six icon sites for the Murray-Darling Basin Authority's Living Murray initiative. River redgums characterise the forest, which is also recognised for its complex network of aquatic habitats including rivers, permanent and temporary creeks, permanent lagoons, swamps and wetlands and the floodplain proper; all of which are totally inundated during large floods from the Murray River. The ecology of B-MF is dependent on flows from the Murray River, and ecological links with the river are important in considerations for understanding the processes affecting the status of B-MF native fish communities.

Historically, twenty eight species of fish were recorded at B-MF (18 native: 10 exotic) (Lyon et al. 2002). This diversity has declined over past decades, with nineteen species recorded between 2007- 2009 (McKinnon 1997; Jones and Stuart 2004; Raymond et al. 2011; Sharpe and Wilson 2012). Since 2009, species diversity has declined further, with the most recent assessments reporting nine native and four non-native fish species (Raymond et al. 2011; Sharpe and Wilson 2012; Sharpe et al. 2014; Pearce et al. 2018; Sharpe 2018).

These include the native large bodied Murray cod, trout cod, golden perch and silver perch as well as small bodied species such as carp gudgeons, Australian smelt, un-specked hardyhead and Murray-Darling rainbowfish amongst others, and exotic species including common carp (carp), goldfish, Oriental weatherloach and Eastern gambusia. Notably, one species has recently become locally extinct - the endangered southern pygmy perch, which has not been recorded at B-MF since 2009 (Sharpe and Wilson 2012; Pearce et al. 2018). Furthermore, several native species including Bony herring, flatheaded gudgeon and trout cod have been recorded as only a few individuals in recent surveys (Raymond et al. 2011; Sharpe and Wilson 2012; Pearce et al. 2018; Sharpe 2018).

The continued decline in overall native species diversity and the increasing rarity of many native species, particularly on the floodplain, is cause for concern for river managers and requires urgent management intervention.

Purpose

This document provides an update on the status of a targeted project that aims to demonstrate the potential for large bodied native fish to colonise lateral anabranch habitats at B-MF upon intervention of restoring perennial, optimised flow regimes to anabranch creeks at Millewa Forest, with the aim of restoring robust large bodied native fish populations. The project logic is to demonstrate if the intervention of restoring perennial flows to regulated anabranches at B-MF can result in the expansion of large bodied native fish populations, rather than the mere re-distribution (i.e. fish move in and out) of native fish from adjacent riverine habitats, which is thought to occur seasonally.

The approach is to monitor the movement of native fish in two anabranch types: i) perennially flowing anabranches (after intervention) and ii) seasonally flowing anabranches. Perennially flowing anabranches are the Edward River (upper reach) and Gulpa Creek, and seasonally flowing anabranches are Toupna Creek and the little Edward River. The objective is to determine if native fish colonise, permanently occupy and reproduce to form self-sustaining populations in the perennially flowing habitat but exit (or attempt to exit) the seasonal habitat when flows cease, which occurs under the current management regime.

The responses of fish to flow interventions are being measured by acoustic telemetry, whereby a sample of fish are tagged with acoustic transmitters and their movements recorded on strategically positioned

acoustic receivers (loggers). The learnings from this work will inform the potential for recovery of native fish populations in anabranches across B-MF, and elsewhere throughout the MDB, via the intervention of restoring perennial flows to suitable habitats.

Project status

The project commenced in summer (January) 2017, when

- Large bodied fish populations were surveyed in Edward River, Gulpa Creek, Toupna Creek and Little Edward River by boat electrofishing and fyke netting.
- *Toupna Creek and Little Edward River were not able to be surveyed by boat electrofishing and fyke netting only was conducted.
 - There were no large bodied native fish surveyed in Toupna Creek or Little Edward River.
 - Table 1 shows the relative proportions of large bodied native fish species sampled in Edward River and Gulpa Creek.
- Figures 1 and 3 show the population structure of large bodied native fish in Edward River and Gulpa Creek, respectively.
- 42 Murray cod from Edward River (n= 26) and Gulpa Creek (n= 16) were implanted with uniquely coded acoustic transmitter tags in January and April 2017. Details of acoustically tagged fish and methods are provided in Appendix 1 Table 1.
- A network of acoustic receivers (loggers) was deployed at key effluent points and at strategic locations throughout Millewa Forest in January 2017 to passively record the movements of acoustically tagged fish throughout the Millewa system. Details of the acoustic receivers are provided in Appendix 1 Table 2.
- Loggers were downloaded in December 2017 and again in March and June 2018, when they were serviced (i.e. batteries changed). Data has been warehoused with NSW NPWS and analysis will be undertaken at a strategic time relative to the project's completion.
- A further 30 acoustic transmitters were procured in August 2018 for deployment into large bodied native fish in the Murray and Edward River's adjacent to the offtakes to the study anabranch creeks (i.e. upstream and downstream of Mary Ada regulator, Edward River offtake, Gulpa Creek offtake, Little Edward River offtake). These are held by NPWS. The aim of tagging fish in the Murray is to increase understanding of their movement patterns from the river into the study anabranch creeks.
 - The additional tags will be deployed in September/October 2018 by the Arthur Rylah Institute (DELWP).
 - At the time of sampling for the deployment of the extra tags, large bodied native fish population structure will again be recorded, providing the 2018 population structure information.
- An additional 6 acoustic receivers were procured in August 2018. These will be deployed in the Murray River and Edward River during October 2018.

Table 1. Species diversity and abundance for large bodied native fish surveyed in Edward River and Gulpa Creek by boat electrofishing in January and April 2017.

Large bodied native fish	Total number	
	Edward River	Gulpa Creek
Murray cod	24	16
Trout cod	13	5
Golden perch	0	1
Silver perch	0	1

Table 2. Description of reaches surveyed by boat electrofishing in Edward River and Gulpa Creek. * Code relates to georeference for each logger listed in Appendix 1 Table 2.

	#	Reach Description	Code*
Edward River	1	100m downstream and up to the abutments of the Edward River offtake regulator	Edward River @ ds ER/Murray R offtake reg
	2	3 km downstream of the Edward River offtake regulator near the junction of Chimney Creek	Edward River 3km ds ER/Murray R offtake reg
	3	From the outfall/junction of Little Edward River to 3 km upstream	Edward River us Little Edward Junction
	4	From the outfall/junction of Little Edward River to 3 km downstream	Edward River 3km ds Little Edward Junction
	5	From the outfall/junction of Gulpa Creek to 300m downstream	Edward River us Gulpa Ck junction
	6	From the outfall/junction of Gulpa Creek to 2 km upstream	Edward River us Gulpa Ck junction
Gulpa Creek	1	30m and up to the abutments of the Gulpa Creek off-take regulator	Gulpa Creek offtake reg ds
	2	3 km downstream of Gulpa Creek offtake regulator	Gulpa Creek 3km ds offtake reg ds
	3	From the Gulpa Creek walk bridge to 5 km downstream	Gulpa Creek 3km ds Mathoura
	4	From the outfall/junction to the Edward River to 2 km upstream	Gulpa Creek us Edward Junction
	5	From Pepe's walk bridge to 1km upstream	Gulpa Ck US Bird hide

In June 2017, the flow path and pattern in Toupna Creek was examined by delivering water held in environmental accounts, via Mary Ada regulator. There was extensive breakout of flow from the Toupna Creek channel to the floodplain, whereby Cornella Creek commenced to flow, and ~80 ha of forest floodplain was inundated. NSW OEH Regional Operations environmental water managers and NSW NPWS staff identified that the breakout of water to the forest was occurring at low flows through Mary Ada Regulator (~200 ML/d; one bay was partially opened) and the regulator was progressively closed, within 6 days of the trial commencing, to avoid further non-target floodplain inundation. It was identified that delivering a perennial flow regime in Toupna Creek was not possible under the current regulated conditions (i.e. non-flood) without accounting for, and causing, floodplain and non-targeted forest inundation.

It was decided by the Millewa Forest Large Bodied Fish Recovery Project steering committee in July 2017 that the focus of restoring perennial and optimised flow regimes for native fish at Millewa Forest would shift to Edward River, Gulpa Creek and potentially, Little Edward River, with Toupna Creek de-prioritised until further examination of hydro-geomorphology processes were undertaken. Rather, the patterns of fish movement into and throughout Toupna Creek are continuing to inform the project, whereby Toupna Creek is considered a 'seasonally flowing anabranch' and is therefore retained in the project logic of informing patterns of native fish movement, residency and population recovery in relation to perennially flowing anabranches (i.e. Edward River, Gulpa Creek).

In December 2017, March and June 2018, fish movement data from the acoustic receiver network was downloaded. There were more than 276000 records of acoustically tagged fish recorded up to June 2018 in the study area. This data has not yet been analysed (nor budgeted for). The acoustic receivers will again be downloaded in October 2018 and again in 2019.

There are two options for analysis of the fish movement patterns recorded by the acoustic loggers:

1. Interim analysis; whereby fish movement patterns would be analysed in 2018 and again in 2019 and the findings used to evaluate the influence of the flow interventions aimed at promoting native fish colonisation and residency in Edward River and Gulpa Creek and movement from the Murray River into Toupna Creek, and from Edward River into Little Edward River. Interim analysis would enable refinements to regulator operations and flow delivery schedules to those target systems to be refined.
2. Analysis of all data at the projected project completion date (2020).

Summary of findings: Large bodied fish population structures at Millewa Forest in Edward River and Gulpa Creek.

Species diversity and abundance: Large bodied native fish

Large bodied native fish were encountered in Edward River and Gulpa Creek, but not in Toupna Creek or Little Edward River during January and April 2017. Large bodied fish species diversity was higher in Gulpa Creek, where silver perch and golden perch were encountered, but these were not detected at the Edward River sites. Murray cod and trout cod were recorded in both Edward River and Gulpa Creek. Table 1 depicts the abundance of large bodied native fish species in Edward River and Gulpa Creek.

Population structure for Murray cod and trout cod in Edward River and Gulpa Creek.

The population structure, or demographic for Murray cod in Edward River and Gulpa Creek was similar (Figure 1). Fish in Edward River ranged from 270 mm- 645 mm long and in Gulpa Creek 316 mm- 747 mm. Notably, there were no young of the year (age 0+ years) juvenile Murray cod recorded in either system and only twelve fish greater than the minimum legal size for take by anglers were recorded, potentially indicating that angling pressure may influence population structure. The Murray cod population structure overall was considered fractured because of the absence of fish < 270mm and larger fish > 750mm. Restoring a more complete population structure, such as that that occurs in the lower Darling River (Figure 2), is the primary aim for both populations and ultimately, the objective of the targeted and optimised flow delivery schedules being applied in Gulpa Creek and Edward River since commencement of this project in January 2017.

Recruitment of Murray cod to Edward River and Gulpa Creek is key to the long-term viability and resilience of those populations, especially in the context of hypoxic blackwater disturbance events that may occur in the future, and to angling pressure. In the regulated Edward River and Gulpa Creek, applying environmental water to ensure that recruitment events are maximised within operational constraints supports native fish population resilience. Maximising population resilience should be recognised as a priority for long-term conservation management for Murray cod at Millewa Forest.

Trout cod were recorded in both Edward River (n= 12) and Gulpa Creek (n= 5). The population structures, albeit that a relatively low number of individuals was recorded, were different between the two systems (Figure 3). Smaller fish were present and dominated the population structure in Edward River < 330 mm long) and there were no larger fish present. In Gulpa Creek, no fish smaller than 310 mm long were recorded (Figure 3). Overall, the population structure for trout cod in both systems was highly fragmented and abundance was low and does therefore not represent a robust or resilient population structure. Like for Murray cod, trout cod population recovery is a main objective of the targeted and optimised flow delivery schedules being applied to Gulpa Creek and Edward River. Trout cod have similar reproductive requirements to Murray cod and it is recognised that the optimised hydrographs being delivered to Gulpa Creek and Edward River can enhance outcomes for this endangered species.

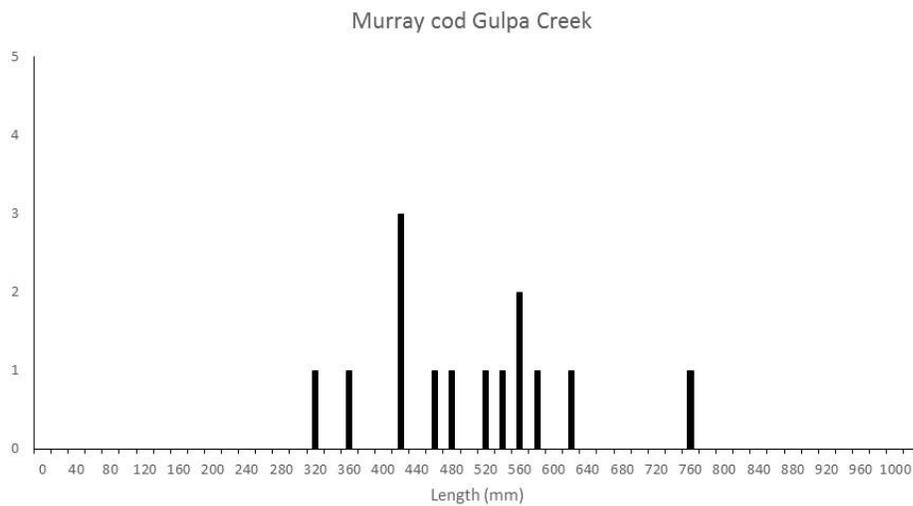
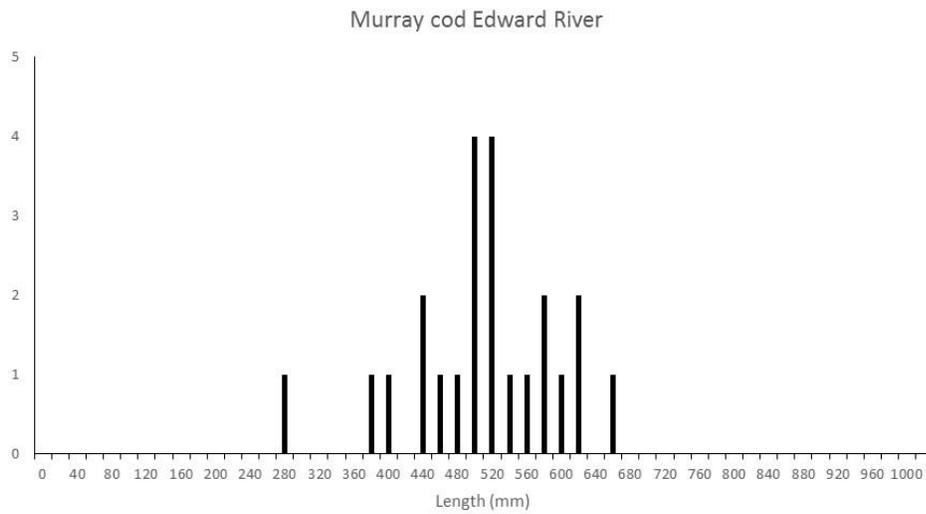


Figure 1. The population structure for Murray cod sampled across six sites in the Edward River (top) and five sites in Gulpa Creek (bottom) in January and April 2017. Young of year (YOY) sized fish spawned during the previous breeding season (October-December 2016), represented by fish less than 115 mm in total length, were absent from both populations.

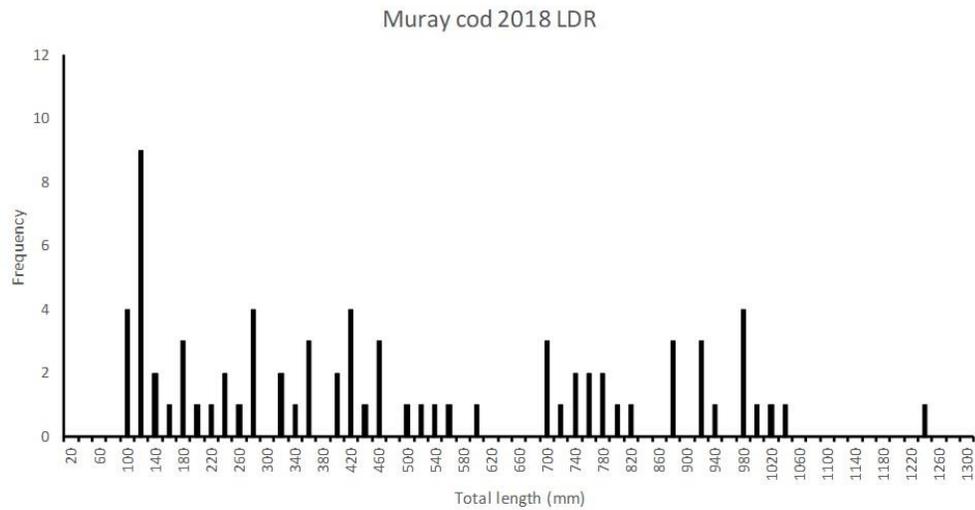


Figure 2. The population structure for Murray cod sampled across thirteen sites of the lower Darling River (LDR) downstream of Menindee during May-July 2018. Young of year (YOY) sized fish spawned during the previous breeding season (October-December 2017) are represented by fish less than 115 mm in total length. Note the frequency for each length class (Y axis) as compared to that for Edward River and Gulpa Creek and the complete population structure – whereby YOY sized fish as well as a full complement of juvenile and adult size classes are represented. Source: Sharpe and Stuart (2018).

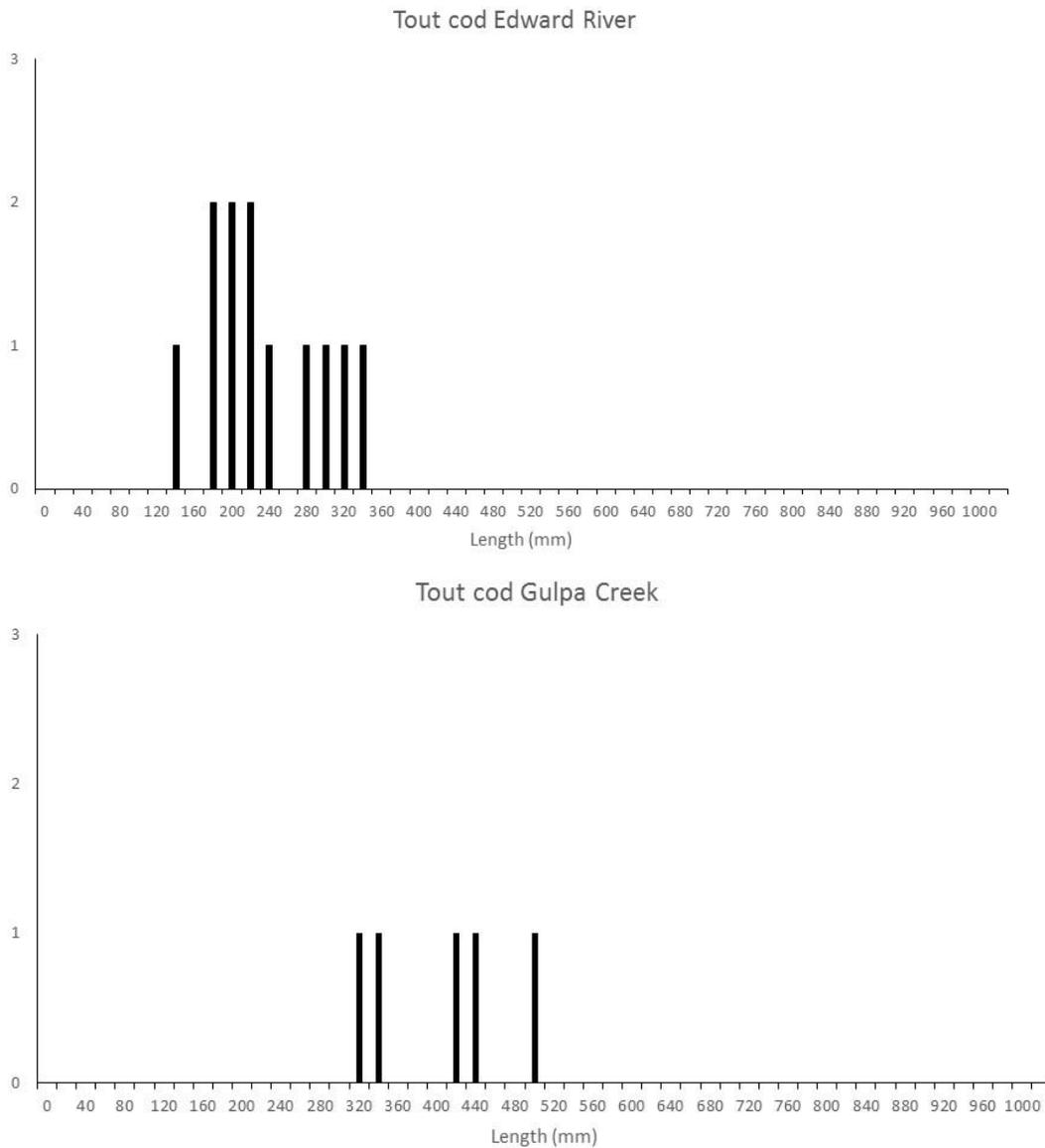


Figure 3. The population structure for trout cod sampled across six sites in the Edward River (top) and five sites in Gulpa Creek (bottom) in January and April 2017. Young of year (YOY) sized fish spawned during the previous breeding season (October-December 2016), represented by fish less than 115 mm in total length, were absent from both populations, as were larger fish > 500 mm long.

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Appendix 1.

Fish survey methods and acoustic tag deployment

The large bodied fish community was surveyed for population structure in Edward River, Gulpa Creek, Toupna Creek and Little Edward River in January and April 2017. Table 2 outlines the location of sampling sites.

Sampling for the fish community survey was conducted from 9th January- 8th April 2017. Small and large fyke nets were set overnight at four sites within each of Edward River, Gulpa Creek, Toupna Creek and Little Edward River (Table 2). Boat electrofishing was conducted at six Edward River and five Gulpa Creek sites, but not in Toupna or Little Edward because of lack of access for the boat (Table 2). All nets were set in the afternoon and retrieved the following morning with set and retrieval time recorded. Large fyke nets had a central wing (8 m x 0.65 m) attached to the first supporting hoop (= 0.55 m) with a mesh entry (0.32 m, stretched) and a stretched mesh size of 28 mm. Small fyke nets had a stretched mesh size of 2 mm, 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).

Boat electrofishing was undertaken at six Edward River and five Gulpa Creek sites (Table 2). The 4.5 m electrofishing boat was equipped with on-board 6.0 Kva Smith–Root Model GPP 5.0 H/L electrofishing systems. The electrofisher was usually operated at 1000 V DC, 7.5 amps pulsed at 120 Hz and 35% duty cycle. The sampling effort at each site (reach) was determined by navigability – whereby fallen trees limited upstream or downstream access. Therefore, sampling time was not standardised at each site, albeit that sampling effort was considerably greater than would have otherwise occurred under routine sampling methodology (Sustainable Rivers Audit methods (Davies et al. 2010) – 12 x 90 second electrofishing shots per survey site).

Large-bodied native fish species were measured for standard total length (TL) or fork length (FL) for fork-tailed species.

There were no large bodied native fish captured in fyke nets at any site. Their use for subsequent elements of this project is considered therefore not efficient and it is recommended that electrofishing only be employed for the survey of large bodied native fish at Millewa Forest.

Acoustic transmitters

Acoustic transmitters are uniquely coded V9-2x-A69-1602 Vemco® type with a 912 day battery life. There were surgically implanted into each fish (Appendix Table 1), under anaesthesia. The surgical techniques followed those developed for Murray cod, Golden perch and other native fish in previous Murray River research projects after O'Connor et al. 2005; 2009; Jones and Stuart 2007; Koehn et al. 2009; Stuart et al. 2010; Sharpe 2011; Stuart and Sharpe 2015. Acoustically tagged fish were measured to the nearest 1.0 mm and their release location (georeference) was recorded (Appendix Table 1).

Acoustic receivers

Acoustic receivers are VR2W-69kHz Coded Acoustic Receiver (69KHz) with BluetoothCode MAP-114Lithium with a Metal Tadiran 5930/F Battery. The deployment locations of receivers are given in Appendix Table 2.

Appendix Table 1. Summary statistics for acoustically tagged fish.

Tag#	Spp	SYSTEM	REACH	Release Date	Release coordinates	
					55H E	S
51448	Murray cod	Gulpa	Gulpa Creek offtake reg ds	8/04/2017	311130	6034684
51663	Murray cod	Edward	Edward River us Gulpa Ck junction	10/01/2017	313509	6051761
51664	Murray cod	Edward	Edward River 3km ds Little Edward Junction	10/01/2017	315398	6039435
51665	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	8/04/2017	317814	6030905
51666	Murray cod	Gulpa	Gulpa Ck us Birdhide	10/01/2017	355057	14458214
51668	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	10/01/2017	317814	6030905
51670	Murray cod	Gulpa	Gulpa Ck us Birdhide	10/01/2017	355057	14458214
51671	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	8/04/2017	355057	14458214
51672	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	8/04/2017	355057	14458214
51673	Murray cod	Edward	Edward River 3km ds Little Edward Junction	10/01/2017	315078	6039820
51674	Murray cod	Edward	Edward River us Little Edward Junction	10/01/2017	316088	6039405
51675	Murray cod	Edward	Edward River us Little Edward Junction	10/01/2017	316088	6039405
51677	Murray cod	Edward	Edward River @ ds ER/Murray R offtake reg	10/01/2017	315612	6039611
51678	Murray cod	Edward	Edward River 3km ds Little Edward Junction	11/01/2017	318898	6031631
51679	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	8/04/2017	355057	14458214
51680	Murray cod	Edward	Edward River 3km ds Little Edward Junction	11/01/2017	315425	6039491
51681	Murray cod	Edward	Edward River us Little Edward Junction	11/01/2017	316088	6039405
51682	Murray cod	Edward	Edward River us Little Edward Junction	9/04/2017	316152	6039491
51684	Murray cod	Edward	Edward River 3km ds Little Edward Junction	11/01/2017	319300	6031264
51685	Murray cod	Edward	Edward River 3km ds Little Edward Junction	11/01/2017	318900	6031631
51686	Murray cod	Edward	Edward River us Little Edward Junction	9/04/2017	35.41'16.0	144.55.42.1
51687	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	8/04/2017	355057	14458214
51688	Murray cod	Gulpa	Gulpa Creek us Edward Junction	11/01/2017	313271	6052190
51689	Murray cod	Gulpa	Gulpa Creek us Edward Junction	11/01/2017	313271	6052190
51690	Murray cod	Edward	Edward River us Gulpa Ck junction	11/01/2017	313516	6051778
51691	Murray cod	Edward	Edward River 3km ds Little Edward Junction	12/01/2017	319300	6031264
51692	Murray cod	Edward	Edward River 3km ds Little Edward Junction	12/01/2017	318884	6031813
51693	Murray cod	Edward	Edward River 3km ds Little Edward Junction	12/01/2017	318887	6031588
51694	Murray cod	Edward	Edward River us Little Edward Junction	9/04/2017	316088	6039405
51695	Murray cod	Edward	Edward River us Little Edward Junction	9/04/2017	316088	6039405
51696	Murray cod	Gulpa	Gulpa Creek 3km ds offtake reg ds	12/01/2017	355057	14458214
51696	Murray cod	Gulpa	Gulpa Creek offtake reg ds	7/04/2017	311130	6034684
51697	Murray cod	Gulpa	Gulpa Creek us Edward Junction	6/04/2017	313206	6052146
51698	Murray cod	Edward	Edward River 3km ds Little Edward Junction	6/04/2017	315819	6039549
51699	Murray cod	Edward	Edward River 3km ds Little Edward Junction	6/04/2017	318914	6031819
51701	Murray cod	Edward	Edward River 3km ds Little Edward Junction	6/04/2017	314688	6040037
51703	Murray cod	Gulpa	Gulpa Creek 3km ds Mathoura	6/04/2017	318055	6030982
51704	Murray cod	Edward	Edward River us Gulpa Ck junction	7/04/2017	313604	6051647
51705	Murray cod	Edward	Edward River 3km ds ER/Murray R offtake reg	7/04/2017	319240	6031115
51706	Murray cod	Edward	Edward River 3km ds Little Edward Junction	7/04/2017	318899	6031610
51707	Murray cod	Edward	Edward River 3km ds Little Edward Junction	7/04/2017	315493	6039452
51708	Murray cod	Gulpa	Gulpa Creek us Edward Junction	7/04/2017	35.41.51.5	144.55.32.6

Appendix Table 2. Acoustic receiver code number, description of location and georeference.

Logger #	Location	UTM	
		55H E	S
100584	Little Edward River ~50m d/s offtake regualtor	55H 0315647	6035553
100597	Pinchgut Ck. d/s guage board	55H 0331556	6033695
103675	Nestrans Regulator	55H 0322771	6032345
104757	Nine Panel Regulator	55H 0323958	6032854
104760	Toupna Bridge	55H 0325988	6034230
126755	u/s Gulpa Creek inlet regualtor	55H 0318768	6030783
126756	Edward River ~5km d/s offtake regualtor u/s fishermans hut	55H 0314681	6040028
126757	Edward River 30m u/s offtake regualtor on standing sheet-pile	55H 0319294	6030867
126758	Gulpa Creek @ Pepes bridge 10m u/s	55H 0316252	6030918
126759	Edward River u/s Little Edward (2)	55H 0316040	6039483
126760	Toupna Creek 300m d/s Mary Ada		
126761	Edward River 30m d/s offtake Reg from Murray on bouys	55H 0319245	6031064
126762	Toupna Creek d/s Mary Ada on guage board	55H 0330900	6034538
126763	Toupna offtake u/s Mary Ada 20m d/s Murray junction	55H 0330828	6034449
126764	Little Edward 75m u/s outfall to Edward River	55H 0315293	6039235
126766	Edward River d/s Little Edward outfall to Edward (1)	55H 0315862	6039440
126767	Gulpa/Edward junction (ds) in E.River	55H 0313607	6052048
126768	Gulpa Ck 500m u/s Edward Junction	55H 03132431	6052050
126769	Toupna/Wild Dog Creek outfall to Edward R	55H 0316362	6034689