Gunbower Island Annual TLM Condition Monitoring Surveys Fish 2017



A report prepared for North Central Catchment Management Authority by CPS Enviro P/L





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Cover photo: Murray cod recruit from Gunbower Creek sampled in 2017. Image: CPS Enviro **Authors:** Clayton Sharpe and Wayne Robinson.

Executive Summary

The Gunbower Island fish community has been monitored annually by the TLM Icon Site condition monitoring program, since 2006. Sampling has been standardised so that each year the same sites are monitored at the same time using the same sampling methods; trapping, netting and electrofishing. The study design enables spatial (between habitat types) and temporal (between years) patterns in fish community structure to be analysed, namely comparing the types of fish species present, their abundance and population demographics, and describes trends for those attributes across habitat types and between survey years.

Analysis of spatial and temporal patterns for the 2017 monitoring year and across the entire monitoring dataset (2006-2017) is based on analytical conventions set by the TLM Condition Monitoring Plan (CMP) for Gunbower Island. This provides the suite of statistical indices for analysis to enable evaluation of the CMP ecological objectives, namely;

Objective 1: An increase in the abundance of native fish species

Objective 2: A range of size classes for each native fish species present in sites

Objective 3: A contribution to population recovery of threatened fish species

The objectives relevant to temporal changes examine trends through time in relation to points of reference (e.g. 2009 for Lagoons; 2010 for River sites). For example, for Objective 1 (increase in abundance of native fish) for the river habitat the *Native species abundance* (I_{SA}) index is calculated as follows:

 I_{SA} = Average status of CPUE (catch per unit effort) (+1 = higher, -1 = lower) for native fish species that were present in 2009.

Continuing with this example for the river, the *Native species abundance* (I_{SA}) index is plotted over time and then the temporal trend in native species abundance can be examined and interpreted in relation to the reference point (i.e. 2010 index) as per Figure i).



Figure i): Index of species abundance at Murray River sites using 2010 abundances as a point of reference. (The ISA has a value of 0 in 2010).

Key findings and ecological condition of the Gunbower Island fish community

The 2017 survey captured a total of 37,298 fish from 14 species (9 indigenous and 5 exotic). Native species far outnumbered exotics but this was due to the numerical dominance of one species; carp gudgeon, which accounted for 64% of the total catch, followed by the exotic Eastern gambusia (17%). The fish community differed considerably between macrohabitats in 2017, with fish being far more abundant at Wetland and Lagoon sites than River or Creek sites. Exotic species were much more prevalent at Wetland sites, comprising around 41% of the total catch in Wetlands, primarily due to very large numbers of the exotic Eastern gambusia. For native fish species to recover in wetlands at Gunbower Forest, connectivity to source populations in Gunbower Creek and Lagoons must be provided, and priority given to maintaining those source populations by provision of appropriate flow regimes to life history requirements. Likewise, movement cues and facilitating movement between source populations is an important management consideration, particularly during managed inundations of Gunbower Forest, when wetlands can be connected to source populations and recovery of wetland fish communities achieved.

Overall, there was a pattern of stability for most ecological indices over time, be it River, Creek, Lagoon or Wetland indices, except for years when there was wide variation, such as 2011 and 2016. The analysis showed that for most indices there was a return to the 'average' or 'stable' level post the variation observed from those years. Those years and fluctuations corresponded to major natural flood events at Gunbower Island, where exotic species such as Common carp and Eastern gambusia increased dramatically in abundance, while native species, especially in Wetlands, declined.

Objective and target attainment summary

Objective # 1 – Increase in the abundance of native fish species

- objective was attained for the River and Creek. In the Lagoon the Objective was not attained, whereby the indices were below the 2009 benchmark, except for I Native abundance and I Native species.
- The Wetland macrohabitat could not be assessed because of an unbalanced experimental design, i.e. because of wet and dry phases for wetlands over the course of the monitoring period.
- In the River, the I Native abundance in 2017 was the highest for any year. This coincided with the collection of particularly low abundances of common carp and Eastern gambusia, and relatively high abundance of Murray-Darling rainbowfish. In the Creek, the I Native abundance was above the 2009 benchmark. Despite exotic species increasing in abundance in the Creek in 2017, the ecological objective was attained.

Objective # 2 – Range of age/size classes of each native species

- The objective was attained for the River, Creek, Lagoon but only for small bodied fish species.
- In 2017, the population structure Murray cod was considerably more robust than in earlier years, especially so compared 2013, when zero recruitment was detected. In 2017, the expected age categories in the creek increased to 47% and this corresponds to numerous individuals being present amongst the juvenile size classes, most likely produced since 2013, and these were most abundant at Gunbower Creek Reach 6 (downstream of Cohuna Weir). The age of the new recruits is post- 2013 (i.e. numerous fish 200-400mm) and this has occurred in association with implementation of the 'large bodied fish hydrograph' by North Central CMA in Gunbower Creek, which targets Murray cod recruitment.

- This was not the case for Murray cod in the River, where there were no young-of-year recruits captured and only 30% of the expected age classes were collected in 2017.
- For golden perch, silver perch and freshwater catfish, populations have remained severely fragmented in size structure and to the point where silver perch were not collected at any site in 2017. As has been frequently reported, recovery of golden and silver perch populations is not expected to occur at Gunbower Island until fish passage is provided at the 'bookend' barriers to Gunbower Creek Headworks and Koondrook Weirs.
- Exotic species including common carp and goldfish populations have always and again in 2017 been represented by strong recruitment and continue to be very robust, whereby abundances increased in the Creek.
- Most small bodied native species exhibited robust population structure with the full range of size/age classes represented.

Objective # 3 – A contribution to population recovery of threatened or absent native fish species.

- Only three of the seven expected threatened species were collected in the River (Murray cod, Murray-Darling rainbowfish and un-specked hardyhead). The diversity of threatened species is low and has declined in 2017. There has been no contribution to threatened species recovery in the River habitat.
- The objective was attained at Creek. The absence of silver perch, but the occurrence of freshwater catfish in the Creek, the first record since monitoring began, has maintained a stable trend for threatened species occurrence in the Creek since 2013.
- In the Lagoon, the occurrence of freshwater catfish, un-specked hardyhead and Murray-Darling rainbowfish has remained patchy and no additional species were recorded in 2017. There has been no contribution to threatened species recovery in the Lagoon habitat.

Descriptive ecological targets from the Gunbower Island CMP:

At least 4 of the 5 commonly occurring native species (i.e. carp gudgeon, flathead gudgeon, Australian smelt, dwarf flathead gudgeon and golden perch) occur in any year.

• This objective was attained for all species with exception of dwarf flathead gudgeon, which was not recorded in 2017.

At least 3 of the 7 less commonly occurring (i.e. bony herring) and/or threatened native species (i.e. Murray-Darling rainbowfish, silver perch, Murray cod, trout cod, un-specked hardyhead, freshwater catfish) occur in any year.

• This objective was attained for four species, albeit that trout cod and silver perch were not recorded in 2017.

A decrease in the abundance of alien fish (i.e. non-indigenous to Gunbower Island) since 2009 (Gunbower Creek and Lagoons) and since 2010 (Murray River)

This objective was not attained at any macrohabitat in 2017, whereby alien species were recorded at similar abundance and spatial distribution

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Introduction

Background

Gunbower Forest comprises the Victorian component of the Gunbower-Koondrook-Perricoota Forest Icon Site, under The Living Murray (TLM) river restoration program managed by the Murray Darling Basin Authority (MDBA). There are six TLM Icon Sites, which are being restored in part via environmental watering and structural works associated with water delivery and fish movement.

This project provides an annual report of the ecological condition of the Gunbower Forest Icon site but reports only on the Victorian component of the Gunbower Forest Icon site and its immediate surrounding waterways, including Gunbower Forest wetlands, Gunbower Creek and associated Lagoons and the Murray River.

The first comprehensive surveys of Gunbower Island fish communities were undertaken in the 1990s (PIRVIC 2007) with subsequent surveys conducted in 1998, 2005 and 2007 (Rehwinkel and Sharpe 2009). In 2008, surveys were aligned to The Living Murray (TLM) Condition Monitoring Program, when survey methods and reporting were standardised and upon from which time surveys have since been conducted annually. In 2016, analysis was based on the application of ecological indices developed specifically for the TLM dataset by Robinson (2015) and that approach is used in this report.

TLM condition monitoring program

This project reports upon progress toward achievement of ecological objectives set for Gunbower Island in the Gunbower Forest Condition Monitoring Plan (CMP) (North Central CMA 2015) by comparing the results of the present survey (2017) to those of previous years for which data are available.

The overarching ecological objectives is:

Maintain healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources

This is assessed by the application of statistical indices outlined in the Gunbower Forest CMP (North Central CMA 2015) that relate to the evaluation of detailed ecological objectives and targets, presented in Table 1.

 Table 1: Relevant objectives for Gunbower fish condition monitoring (adapted from DELWP & NORTH

 CENTRAL CMA 2015).

Overarching objective	Detailed objectives	Targets
Maintain healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources	 An increase in the abundance of native fish using the 2009 abundance as a baseline for Lagoons and the 2010 abundance for the River Murray A range of age/size classes present for each native fish species evidence of recruitment as indicated by Young of Year (YOY) native fish using the species-specific thresholds identified in Sharpe and Villizi (2014) A contribution to population recovery of threatened fish species recovery inferred by an increase in the abundance of each threatened species from 2009 levels 	 At least four of the five commonly occurring native species (i.e. carp gudgeon, flathead gudgeon, Australian smelt, dwarf flathead gudgeon and golden perch) occur in any year. At least four of the seven less commonly occurring (i.e. bony herring) and/or threatened native species (i.e. Murray-Darling rainbowfish, silver perch, Murray cod, trout cod, freshwater catfish) occur in any year. A decrease in the abundance of alien fish (i.e. non-indigenous to Gunbower Island) since 2009.

A number of indicators, associated indices and points of reference were developed and trialled as part of earlier reviews of the TLM Condition Monitoring Program (Robinson 2014, Sharpe and Villizi 2014, Robinson 2015), and are now incorporated into the Gunbower Forest CMP (North Central CMA 2015). These were refined in 2016 by Ecology Australia (2016) which provided a comprehensive revision and development of appropriate indices based primarily on the detailed objectives, with reference to the associated targets where practicable. The points of reference from the 2016 report have been retained here, with 2010 used as a point of reference for the Murray River, and 2009 used as a point of reference for Gunbower Creek and Lagoon macrohabitats.

Monitoring locations

A list of monitoring reaches (within macrohabitats) and years in which each site has been monitored is provided in Table 2. The location coordinates of these sites are listed in the Gunbower Forest CMP (North Central CMA 2015).

Table 2: The Gunbower Forest fish community monitoring site names, macrohabitat categories and years i	in
which they have been sampled.	

Macrohabitat	Site name	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	# of years
	Gunbower Creek Reach 1	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
	Gunbower Creek Reach 2	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
	Gunbower Creek Reach 3	\checkmark	✓	✓	✓	✓	✓	✓		✓	✓	9
Creek	Gunbower Creek Reach 4	\checkmark	✓	✓	✓	✓	✓	✓		✓	✓	9
	Gunbower Creek Reach 5		✓	✓	✓	✓	✓	✓		✓	✓	9
	Gunbower Creek Reach 6	\checkmark	✓	✓	✓	✓	✓	✓		✓	✓	9
	Gunbower Creek Reach 7	\checkmark	✓	✓	✓	✓	✓	✓		✓	✓	9
	Cockatoo Lagoon	\checkmark	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Gum Lagoon	\checkmark	✓	✓	✓	✓	✓	✓		✓	✓	9
	Longmore Lagoon	✓	✓	✓	✓	✓	✓	✓		✓	~	9
Lagoon	Phyland Lagoon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Safe Lagoon	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
	Splatt Lagoon	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
	Taylor Lagoon	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
	Turner Lagoon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Upper Gunbower Lagoon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Black Charlie Lagoon				✓	✓	✓	✓		✓	✓	6
	Black Creek		✓									1
	Black Swamp	✓	✓			✓			✓	✓	✓	6
	Charcoal Swamp				✓	✓						2
	Corduroy Swamp	✓	✓			✓			✓	✓	✓	6
Wetland	Cravfish Island	✓		✓	✓	✓	✓	✓	✓	✓	✓	9
	Green Swamp	✓	✓		✓	✓	✓	✓	✓	✓	✓	9
	Little Reedy Lagoon	✓	✓						✓	✓	~	5
	Reedy Lagoon			✓	✓	✓	✓	✓	✓	✓	✓	8
	Yarran Creek	✓	✓		✓	✓						4
	Murray River Cohuna			✓	✓	✓	✓	✓		✓	✓	7
River	Murray River Koondrook			✓	✓	✓	✓	✓		✓	✓	7
	Murray River Torrumbarry			✓	✓	✓	✓	✓		✓	✓	7
Number of sites s	ampled per vear	22	22	21	25	28	24	23	10	26	26	

In terms of data continuity, the following observations are made:

- Four Lagoon sites have been monitored every year since 2008;
- All Creek sites and the remaining Lagoon sites have been monitored every year since 2008, with the exception of 2015;
- Two Wetland sites have been monitored in nine out of the ten year monitoring period, with Reedy and Crayfish Island monitored annually since 2010;
- The River sites have been monitored annually since 2010, again with the exception of 2015; and
- Most Wetland sites have been monitored sporadically over the monitoring period, with their annual selection being prioritised according to water and habitat availability.

Methods

Fish sampling

Fish surveys were conducted following the methods used in previous condition monitoring surveys and followed the TLM consistent monitoring framework for fish (North Central CMA 2015). Boat electrofishing followed Sustainable Rivers Audit (SRA) protocols (12 × 90 s machine time shots) and was conducted at all seven reaches of Gunbower Creek, within each of the nine Lagoon reaches, and at the three reaches of the River Murray. At each of the seven Wetland reaches, backpack electrofishing was conducted following SRA protocols for wetlands (8 × 150 s machine time shots). At each electrofishing site, 10 unbaited concertina bait traps were set for a minimum of two hours soak time. Four pairs of large and small fyke nets were set at each survey site. Nets were set in the afternoon and retrieved the following morning with set and retrieval time recorded for calculation of catch per unit effort (CPUE). Details for nets are described by Sharpe et al. (2012). Fish identifications followed McDowall (1996) and Lintermans (2007). All carp gudgeons were identified to genus level only (i.e. Hypseleotris spp.) owing to the current taxonomic uncertainty. The first 50 individuals captured from each species at each site were measured for standard (SL) and total length (TL) (nearest 1 mm), whilst individual weights (nearest 1 g) were recorded for the large-bodied species only.

As per the TLM and SRA approaches, the choice between boat or backpack electrofishing at a given site, depended on waterbody size, depth and boat access considerations. An outline of the sites sampled and sampling techniques for the 2017 program is provided in Table .

 Table 3: Sites sampled and sampling effort for fish in Gunbower Forest Icon Site in 2017.

		Electrofishing 'power c	g effort (shots of on' seconds)	Bait	Fyke nets (#)		
Macronabitat		Boat Backpack		traps (#)	Coarse- meshed	Fine- meshed	
	Gunbower Creek Reach 1	12 x 90		12	4	4	
	Gunbower Creek Reach 2	12 x 90		12	4	4	
	Gunbower Creek Reach 3	12 x 90		2	4	4	
Creek	Gunbower Creek Reach 4	12 x 90		12	4	4	
	Gunbower Creek Reach 5	12 x 90		12	4	4	
	Gunbower Creek Reach 6	12 x 90		12	4	4	
	Gunbower Creek Reach 7	12 x 90		12	4	4	
	Cockatoo Lagoon	12 x 90		12	4	4	
	Gum Lagoon	12 x 90		12	4	4	
	Longmore Lagoon	12 x 90		12	4	4	
	Phyland Lagoon	12 x 90		12	4	4	
Lagoon	Safe Lagoon	12 x 90		12	4	4	
	Splatt Lagoon	12 x 90		12	4	4	
	Taylor Lagoon	12 x 90		12	4	4	
	Turner Lagoon	12 x 90		12	4	4	
	Upper Gunbower Lagoon	12 x 90		12	4	4	
	Black Charlie Lagoon	12 x 90		12	4	4	
	Black Swamp		8 x 150	12	4	4	
	Corduroy Swamp		8 x 150	12	4	4	
Wetland	Crayfish Island	8 x 90		12	4	4	
	Green Swamp		8 x 150	12	4	4	
	Little Reedy Lagoon		8 x 150	12	4	4	
	Reedy Lagoon		8 x 150	12	4	4	
	Murray River Cohuna	12 x 90		12	4	4	
River	Murray River Koondrook	12 x 90		12	4	4	
	Murray River Torrumbarry	12 x 90		12	4	4	

2017 Index calculations

The fish condition monitoring objectives fall within three categories:

Objective 1: Abundance of native fish

Objective 2: Size classes of native fish species

Objective 3: Threatened native fish species populations

The objectives are addressed separately for each macrohabitat (i.e. River, Creek, Lagoon & Wetland) by examining the scores of selected indices within each objective category. Full details and examples of the calculations for each objective and the corresponding indices are included in Appendix 1 of the 2016 report (Ecology Australia 2016).

Objective 1: Abundance of native fish species

For each site, the following indices were calculated:

I Native abundance = the proportion of fish abundance in each site that are native,

I Native species = the proportion of fish species in each site that are native and,

I Native expected = the proportion of historically expected native species present in each site.

Objective 2: Size classes of native species

These indices are calculated for each micro habitat;

I Age category = the proportion of native fish species age categories present compared to the reference value for that macrohabitat, and;

 $I_{Recruitment}$ = the proportion of native fish species present that had YOY × (the number of native species collected ÷ the best achievable number of species collected for that macrohabitat).

Objective 3: Threatened native fish species

The following site-based index is calculated:

I _{Threatened species present} = The number of threatened species present ÷ expected number present for each site

Further, an overall index for each habitat for the year is calculated:

I Threatened species occurrence = The average proportion of sites that the threatened species occur in for that habitat

2008-2017 Index calculations and comparisons

The objectives relevant to the temporal changes are the same as applies to the 2017 data. However, the focus is to examine trends through time and the qualifying aspects of the objectives (e.g. 'an increase in...') in relation to points of reference (e.g. 2009 for Lagoons). Further, the nature of the data collected require some changes to individual indices. The age classes objective in the long-term trend analyses is restricted to the two large-bodied species Murray cod and Golden perch, as these are the species of greatest interest in terms of recruitment, and they also have consistent length

measurement data back to 2008. Examples of the calculations for each objective and each of the corresponding indices are included in Appendix 1 of the 2016 report (Ecology Australia 2016). All of the indices scores are set to a maximum of one and a minimum of zero.

Objective 1: An increase in the abundance of native fish species

The Native species abundance (I_{SA}) index

 I_{SA} = Average status of CPUE (+1 =higher, -1 = lower) for native fish species that were present in 2009.

Objective 2: A range of size classes for each native fish species present in sites

The length data for are Murray cod and golden perch and the threshold lengths for adults and YOY are used to calculate a Large Bodied age categories (LBAC) index.

• I_{LBAC} = number of Murray cod and golden perch YOY, Sub-adult, and adult age categories present ÷ 5

An additional index to determine how many of the sites sampled had YOY present for each of the large bodied species (*large-bodied native species YOY extent (LBYOY*)) is also calculated;

 $I_{\mbox{\tiny LBYOY}}$ = average proportion of (creek or river) sites containing Murray cod and golden perch YOY

Objective 3: A contribution to population recovery of threatened fish species

The two indices calculated are *Proportion of Threatened Species Compliance*, and; *Threatened Species Occurrence*:

I Threatened species occurrence= The average proportion of sites that the threatened species occur in for that habitat

I Threatened species compliant = The proportion of the seven threatened species that occur in at least as many sites as expected

The *threatened species compliance* index differs from the 2017 snapshot *threatened species present* index as it is calculated to apply to the entire macrohabitat rather than the individual site.

Results

Overview

The 2017 survey captured a total of 37,298 fish from 14 species (9 indigenous and 5 exotic) (Table 4). Native species far outnumbered exotics and the most abundant species was the native carp gudgeon (64% of the total catch) followed by Eastern gambusia (17%). The fish community differed considerably between macrohabitats, with fish being far more abundant at Wetland and Lagoon sites than River or Creek sites. Exotic species were much more prevalent at Wetland sites, comprising around 41% of the total catch, primarily due to very large numbers of Eastern gambusia. Notably, the native species, bony herring (*Nematalosa erebi*), and freshwater catfish (*Tandanus* tandanus) were only recorded in low numbers, whilst trout cod (*Maccullochella macquariensis*) and silver perch were not recorded in any habitats in 2017.

Table 4: Overview of Gunbower Icon Site 2017 survey catch results (exotic species shaded). Note that the table does not and is not intended to provide an estimation of absolute abundance at a macrohabitat or whole of icon site scale.

Common name	River	Creek	Lagoon	Wetland	Total
Australian smelt	224	425	2478	160	3291
Bony herring	10	4	0	0	14
Carp gudgeon	315	2168	15858	6520	25316
Flathead gudgeon	1	13	740	2	826
Freshwater catfish	0	1	1	0	5
Golden perch	7	12	1	0	20
Murray cod	6	28	1	0	34
Murray-Darling rainbowfish	57	40	65	61	226
Un-specked hardyhead	5	428	1565	12	2011
Common carp	21	75	78	551	744
Eastern gambusia	7	487	696	4046	6722
Goldfish	0	5	30	60	97
Redfin	0	0	5	2	7
Oriental weatherloach	0	3	0	22	25
Number of fish caught	653	3689	21520	11436	39346
# native	647	3089	21252	6756	31744
# exotic	28	570	2316	4681	7595

River

The 2017 survey of the River sites captured 653 fish from 10 species (8 native and 2 exotic) (Table 4). Three small-bodied species, Carp gudgeon, Australian smelt (*Retropinna semoni*) and Murray-Darling rainbowfish (*Melanotaenia fluviatilis*) together comprised 91.27% of the total catch. The most abundant large-bodied species was common carp (3.22%) and golden perch (1.07%). Silver perch were not collected at any of the three river sites in 2017 (Table 5).

Creek

The 2017 survey of Gunbower Creek captured 3689 fish from 13 species (9 native and 4 exotic) (Table 4). Three small-bodied native species, Carp gudgeon, Australian smelt and Un-specked hardyhead together comprised 82% of the total catch. Carp were the most captured large-bodied species. Silver perch were not collected in the Creek, while Freshwater catfish were (Table 6).

Lagoon

The 2017 survey of the Lagoon sites captured 21,520 fish from 12 species (8 native and 4 exotic) (Table 4). Carp gudgeon dominated the catch (73.69%) followed by Australian smelt (11.52%) and Un-specked hardyhead (7.27%). Flathead gudgeon were collected at higher abundance in the Lagoon compared to all other habitats and Murray-Darling rainbowfish were collected at the majority of Lagoon sites (Table 7).

Wetland

The 2017 survey of the Wetland sites captured 11,436 fish from 10 species (5 native and 5 exotic) (Table 4). Two small-bodied species, Carp gudgeon and Eastern gambusia, together comprised 92.80% of the total catch. Carp were the most abundant large-bodied species captured. A single Golden perch was collected in Black Charlie Lagoon, the first record of this species there. Murray-Darling rainbowfish were particularly abundant in 2017 and occurred at the majority of wetlands (Table 8).

Common name	Murray River Cohuna	Murray River Koondrook	Murray River Torrumbarry	Total
Australian smelt	163	18	43	224
Bony herring	7	0	3	10
Carp gudgeon	37	232	46	315
Flathead gudgeon	1	0	0	1
Golden perch	3	4	0	7
Murray cod	1	4	1	6
Murray-Darling rainbowfish	43	3	11	57
Un-specked hardyhead	2	3	0	5
Common carp	10	8	3	21
Eastern gambusia	2	5	0	7
Total	269	277	107	653

Table 5: 2017 survey catch results for River sites (exotic species shaded).

C	Gunbower Creek							
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Total
Australian smelt	87	2	161	21	3	5	146	425
Bony herring	2	0	2	0	0	0	0	4
Carp gudgeon	793	182	851	52	36	80	174	2168
Flathead gudgeon	3	0	10	0	0	0	0	13
Freshwater catfish	0	0	1	0	0	0	0	1
Golden perch	0	2	4	0	1	3	2	12
Murray cod	2	3	3	4	4	12	0	28
Murray-Darling rainbowfish	13	0	9	0	13	5	0	40
Un-specked hardyhead	10	6	60	9	12	19	312	428
Common carp	2	18	18	15	15	4	3	75
Eastern gambusia	10		109	228	58	65	17	487
Goldfish		1	3		1			5
Oriental weatherloach							3	3
Total	922	214	1231	329	143	193	657	3689

Table 6: 2017 survey catch results for Creek sites (exotic species shaded).

Table 7: 2017 survey catch results for Lagoon sites (exotic species shaded)

Common name	Cockatoo Lagoon	Gum Lagoon	Longmore Lagoon	Phyland Lagoon	Safe Lagoon	Splatt Lagoon	Taylor Lagoon	Turner Lagoon	Upper Gunbower Lagoon	Total
Australian smelt	9	9	88		2321	18		27	6	2478
Carp gudgeon	3560	6175	2058	1953	56	455	666	905	30	15858
Flathead gudgeon	13	23	504	130	9	32	1	28		740
Freshwater catfish								1		1
Murray cod		3						1		1
Murray-Darling Rainbowfish	8	18	9			28		2		65
Un-specked hardyhead	9	121	640	42	147	101	87	347	71	1565
Common carp	7	7	3	18	20	2	2	8	11	78
Eastern gambusia	40	7	128	104	70	173	3	97	74	696
Goldfish	3	1		3	7	2	1	8	5	30
Redfin		3	1			1				5
Total	3649	6367	3431	2250	2630	812	760	1423	197	21520

Table 8: 2017 survey	v catch results for	Wetland sites	(exotic s	pecies shaded)).
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Common name	Black Charlie Lagoon	Black Swamp	Corduroy Swamp	Crayfish Island	Green Swamp	Little Reedy Lagoon	Reedy Lagoon	Total
Australian smelt	4	60	16	21	34	10	19	164
Carp gudgeon	463	448	1194	212	3049	841	776	6983
Flathead gudgeon	70		2					72
Golden perch	1							1
Murray-Darling rainbowfish	3		16		39	6		64
Un-specked hardyhead	1	10	2					13
Common carp	19		34	226	31	248	12	570
Eastern gambusia	1486	69	447	20	499	94	2917	5532
Goldfish	2		18		6	28	8	62
Oriental weatherloach			3	3	10	5	1	22
Redfin						2		2
Total	2049	587	1732	482	3668	1234	3733	29670

2017 TLM Icon Site Indices Objective 1: The abundance of native fish species

The proportion of native fish caught (I Native abundance)

Lagoon habitats averaged 90% native fish by abundance in 2017 (Figure 1). All lagoon sites except Splatt Lagoon and Upper Gunbower Lagoon were above the 90% reference point for high abundances of native fish. Average native fish abundances in Creek and Wetland macrohabitats were 73% and 58% respectively. Average native fish abundance in the River was the highest, with 96% native species in 2017.



Figure 1: The average proportion of native fish caught (I native abundance) for each macrohabitat in 2017.

The proportion of native fish species caught (I Native species)

In 2017, 80% of the fish species in the River sites in 2017 were native (Figure 2) and the proportion was consistent at all three River sites. In the Creek, 70% of fish species were native. The Lagoon and Wetland macrohabitats had relatively fewer native species, with approximately half the species present at both macrohabitats being exotic.



Figure 2: The average proportion of native fish species caught (I native species) for each macrohabitat in 2017.

The proportion of historically expected native fish species present (I Native expected)

All macrohabitats averaged less than 70% of historically expected native species (Figure 3). Several individual sites including Gunbower Creek Reach 3, Gum Lagoon, Turner Lagoon and Black Charlie Lagoon had more than 80% of expected species present.





Objective 2: Size classes of native species

The proportion of native fish species age categories present compared to reference (I Age category)

Average index scores for the native fish age categories in 2017 ranged between an of 0.69 for the River macrohabitat and 0.79 for the Lagoon macrohabitat sites (Figure 4). Four Lagoon sites, two Wetland and one Creek site all had scores of 1.0, indicating YOY recruitment and a range of age categories present across multiple species. Lower levels of recruitment (I _{age category} scores of 0.5 or less) were observed in Turner Lagoon, Upper Gunbower Lagoon and Crayfish Island.



Figure 4: The average proportion of native fish species age categories present (I age categories) in 2017 compared to the best achievable for each macrohabitat.

The proportion of native fish species with YOY present compared to reference (I Recruitment)

The River sites had the lowest levels of YOY recruitment with an average I_{recruitment} Score of 0.42 and the best was 0.59 across the Lagoon macrohabitat (Figure 5).



Figure 5: The average proportion of native fish species with YOY compared to the best achievable for each macrohabitat (I recruitment) in 2017.

Objective 3: Threatened native fish species

The number of threatened species present compared with expected (I Threatened Species present)

The Creek and River macrohabitats on average supported more threatened species with I threatened species with I threatened species present scores of 0.87 and 0.70 respectively (Figure 6.). All the expected threatened species were recorded at Gunbower Creek Reaches 3, 5 and 6. Two wetland sites, Crayfish Island and Reedy Lagoon had none of the expected threatened species recorded in 2017.



Figure 6: The number of threatened native fish species present compared to the number of expected for each site (I threatened species present) averaged for each macrohabitat for 2017.

The proportion of sites that the threatened species occur in for each macrohabitat (I Threatened Species occurrence)

Threatened species occurrence scored higher than 0.9 in Gunbower Creek and Murray River (Figure 7), with Lagoon and Wetland macrohabitats recording less than 0.42.



Figure 7: The proportion of sites that the threatened species occur in for each macrohabitat (I Threatened species occurrence

Ecological Targets 2008-2017 Objective 1: An increase in the abundance of native fish species River

Native species abundance (I_{SA})

Native fish abundance at the Murray River sites dropped from 2010 levels through to 2013, but have been above 2010 levels in 2014-2016, albeit that native abundance dropped in 2017 (Figure 8). Alien fish abundance followed a similar pattern but were above 2010 levels in 2017, a pattern that has persisted since monitoring in the river commenced.



Figure 8: Index of species abundance at Murray River sites using 2010 abundances as a point of reference. (The ISA has a value of 0 in 2010).

Native fish relative abundance (I Native abundance) and Native fish relative species richness (I Native species)

Native fish comprised an average of 90% (I _{Native abundance} = 0.9) of the fish collected at Murray River sites in 2017 and this is the highest since monitoring began (Figure 9). Native species averaged 78% (I _{Native abundance} = 0.78) of species caught in river sites 2017 which is consistent with scores since 2013 (Figure 9).



Figure 9: Average native fish relative abundance (I native abundance) and relative species richness (I native species) scores at Murray River monitoring sites

Creek

In Gunbower Creek, average native fish abundances in 2017 were above the benchmark 2009 levels and have remained at similar levels since 2012 (Figure 10). Alien fish species abundances in 2017 were higher by 0.4 than 2009 and 2016.

About 80% of the fish collected from Gunbower Creek sites in 2017 were native (I_{Native abundance = 0.8}) and this maintains the generally high relative abundance seen since 2012 (Figure 11). Likewise, the proportion of fish species collected from Gunbower Creek sites in 2017 that were native (I_{Native species}) corresponded to a generally consistent trend and stability in the range of 0.6 to 0.7 after the low year of 2011 (0.53) (Figure 11).



Figure 10: Index of species abundance in Gunbower Creek sites using 2009 abundances as a point of reference.



Figure 11: Average native fish relative abundance (I native abundance) and relative species richness (I native species) indices scores at Gunbower Creek monitoring sites. The Indices are the percentage÷100.

Lagoon

Native species abundance (I_{SA})

Native and alien fish abundances in the four Lagoon sites with contiguous data (Cockatoo, Phyland, Turner and Upper Gunbower Lagoons) were marginally below the 2009 reference level in 2017 (**Figure** 12). Native fish abundances have been steady and remained close to the 2009 levels since 2012, whilst alien fish species abundances showed a slight decline in 2017.





Native fish relative abundance (I Native abundance) and Native fish relative species richness (I Native species)

Native fish relative abundance averaged 85% at the four Gunbower Lagoon sites in 2017, with Index scores remaining consistently high since 2011 (Figure 13). Native fish relative species richness averaged 0.62 at the four Gunbower Lagoon sites in 2017 and has generally remained consistent through time (Figure 13).



Figure 13: Average native fish relative abundance (I _{Native abundance}) and relative species richness (I _{Native species}) indices at Lagoon monitoring sites. The Indices are the percentage+100.

Objective 2: A range of size classes for each native fish species present

River

Large-bodied fish age categories (I_{LBAC})

Only 30% of large-bodied native fish age categories were collected on average from River sites in 2017 (Figure 14). This is a return to typical levels see during TLM monitoring after the high of 2016 (Figure 14).

Large-bodied fish YOY extent (ILBYOY)

Murray cod and Golden perch Young of Year (YOY) were not collected in the Murray River in 2017 (Figure 14). This is a typical finding for the condition monitoring program, and highlights the unusual values observed in 2016 (Figure 14).



Figure 14: Average large-bodied fish age categories and YOY extent indices at Murray River monitoring sites.

Creek

Large-bodied fish age categories (I_{LBAC})

An average of 47% of expected Murray cod and golden perch age categories were observed in Gunbower Creek sites in 2017 (Figure 15). This is the highest result since monitoring began, with a steady increase evident in the index scores, since the low recorded in 2011.

Large-bodied fish YOY extent (ILBYOY)

No golden perch or Murray cod Young of Year (YOY) were detected at Gunbower Creek sites before 2013 (Figure 15) but since then Murray cod YOY have been detected by at least one individual every year including 2017, whilst Golden perch YOY were only detected in 2013 (Figure 15).



Figure 15: Average large-bodied fish age categories and YOY extent indices at Gunbower Creek monitoring sites.

Objective 3: A contribution to population recovery of threatened fish species River

Threatened species compliant (I Threatened species compliant), and

Threatened species occurrence (I Threatened species occurrence)

Only three of the seven threatened species occurred at River sites in 2017 (Figure 16), however these species were well distributed, occurring at nearly every site as expected, as they have since 2012 (Figure 16).



Figure 16: Average Threatened species compliant (I Threatened species compliant) and Threatened species occurrence (I Threatened species occurrence) indices scores at Murray River monitoring sites.

Creek

Threatened species compliant (I Threatened species compliant); and

Threatened species occurrence (I Threatened species occurrence)

There was a slight decrease in threatened species indices in the creek since 2017 (Figure 17), but both measures are in the range of their long-term averages, and well above the low scores of 2011.



Figure 17: Average Threatened species compliant (I Threatened species compliant) and Threatened species occurrence (I Threatened species occurrence) indices scores at Gunbower Creek monitoring sites.

Lagoon

Threatened species compliant (I Threatened species compliant); and

Threatened species occurrence (I Threatened species occurrence)

Freshwater catfish, un-specked hardyhead and Murray-Darling rainbowfish are the only threatened species recorded from the four selected Lagoon sites over the monitoring period. However, over the course of the monitoring period, none of these species have occurred in the number of Lagoon sites required to indicate their recovery.

The threatened species that were recorded in the Lagoon sites in 2017, occurred in about 40% of the sites expected (Figure 18). The 2017 scores were similar to most other years and represented a slight reduction from the high reached in 2014.



Figure 18: Average Threatened species compliant (I Threatened species compliant) and Threatened species occurrence (I Threatened species occurrence) indices scores at Gunbower Lagoon monitoring sites.

Individual species catch data summaries

Note that the Catch Per Unit Effort (CPUE) referred to in Figure 19 and throughout this section refer to the standard effort used at these macrohabitats. It is not per hour or per net or electro shot, just per any site combined standard effort.

Large-bodied fish species catch data summaries

Bony Herring

Bony herring have primarily been captured from the Murray River sites and were most abundant there in 2017. Abundance increased in Gunbower Creek in 2017 relative to earlier years (Figure 19).

Freshwater Catfish

Prior to 2017, Freshwater catfish have only been recorded from Lagoon sites, particularly Gum Lagoon, Phyland Lagoon and Turner Lagoon. In 2017, there were four individuals caught in Lagoons; three in Gum and one in Turner Lagoon. The notable exception in 2017 was the record of one individual captured in Gunbower Creek Reach 3. This reach is adjacent to Lagoons where the species has been consistently recorded (i.e. Gum, Longmore, Phyland). Generally, abundances per effort were similar to those reported since 2012 (Figure 19).

Golden Perch

Golden perch have been sampled at a consistent level in Gunbower Creek since 2012 (Figure 19). In the River, abundance peaked in 2016, but 2017 was consistent with earlier surveys (Figure 19). Golden perch have always been rare in lagoons (Figure 19) and especially so in the Wetlands, albeit that one individual was collected in Black Charlie Lagoon in 2017.

Murray cod

As for golden perch, Murray cod are typically recorded only from the River and Creek sites. In 2017, the species was collected at each River site and all but one Creek site (Reach 7). Average abundance in the River was highest in 2016, and in 2017 was similar to earlier survey years (Figure 19). This was similar in the Creek, where abundances were highest in 2016 (Figure 19).

Silver Perch

Silver perch have only been recorded from the River and Creek macrohabitats (Figure 19). The average abundance recorded from Murray River sites in 2016 was the highest recorded over the monitoring program. Average abundance in the Creek is overall relatively low and variable through time and reflects the absence of the species in 2017.

Trout Cod

Trout cod have only been recorded twice over the monitoring period, and only from Gunbower Creek (2008 and 2016). No trout cod were detected in 2017 (Figure 19).

Carp

Carp are typically abundant in all macrohabitats (Figure 19). In 2017, abundances were similar to all other years (Figure 19). Common carp abundance in the River was in 2017 was the lowest recorded for the duration of the monitoring program.

Redfin (European perch)

With the exception of 2011, Redfin tend to be most abundant in Lagoon habitats and are generally recorded there, albeit that CPUE is low relative to other large bodied species (Figure 19). Since 2012, Redfin have been absent in the River and Creek macrohabitats but were collected in the Wetland in 2017 (Little Reedy Lagoon).

Goldfish

Goldfish have been regularly captured from all macrohabitats and over the monitoring period were particularly abundant at Creek and Lagoon sites in 2011 (Figure 19). Gold fish were absent in river sites and in very low numbers in creeks in 2017. They were more abundant in Lagoons in 2017, but generally present low numbers compared to other years (Figure 19).

Oriental Weatherloach

Oriental weatherloach have been recorded from all macrohabitats, however their abundance appears to have declined since 2008 (Figure 19).

Small-bodied fish species catch data summaries

Australian Smelt

Australian smelt are typically abundant in all macrohabitat and in the Lagoon were most abundant in 2017. The dataset shows recruitment has been detected every year and from all macrohabitats, with the exception of the Wetland macrohabitat in 2011 and 2012.

Carp Gudgeon

Carp gudgeon are the most abundant species encountered at Gunbower Island and are typically abundant across all macrohabitats surveyed. As in every other year, evidence of recruitment been widespread (Figure 19).

Dwarf Flathead Gudgeon

Dwarf flathead gudgeon were most abundant in 2010, but have otherwise rarely been recorded, and not in 2017 (Figure 19). The raw dataset shows evidence of recruitment for this species in the Creek, Lagoon and Wetland sites, most recently from Phyland Lagoon and Gunbower Creek in 2014.

Flathead Gudgeon

Flathead gudgeon have been regularly recorded in Lagoon habitats but have rarely captured from River or Creek habitats since 2010 (Figure 19). Abundance in Lagoons has declined since 2010 and the species is now recorded at considerably lower abundance compared to other generalist species.

Murray-Darling Rainbowfish

Murray-Darling rainbowfish abundance has fluctuated considerably over time with highest abundance collected in 2014 (Figure 19). They were collected across all habitats in 2017, although were most abundant at River sites.

Un-specked Hardyhead

Un-specked hardyhead are typically most abundant at Creek and Lagoon sites (Figure 19). Abundances across the Creek sites were markedly higher in 2016 and 2017 than all other survey years, while at the Lagoon, abundances were similar to other years (Figure 19).

Eastern Gambusia

The average abundance of Eastern gambusia has generally been highest at Lagoon sites and lowest at River sites, however the species abundance can fluctuate broadly (Figure 19). Abundances have been relatively low since 2011, when the species dominated the overall catch.



Discussion

2017 condition

The diversity of fish species at Gunbower Forest in 2017 was similar to other survey years, with nine native and five exotic species recorded. Native species collected in other years but not in 2017 were trout cod, silver perch and dwarf flathead gudgeon, while each exotic species recorded previously was again collected in 2017. Like earlier years, carp gudgeon dominated the catch across Gunbower Island and at each of the 26 survey sites, representing > 80% of overall abundance at most sites. The native Australian smelt and to lesser extent un-specked hardyhead and exotic Eastern gambusia also accounted for a large proportion of fish collected in 2017. All other native species were recorded at considerably lower abundance (e.g. flathead gudgeon, Murray-Darling rainbowfish) and this was especially so for the large bodied species. This indicates that of the nine native species recorded across the Icon Site, only three species can be considered 'common', or actually be expected to be collected. For the species collected at low relative abundances that are traditionally considered less common, such as un-specked hardyhead, flathead gudgeon and Murray-Darling rainbowfish etc, and more so for large bodied native species such as silver perch, freshwater catfish and golden perch etc, the persistent low level of abundance, fractured population structures and spatial distribution does not indicate overall good ecological condition of the fish community at Gunbower Forest.

In 2017 and since initiation of the condition monitoring program none of the threatened wetland specialist species have been collected across Gunbower Forest. Indeed, for the Wetland and Lagoon sites, indices for native species occurrence, abundance and recruitment averaged below 40% expected, and as low as 30%. This does not reflect positive ecological condition for the Wetland and Lagoon habitats. This was not the case however for the River and Creek, which recorded > 50% and up to 80% proportion native species and abundance of native species overall, although this reflects a lower diversity of exotic species present and when considering the generally fractured structure of native species, ecological condition in River and Creek too can be considered less than good. There has, however, been a pattern of stability for most indices over time, be it River, Creek, Lagoon or Wetland indices, except for particular years where these exhibited wide variation, such as 2011 and 2016. The analysis reflects that for most indices there is a return to the 'average' or 'stable' level post the variation observed from those years. Those years and fluctuations correspond to major natural flood events at Gunbower Island, where exotic species such as Common carp and Eastern gambusia increased dramatically in abundance, while native species, especially in Wetlands, declined.

Except for the flood years, the apparent stability for most indices is not considered to indicate good ecological condition, nor progress toward improvement in the condition of the fish community overall. This is because of low overall abundance, fractured spatial distribution and population structures for the majority of species, highlighted above. Until significant improvement in the occurrence, abundance and recruitment of apparently 'common' and especially threatened native fish occurs, the ecological condition of the Gunbower Forest Icon site will remain less than 'good'.

Objective and target attainment summary

The overall ecological objective for fish at Gunbower Forest is to "Maintain healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources", with the attainment of the detailed objectives described below.

Objective # 1 – Increase in the abundance of native fish species

This objective uses the 2009 fish species abundances as a baseline for Creek, Wetland and Lagoon and 2010 for the River macrohabitats. The relevant indices used to evaluate progress toward this object are: I Native abundance; I Native species; I Native expected; ISA

This objective was attained for the River and Creek. In the Lagoon, these indices were below the 2009 benchmark, except for I Native abundance and I Native species which does not indicate that the ecological objective was attained. The Wetland macrohabitat could not be assessed because of an unbalanced experimental design, i.e. because of wet and dry phases for wetlands over the course of the monitoring period.

In the River, the I_{Native abundance} in 2017 was the highest for any year. This coincided with the collection of particularly low abundances of common carp and Eastern gambusia, and relatively high abundance of Murray-Darling rainbowfish. In the Creek, the I_{Native abundance} was above the 2009 benchmark however exotic species increased in abundance in 2017 and the ecological objective was attained.

Objective # 2 – Range of age/size classes of each native species

This objective was evaluated by evidence of recruitment as indicated by Young of Year (YOY) native fish using the species-specific thresholds identified in Sharpe and Villizi (2014). The indices used for evaluating progress toward this objective are: I Age category; I Recruitment; ILBAC; ILBYOY.

Key points to note are:

- In 2017, the population structure Murray cod was considerably more robust than in earlier years, especially so compared 2013, when limited or zero recruitment was detected. In 2017, the expected age categories in the creek increased to 47% and this corresponds to numerous individuals present amongst the juvenile size classes, most likely produced since 2013 and these were most abundant at Gunbower Creek Reach 6 (downstream of Cohuna Weir). The age of the new recruits corresponds to the successful spawning for Murray cod in Gunbower Creek observed during spring 2013, 14 and 15 (i.e. 200-400mm) and has occurred in association with implementation of the 'large bodied fish hydrograph' by North Central CMA.
- This was not the case for Murray cod in the River, where there were no young-of-year recruits captured and only 30% of the expected age classes were collected in 2017.
- For golden perch, silver perch and freshwater catfish, this was not the case, whereby populations have remained severely fragmented in size structure and to the point where silver perch were not collected at any site in 2017. As has been frequently reported, recovery of golden and silver perch populations is not expected to occur until fish passage is provided at the 'bookend' barriers to Gunbower Creek Headworks and Koondrook Weirs.
- Exotic species including common carp and goldfish populations have always and again in 2017, been represented by strong recruitment and continue to be very robust, whereby abundances increased in the Creek.
- Most small bodied native species exhibited robust population structure with the full range of size/age classes well represented.
- The objective was attained for the River, Creek, Lagoon (small bodied fish only)

Objective # 3 – A contribution to population recovery of threatened or absent native fish species. This objective uses the 2009 abundances as a baseline for Creek, Wetland and Lagoon and 2010 for the River macrohabitats. The relevant indices used to evaluate progress toward this object are: I

Threatened $I_{\text{species compliant;}}$ I Threatened species occurrence

Key points are:

- Only three of the seven expected threatened species were collected in the River (Murray cod, Murray-Darling rainbowfish and un-specked hardyhead). Silver perch were not collected in 2017 and while the occurrence of the former species is consistent to earlier years, and is consistent with the 2009 benchmark, the diversity of threatened species is low and has declined in 2017. There has been no contribution to threatened species recovery in the River habitat.
- The objective was attained at Creek, principally because of comparison to the 2009 benchmark (five of nine threatened species collected in 2017). The absence of silver perch, but the occurrence of freshwater catfish in the Creek, the first record since monitoring began, has maintained a stable trend for threatened species occurrence in the Creek since 2013.
- In the Lagoon, the occurrence of freshwater catfish, un-specked hardyhead and Murray-Darling rainbowfish has remained patchy in distribution across sampling sites and no additional species were recorded in 2017. There has been no contribution to threatened species recovery in the Lagoon habitat.

Species specific evaluations, based on relative abundance, spatial distribution and population structure (including evidence for recent recruitment) are:

- Silver perch Abundance declined in 2017 to undetectable levels, i.e. silver perch were not recorded in 2017 and hence there has been a negative contribution to recovery.
- Freshwater catfish Were present in similar abundance in 2017 to earlier years and spatial distribution increased, with one individual collected in Gunbower Creek Reach 3. Very low abundance relative to historical levels, – the population remains fragmented and there has been no progress toward population recovery.
- Murray cod Increased in abundance in 2017 and was recorded in Gunbower Creek at the second highest abundance across years. Evidence of recruitment to the Gunbower Creek population since 2013 was recorded by the presence of young-of-year size classes as well as age 1+, 2+ and 3+ size classes, especially at Gunbower Creek Reach 6, where there were more than triple the number of individuals collected relative to upstream reaches, supporting a positive contribution to population recovery.
- Trout cod Were recorded in 2008 and 2016, indicating that a remnant population of this species is present in Gunbower Creek, though not recorded in 2017.
- Un-specked hardyhead In the Creek, River, and Lagoon, populations were similar in abundance and size structure in 2017 compared to earlier years. Populations in Wetlands increased in 2017, indicating contribution to recovery across the Icon Site.
- Murray-Darling rainbowfish Exhibited an increase in abundance and spatial distribution in 2017, being recorded at 16 of 26 sites. The population in the River, Creek and Wetland macrohabitats was more abundant that in earlier survey years. There has been a positive contribution to population recovery.
- For silver perch, golden perch, (to a lesser extent) trout cod, freshwater catfish and bony herring, recovery potential is severely limited and unlikely until barriers to recolonisation of Gunbower Creek from the Murray River at Koondrook Weir and Headworks regulator are removed and between Lagoon and Creek habitats, by installation of fish passage. Likewise, flow

regimes suitable to the survival of larvae and YoY juveniles for those species have been identified as a key factor limiting the status and recovery of populations in Gunbower Creek (Mallen-Cooper et al. 2013).

• For Murray cod, which can complete their life history at a local spatial scale (10's of kilometres), and for which a breeding population has persisted in Gunbower Creek, the implementation of the 'Large bodied fish hydrograph' in Gunbower Creek since 2013/14 has facilitated regular and relatively strong recruitment success.

The descriptive ecological targets (from North Central CMA 2015) are:

At least 4 of the 5 commonly occurring native species (i.e. carp gudgeon, flathead gudgeon, Australian smelt, dwarf flathead gudgeon and golden perch) occur in any year.

• This objective was attained for all species with exception of dwarf flathead gudgeon, which was not recorded in 2017.

At least 3 of the 7 less commonly occurring (i.e. bony herring) and/or threatened native species (i.e. Murray-Darling rainbowfish, silver perch, Murray cod, trout cod, un-specked hardyhead, freshwater catfish) occur in any year.

• This objective was attained for four species, albeit that trout cod and silver perch were not recorded in 2017.

A decrease in the abundance of alien fish (i.e. non-indigenous to Gunbower Island) since 2009 (Gunbower Creek and Lagoons) and since 2010 (Murray River)

• This objective was not attained at any macrohabitat in 2017, whereby alien species were recorded at similar abundance and spatial distribution across the icon site compared to other monitoring years.

Recommendations

The following section outlines management recommendations in relation to key observations from analysis of the 2008-2017 data set, with emphasis on the 2017 survey.

One of the few positive contributions to population recovery observed in 2017 was for Murray cod in Gunbower Creek, particularly at Gunbower Creek Reach 6. There, the number of juvenile fish by far outweighed those of adults, and abundance overall was dramatically higher than for any other Creek reach. This is considered to reflect a substantial recovery for the Gunbower Creek Murray cod population, which until 2013, had exhibited persistent decline in abundance and population structure (Sharpe et al. 2014). The efforts by North Central CMA to mitigate factors thought to be limiting Murray cod recruitment in Gunbower Creek, particularly downstream of Cohuna, coincide directly with this population increase and can be perceived as influential to the sustainability of Murray cod in Gunbower Creek. We recommend that the recovery plan actions for Murray cod undertaken by North Central CMA in Gunbower Creek downstream of Cohuna be extended to the ~80km of Creek upstream of Cohuna. Recovery actions include mitigating periods of cease to flow during winter and delivering more stable flows during the spring/summer breeding and early recruitment periods, by reducing the wide daily fluctuations in water levels that traditionally occur as a result of irrigation demand. The benefits from these and other recent interventions aimed at improving the success of Murray cod spawning and recruitment are now being realised, notably, by increased recruitment to the Gunbower Creek population. We emphasise that the perennial flow regime and the 'Large bodied fish hydrograph' outlined by Sharpe et al. (2016) must be embedded into long-term flow management for the entire Gunbower Creek for the long-term recovery of Murray cod to be realised.

Golden perch have consistently exhibited relatively low abundance at Gunbower Island in previous survey years and the species was collected at similar abundances in the 2017. The overall population structure in 2017 consisted of individuals of adult size classes, with zero juvenile sized fish encountered. Golden perch are long lived (> 20yrs) (Mallen-Cooper and Stuart 2003), and whilst not thought to spawn in the Gunbower system (Mallen-Cooper et al. 2013), spawning in the Murray River and subsequent larval drift into Gunbower Creek, may compensate for irregular annual recruitment patterns within the local population, or be augmented via artificial stocking. It is however thought that the main factor limiting the status of the golden perch population is the lack of recolonisation potential by actively migrating fish in the Murray River. The contemporary thinking is that the existing barriers to fish passage between the Murray River and Gunbower Creek, principally at Koondrook Weir, are limiting potential for a broader range of size classes and rapid recovery of the Gunbower Creek population. Therefore, until those barriers are mitigated by fishways, recovery of the Gunbower Creek population is unlikely.

It has recently been proven in the Darling River system that golden perch recruitment can be managed by giving recently spawned larvae access to large floodplain habitats, which function as nursery areas where there is extraordinarily high survivorship, compared to riverine habitats (Sharpe and Stuart 2017). The strongest recruitment to the Darling's riverine population occurs when dispersal of juveniles occurs from the floodplain nursery habitats back to the river. In the Darling River in 2016 and 2017, this was managed by using environmental water and infrastructure operations. There is opportunity at Gunbower Island to mimic this recruitment model by

management intervention in the absence of fish passage at the bookend barriers of Koondrook and Headworks and lesser extent internal barriers such as Cohuna Weir.

A model for golden perch recruitment to Gunbower Creek using environmental flows: a preview

Based on the model of floodplain recruitment for golden perch proven in the Darling River (Sharpe 2011; Sharpe and Stuart 2017), and from hatchery management regimes for the commercial production of golden perch, a brief outline of a potential management approach to enhancing the recovery of golden perch in Gunbower Creek is provided below:

- Upon inundation of Gunbower Forest with environmental water from Hipwell Regulator, inoculate particular areas of the floodplain with larval or early juvenile golden perch sourced from commercial hatcheries.
- Early juvenile growth and survivorship is high on the productive Forest floodplain
- At the completion of the environmental watering event and commencement of floodplain drawdown, implement the Gunbower Forest Fish Exit Strategy (Sharpe et al. 2016). This has been proven to promote golden perch exit from the Forest and would likewise be applied to promote the exit of early juveniles from the floodplain to Gunbower Creek.
- Expansion of the Gunbower Creek golden perch population would be evaluated by the TLM condition monitoring program.

Freshwater catfish

In 2009, a targeted survey of freshwater catfish was undertaken in some of the lagoons on Gunbower Creek. Noting the lack of evidence for recent recruitment from the 2017 findings, it is recommended that another targeted survey investigating the population status of freshwater catfish at priority sites (e.g. Turner Lagoon, Phyland Lagoon, Gum Lagoon) be undertaken to inform the management of habitats and to ascertain sustainability of this species at Gunbower Island.

Small-bodied wetland specialist species

Wetland specialist species including southern pygmy perch, Murray jollytail, olive perchlet and purple spotted gudgeon have suffered dramatic declines in distribution throughout the MDB and are generally considered to be locally extinct at Gunbower Island. It is recommended that the rehabilitation model described for these species at Gunbower Island by Mallen-Cooper et al. (2014) be implemented. Such a recovery plan would:

- 1. identify habitat characteristics associated with robust populations elsewhere i.e. densities and types of aquatic plants, flow regimes,
- 2. identify direct and indirect threatening processes associated with the species decline at Gunbower Island, i.e. competition or predation associated with exotic species, the effects of regulated flow regimes upon recruitment and dispersal, etc.
- identify management options at specific habitats to remove direct and indirect threats, i.e.
 drying of particular wetlands to remove exotic species; reintroduction of indigenous aquatic plants; management options to maintain refuge (i.e. pumping); dispersal pathways,
- 4. identify source populations for reintroduction
- 5. reintroduce into targeted wetlands,
- 6. monitor status of reintroduced populations, monitor dispersal

Conclusions

The Gunbower Island fish community is relatively diverse. This reflects the diversity of flow-habitat types available across the icon site. Each commonly occurring fish species was recorded in 2017. Amongst the large bodied native species, with exception of Murray cod, populations exhibit very limited or no recruitment and some species have contracted in abundance over time (freshwater catfish, golden perch and silver perch). The factors affecting recruitment to Gunbower populations include

- i) lack of recolonisation potential from more abundant populations in the adjacent Murray River (due to persistent barriers to fish movement at Koondrook and Headworks Weir);
- ii) limited habitat availability, including floodplain access and appropriate flow regimes. This is being addressed by implementing a large bodied fish hydrograph for Murray cod population recovery and is proving successful. This example demonstrates that the recovery of other large bodied native fish and population of small bodied threatened species is achievable by incorporating the latest scientific knowledge into flow and habitat management.

• Ensuring connectivity to the range of habitats available across the Gunbower system is key to enhancing the overall native fish assemblage.

• Fish populations are variable, with small bodied species in particular, fluctuating in abundance and distribution between survey years. Most large bodied native species have shown limited recruitment and exhibit fractured population structure across the icon site. This is an important consideration in relation to the future sustainability of these populations. Barriers to colonisation of Gunbower Creek and Lagoons from populations in the River Murray are amongst the key factors limiting the status and recovery of large bodied native fish at Gunbower Island.

• Native fish diversity in wetlands is low relative to earlier survey years (2008, 2009, 2010). For native fish species to recolonise wetlands in Gunbower Forest, connectivity to source populations in Gunbower Creek and Lagoons must be provided, and those source populations maintained by provision of appropriate flow regimes to life history requirements. Accordingly, understanding the factors affecting the development of a diverse native fish community in wetlands is critical to the recovery of robust wetland fish communities. Likewise, movement cues and facilitating movement between source populations in the Murray River and Gunbower Creek is an important management consideration, particularly during managed inundations of Gunbower Forest.

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