

Long-term reintroduction plan for threatened floodplain specialist fish in the Murray Corridor

*Sylvia Zukowski, Scott Huntley,
Maiko Lutz & Tessa Roberts*

A recovery plan for the



This report may be cited as:

Zukowski, S., Huntley, S., Lutz, M., and Roberts, T. (2024). Long-term reintroduction plan for threatened floodplain specialist fish in the Murray Corridor. A report for the Tri-State Murray NRM Regional Alliance. Nature Glenelg Trust, Victor Harbor.

Correspondence in relation to this report contact

Dr Sylvia Zukowski
Senior Aquatic Ecologist
Nature Glenelg Trust
MOB: 0438 815 489
sylvia.zukowski@ngt.org.au

Disclaimer

Although reasonable care has been taken in preparing the information contained in this publication, neither Nature Glenelg Trust, nor the North Central Catchment Management Authority or Murray–Darling Basin Authority accept any responsibility or liability for any losses of whatever kind arising from the interpretation or use of the information set out in this publication.

Acknowledgements

Thanks to Peter Rose (North Central CMA) for project instigation, management and input. We greatly appreciate all the contributors who provided the invaluable fish site information for the plan including but not limited to and in alphabetical order - Andrew Briggs (Victorian Fisheries Authority), Anthony Sloan (North Central CMA), Catherine Mcinerney (North East Central CMA), Darren Willis (Murraylands and Riverland Landscape Board (SA)), Greg Cranston (Mallee CMA), Iain Ellis (Millewa Pumping), Jason Mullins (Goulburn Broken CMA), Jimmy Walker (NSW Fisheries), John Conallin (Charles Sturt University), Josh Campbell (Murray Local Land Services), Kate Mason (Murraylands and Riverland Landscape Board (SA)), Kaye Gottschutzke (Western Local Land Services), Leigh Fletcher (Western Murray Land Improvement Group), Luke Pearce (NSW Fisheries), Max Smiles Schmidt (NSW National Parks and Wildlife Service), Peter Unmack (University of Canberra), Roger Knight (Western Murray Land Improvement Group), Sam Hardy (Murraylands and Riverland Landscape Board (SA)), Scott Raymond (Arthur Rylah Institute), Simon Casanelia (Goulburn Broken CMA), Tarmo Raadik (Arthur Rylah Institute), and Taylor Hunt (Victorian Fisheries Authority). We thank the contributions of the attendees of the 2024 Tri State Wetland Warriors conference attendees. Thanks to Nick Whiterod (CLLMM Research Centre) for report revision and input and Lachlan Farrington (Nature Glenelg Trust) for mapping.

The efforts of a wide range of people, from managers to surrogate refuge and wild site custodians, who have been involved previously or continue to be involved in the conservation of the target species are acknowledged. We thank all involved for providing their hard-earned knowledge to help conserve these threatened species.

This project is funded by the Tri State Murray NRM Regional Alliance and the Native Fish Recovery Strategy.

Acknowledgement of the Traditional Owners of the Murray–Darling Basin

We respectfully acknowledge the Traditional Owners, their Elders past, present and emerging, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual, and economic connection to their lands and waters.

Glossary of acronyms

AIBG	Australian Inland Botanic Gardens
ARI	Arthur Rylah Institute for Environmental Research
BC&S	Biodiversity, Conservation & Science (Federal DCCEEW)
BL4	Big Little Four
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CMA	Catchment Management Authority (Vic)
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Federal)
DEECA	Department of Energy, Environment and Climate Action (Vic)
DEW	Department for Environment and Water (SA)
EHG	NSW Environment and Heritage
EMLR	Eastern Mount Lofty Ranges
EWAA	Edward-Wakool Angling Association
GBCMA	Goulburn Broken Catchment Management Authority (Vic)
GMW	Goulburn Murray Water
H&FLB	Hills and Fleurieu Landscape Board (SA)
JIG	Joint Indigenous Group
KPA	Koondrook Perricoota Alliance
LALC	Local Aboriginal Land Council
LLS	Local Land Services (NSW)
M&RLB	Murraylands and Riverland Landscape Board (SA)
MCMA	Mallee Catchment Management Authority (Vic)
MDBA	Murray–Darling Basin Authority (Federal)
MDWWG	Murray–Darling Wetlands Working Group
MLLS	Murray Local Land Services (NSW)
NCCMA	North Central Catchment Management Authority (Vic)
NECMA	North East Catchment Management Authority (Vic)
NGT	Nature Glenelg Trust
NPWS	National Parks and Wildlife Service
NSW DPI	NSW Department of Primary Industries
NW Aquaculture	North West Aquaculture
PV	Parks Victoria
RGA ECP	Ricegrowers' Association of Australia - Environmental Champions Program
TLaWC	Taungurung Land and Waters Council
TLM	The Living Murray Program (MDBA)
TO	Traditional Owners
VEWH	Victorian Environmental Water Holder
VFA	Victorian Fisheries Authority
WLLS	Western Local Land Services (NSW)
WMLIG	Western Murray Land Improvement Group
YACTAC	Yanco Creek and Tributaries Advisory Council (NSW)
YYNAC	Yorta Yorta Nation Aboriginal Corporation

Table of Contents

Glossary of acronyms.....	iii
1. Background	1
2. Species Summaries.....	5
2.1 Murray Hardyhead <i>Craterocephalus fluviatilis</i>	5
2.1.1 Historic and current distribution.....	5
2.1.2 Biological information	6
2.1.3 Conservation status.....	7
2.1.4 Key threats and knowledge gaps.....	7
2.2 Southern Purple-spotted Gudgeon <i>Mogurnda adspersa</i>	9
2.2.1 Historic and current distribution.....	9
2.2.2 Biological information	10
2.2.3 Conservation status.....	11
2.2.4 Key threats and knowledge gaps.....	11
2.3 Olive Perchlet <i>Ambassis agassizii</i>	12
2.3.1 Historic and current distribution.....	12
2.3.2 Biological information	13
2.3.3 Conservation status.....	13
2.3.4 Key threats and knowledge gaps.....	14
2.4 Southern Pygmy Perch <i>Nannoperca australis</i>	15
2.4.1 Historic and current distribution.....	15
2.4.2 Biological information	16
2.4.3 Conservation status.....	17
2.4.4 Key threats and knowledge gaps.....	17
2.5 Flathead Galaxias <i>Galaxias rostratus</i>	19
2.5.1 Historic and current distribution.....	19
2.5.2 Biological information	19
2.5.3 Conservation status.....	20
2.5.4 Key threats and knowledge gaps.....	20
2.6 Yarra Pygmy Perch <i>Nannoperca obscura</i>	21
2.6.1 Historic and current distribution.....	21
2.6.2 Biological information	22
2.6.3 Conservation status.....	23

2.6.4 Key threats and knowledge gaps.....	23
3. Recovery approaches in-place.....	24
3.1 Murray Hardyhead <i>Craterocephalus fluviatilis</i>	25
3.2 Southern Purple-spotted Gudgeon <i>Mogurnda adspersa</i>	26
3.3 Olive Perchlet <i>Ambassis agassizii</i>	27
3.4 Southern Pygmy Perch <i>Nannoperca australis</i>	28
3.5 Flathead Galaxias <i>Galaxias rostratus</i>	29
3.6 Yarra Pygmy Perch <i>Nannoperca obscura</i>	30
4. Target numbers for managed surrogate and wild sites	31
4.1 Murray Hardyhead <i>Craterocephalus fluviatilis</i>	31
4.2 Southern Purple-spotted Gudgeon <i>Mogurnda adspersa</i>	32
4.3 Olive Perchlet <i>Ambassis agassizii</i>	32
4.4 Southern Pygmy Perch <i>Nannoperca australis</i>	33
4.5 Flathead Galaxias <i>Galaxias rostratus</i>	33
4.6 Yarra Pygmy Perch <i>Nannoperca obscura</i>	34
4.7 Target summary	34
5. Potential reintroduction sites.....	35
5.1 Murray Hardyhead <i>Craterocephalus fluviatilis</i>	36
5.2 Southern Purple-spotted Gudgeon <i>Mogurnda adspersa</i>	39
5.3 Olive Perchlet <i>Ambassis agassizii</i>	45
5.4 Southern Pygmy Perch <i>Nannoperca australis</i>	50
5.5 Flathead Galaxias <i>Galaxias rostratus</i>	57
5.6 Yarra Pygmy Perch <i>Nannoperca obscura</i>	61
6. Key knowledge gaps and recommendations.....	63
6.1 Key knowledge gaps.....	63
6.2 Recommendations	64
7. Conclusion	66
8. References.....	67

1. Background

Global biodiversity is currently declining at unprecedented rates (Harrison *et al.* 2018), and approximately one million described species are threatened with extinction unless management actions are implemented to reverse negative trends (Díaz *et al.* 2019). Freshwater ecosystems and populations associated with these habitats are considered at high risk, with declines of more than 80% in monitored freshwater populations since 1970 (Darwall *et al.* 2018; Garcia-Moreno *et al.* 2014; WWF 2022). Almost 9000 species associated with freshwater ecosystems are currently considered extinct or at threat of extinction according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2024). However, it is likely that this is an underrepresentation of extinction risk, as many freshwater species have not been assessed or remain undescribed (Adams *et al.* 2014; Garcia-Moreno *et al.* 2014).

Freshwater fish are amongst the most imperilled groups, with approximately 26% of the species currently evaluated on the IUCN Red List at risk of extinction (Darwall and Freyhof 2016; Sayer *et al.* in review). The main threats impacting freshwater fish populations include habitat loss and degradation, non-native species, water abstraction and flow alteration, pollution, over-exploitation, and climate change (Arthington *et al.* 2016; Darwall and Freyhof 2016; Dudgeon *et al.* 2006). These threats place freshwater fish species at extreme risk in Australia, the world's driest inhabited continent with low and highly variable rainfall levels and runoff (Thoms and Sheldon 2000). Almost 40% of the assessed 241 Australian freshwater fish are threatened with extinction (Lintermans *et al.* 2024, in review) and with an estimated third not formally described (Unmack 2018), it is likely that this is an underrepresentation of the actual extinction risk experienced by Australian freshwater fish.

Some of the factors contributing to the likelihood of extinction of Australian freshwater fishes include their occurrence in small and geographically isolated populations and the impact of a mix of threatening processes (such as non-native species and climate change) (Lintermans *et al.* 2020). Indeed, some 20 small-bodied freshwater fish with restricted ranges and isolated populations were assessed as having a greater than 50% probability of extinction by ~2040 (Lintermans *et al.* 2020). Here forecasting predicts severe declines in suitable habitat for native freshwater fish under climate change, with the natural habitat of five fishes projected to be completely lost by the end of the century (Galego de Oliveira *et al.* 2019).

The native freshwater fishes of the MDB have also been heavily impacted by recent prolonged drought (Millennium drought from 2001-2009, as well as severe drought and lowest-on-record inflows through 2016–19 for some basin regions) and widespread bushfires over 2019–20. Mass fish deaths, such as occurred in the lower Darling River in 2018–19, have

devastating impacts on native freshwater fish populations, ecosystem health, and water quality, and cause considerable distress to local communities and Indigenous traditional owners (Koehn 2022). These fish death events are projected to increase in severity and frequency under climate change (Koehn 2022). Following the death of millions of fish in the lower Darling River in 2018–19, the Native Fish Recovery Strategy (the Strategy) was developed with the aim to protect and recover native fish populations in the MDB (MDBA 2020). The Strategy builds on existing efforts that protect and support native fish and is implemented collaboratively between MDB states, First Nations peoples, aquatic ecology experts and local communities.

Floodplains, considered some of the most productive and dynamic habitats, and the species associated with them, are imperilled due to the impacts of numerous threats such as alteration of flow regimes, water extraction and climate change (Balcombe *et al.* 2011; Graham and Harris 2005). Numerous freshwater fishes in the MDB rely on floodplains for at least part of their life-cycles (for example, for breeding, foraging and shelter), and a reduction in connectivity of floodplains to river channels, due to changes in flow regimes, prevents fish from moving into these habitats (Gonzalez *et al.* 2011; Koehn *et al.* 2014; Koehn *et al.* 2020b). Conservation actions such as overbank flows to connect floodplain habitats, flushing flows, fish passages at barriers and removal of redundant structures, are required to restore populations of floodplain specialists (Koehn *et al.* 2020b).

Translocations are commonly used conservation actions to support the recovery of native freshwater fish populations (Lintermans 2013). To ensure that translocations of threatened freshwater fish within (i.e., reintroductions) and outside (i.e., conservation introductions) their known ranges are successful, numerous considerations are required. These are outlined in translocation plans that been prepared for threatened freshwater fish species in South Australia and New South Wales and provide guidance for the current project to adhere to the [SA translocation strategy](#) (Whiterod 2019) and the [NSW conservation translocation handbook](#) (Zukowski *et al.* 2021).

In the Murray Corridor of the southern MDB, once common small-bodied native fish species, have suffered extensive range and distribution declines. It is imperative that recovery is aimed to create resilient self-sustaining populations at a sufficient scale to ensure species persist long term. One of the initiatives of the Tri-State Murray NRM Regional Alliance (hereby referred to as the Tri-state Alliance) is to recover populations and prevent the extinction of threatened native fish species across the region. The Tri-state Alliance consists of seven regional NRM bodies (North East, Goulburn Broken, North Central and Mallee Catchment

Management Authorities in Victoria, the NSW Murray and Western Local Land Services and Murraylands and Riverland Landscape Board in SA).

This Reintroduction Plan provides a synthesis of knowledge, obtained through extensive collaboration and consultation, of six target threatened floodplain specialist fish species in the Murray Corridor (Figure 1) for the Alliance to guide best-practice recovery actions. The included floodplain specialist fishes have all experienced historical declines in distribution and abundance and need urgent conservation management for recovery. The species are:

- Murray Hardyhead *Craterocephalus fluviatilis*
- Southern Purple-spotted Gudgeon *Mogurnda adspersa*
- Olive Perchlet *Ambassis agassizii*
- Southern Pygmy Perch *Nannoperca australis*
- Flathead Galaxias *Galaxias rostratus*
- Yarra Pygmy Perch *Nannoperca obscura*

In this Plan, Section 2 provides a summary of the distribution (historic and current), biological information, key threats, conservation and population status, and key knowledge gaps for the six target species (up until August 2024). Section 3 outlines the current approaches used by the Tri-State Alliance to recover the species. While approaches used may vary between species, they generally include: protection of existing populations; collection of broodstock; intensive captive breeding to secure species; reintroduction of offspring into secure, predator free 'surrogate' sites (natural hatcheries); translocations from surrogate sites to additional surrogate sites and to managed wild sites; and support of dispersal from managed wild sites to other wild sites (e.g., through water for the environment). Section 4 outlines targets (for a time frame of 2024 to 2040) for current managed surrogate and wild sites for each species for each of the seven NRM regions of the Tri-State Alliance. Section 5 identifies potential target managed wild sites, wetland complexes, or floodplain areas (these generally receive environmental water) that could be used for species reintroductions. A brief description of site conditions, target species for reintroduction, relevant land managers and stakeholders, and where known, key management actions required to create a suitable receiving environment for threatened fish are outlined. Section 6 identifies key knowledge gaps to be addressed to assist with the success of species reintroductions and provides overarching recommendations.

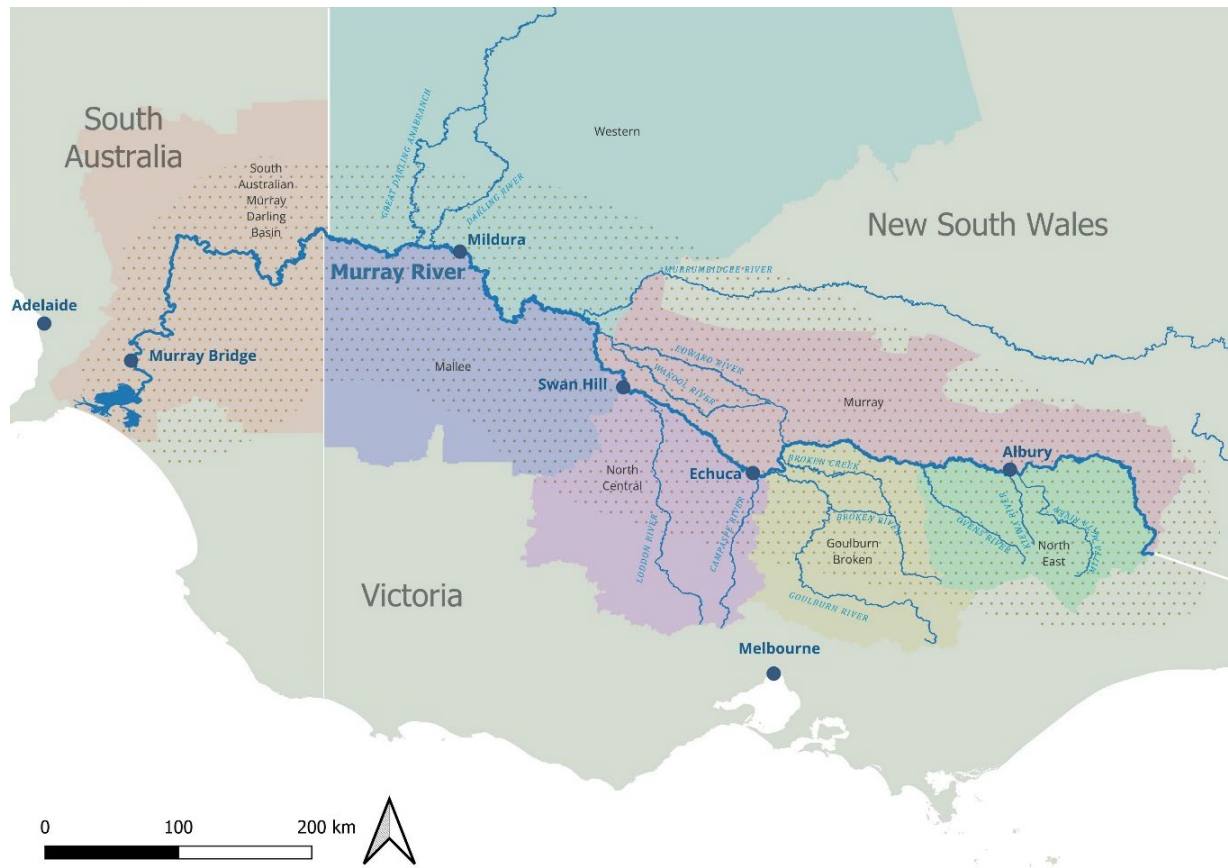
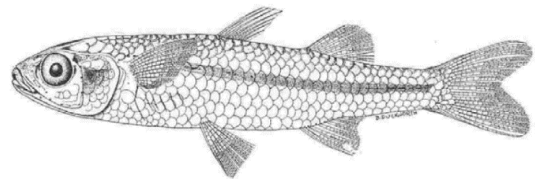


Figure 1. The Murray Corridor (black dots) for the Tri-State Murray NRM Regional Alliance with the seven NRM regions highlighted.

2. Species Summaries

2.1 Murray Hardyhead *Craterocephalus fluviatilis*



B Duckworth and Crowley and Ivantsoff (1990)

2.1.1 Historic and current distribution

Murray Hardyhead is endemic to the mid and lower MDB (Ebner *et al.* 2003; Ivantsoff and Crowley 1996; Lloyd and Walker 1986). Its precise historic distribution is unclear due to confusion with other hardyhead species (Crowley and Ivantsoff 1990). However, the species was once abundant from Lake Alexandrina (near the Murray Mouth in South Australia) to the upstream reaches of the Murray (near Yarrowonga in Victoria) and Murrumbidgee rivers (near Narrandera in New South Wales) (Ellis 2005; Hammer *et al.* 2002; Ivantsoff and Crowley 1996). It has severely declined in range and abundance and is considered locally extinct at numerous historic sites across its range. The species was considered extinct in New South Wales with the last individual recorded in 2005 (NSW DPI 2006; Stoessel *et al.* 2019). In 2018, the species was reintroduced into Little Frenchman's Creek with the population demonstrating recruitment over three breeding season (2018–19, 2019–20, 2020–21) (Whiterod *et al.* 2021) before being severely affected by summer 2022–23 flooding, dispersing the population (Walker and Ellis 2023). Fish rescues were conducted prior to this flooding and backup and surrogate sites were established including holding tanks on site and a new surrogate site at the Australian Inland Botanic Gardens in Buronga (Walker and Ellis 2023).

In Victoria, Murray Hardyhead have been extirpated from most historic sites (10 out of 13) and only a few remnant populations in a small number of saline deflation basin lakes remain. The extant populations are: 1) one historic population (Round Lake); 2) one re-established population via translocation (Lake Elizabeth); 3) a non-historic population established through translocation (Lake Koorlong); and 4) a population discovered following floods in 2011 (Lake Kelly) (Stoessel 2012; Whiterod *et al.* 2021). Additionally, a single individual was recorded in Reedy Lake in 2013 suggesting that the species might persist at that site (Byrne *et al.* 2013). However, the populations at Lake Kelly have experienced severe declines and may be too small to be viable (Stoessel *et al.* 2019).

In South Australia, the species was historically found in the Murray River and many of its tributaries from Lake Alexandrina to the Victorian border (Lloyd and Walker 1986). It is now thought to be restricted to four isolated, core populations at Disher Creek, Berri Evaporation Basin (near Berri), Rocky Gully Wetland (near Murray Bridge) and several sites near Lake Alexandrina and Goolwa Channel (Bice *et al.* 2012; Ellis *et al.* 2013; Wedderburn and Barnes

2012; Wedderburn and Barnes 2018; Wedderburn and Sutor 2012; Wedderburn *et al.* 2019b; Whiterod *et al.* 2015). Translocations may also have helped to establish a population in Causeway Lagoon (Berri) (Stoessel *et al.* 2019).

Recent population genetic analyses identified two meta-populations for which there are nine partially isolated subpopulations (Thiele *et al.* 2020). The meta-populations being the (1) lower Murray River and Lower Lakes, (2) the Riverland and Victorian Mallee regions and, although they did not form part of the analyses, NSW subpopulations (e.g. the reintroduced subpopulation as well as any future subpopulations). It is increasingly recognised that separate management of subpopulations may be reinforcing genetic isolation, thus managing more broadly (e.g. meta-population level) is now recommended (Thiele *et al.* 2020).

2.1.2 Biological information

Murray Hardyhead is a small (commonly 30–65 mm total length (TL) with a maximum TL of 95 mm) and short-lived species (generally annual with just some individuals surviving into the second year) (Lintermans 2023). Individuals mature in their first year of life and spawning



takes place from September to March, with peak larval abundance usually occurring in late October to early November (Ellis 2005; Lintermans 2023). The species is a batch spawner that deposits 10–100 adhesive eggs per clutch on submerged structures (Lintermans 2023). Young hatch 5–10 days after fertilisation with water temperatures of more than 20°C (Lintermans 2023). Adults are generally replaced by maturing juveniles at the end of the breeding season (January/February) and failed spawning and recruitment can therefore lead to severe declines and extirpations (Ellis 2005; Stoessel 2010).

Murray Hardyhead inhabits lakes, wetlands, backwaters and billabongs, and has a preference for still or slow flows (Lintermans 2023). It is often associated with dense aquatic vegetation and with sand or silt substrate (Lintermans 2023). It can tolerate saline environments with juveniles (and likely adults) capable of surviving salinities as high as 98,000 μScm^{-1} electrical conductivity (EC) (Stoessel *et al.* 2020). Research identified that brackish salinity of 12–45 parts per thousand should be maintained when managing wetlands for Murray Hardyhead conservation (Stoessel *et al.* 2020).

The species can also survive a wide range of water temperatures having been recorded in water of temperatures ranging from 5–33°C (Lintermans 2023). Murray Hardyhead is typically associated with isolated moderately to highly saline wetlands but is also found in the

freshwater Lower Lakes in SA. It is an omnivore that primarily feeds on microcrustaceans as well as aquatic insects and algae (Lintermans 2023). Flooding of off-channel habitats during the spawning period (spring to summer) enhances zooplankton abundance which likely benefits recruitment success (Ellis 2005; Wedderburn *et al.* 2010).

2.1.3 Conservation status

IUCN Red List¹: *Critically Endangered*

EPBC Act²: *Endangered*

States³: *Critically Endangered* (NSW, Vic, SA)

2.1.4 Key threats and knowledge gaps

The precise causes of the rapid population declines remain unknown, but likely include a combination of multiple compounding threats such as deterioration and loss of habitat, changes to salinity levels, altered flow regimes, fragmentation, river regulation, drought, changes to irrigation practices and impacts of non-native species (DELWP 2017; Ellis *et al.* 2013; Hammer *et al.* 2013). The key threats impacting populations relate to the deterioration and loss of shallow vegetated saline wetland habitats preferred by Murray Hardyhead (Wedderburn *et al.* 2007). These habitats have been affected by river regulation for decades, but impacts were compounded during the Millennium Drought. Several known populations became extinct or were relegated to small captive breeding populations during the drought, while others experienced dramatic declines in abundance (DELWP 2017). Captive breeding attempts have been largely successful, with knowledge regarding the biology and behaviour of the species gained via captive management informing the in-situ management of wild and reintroduced populations (Ellis *et al.* 2013). Additionally, a better understanding of salinity tolerances at various life stages has informed environmental watering of known (and reintroduction) sites that support this species (Stoessel *et al.* 2020).

Table 2-1 was adapted from Koehn *et al.* (2020b) and summarises the knowledge available to adequately manage the recovery of Murray Hardyhead for each life stage (eggs, larvae, juveniles and adults). Assessment scores for each knowledge category and life stage indicated limited to moderate knowledge for Murray Hardyhead with 24 of 25 scores assigned to a

¹ International Union for Conservation of Nature (IUCN) Red List of Threatened Species

² Environment Protection and Biodiversity Conservation Act 1999

³ NSW: Fisheries Management Act 1994; SA: Action Plan for South Australian Freshwater Fishes 2009 and Fisheries Management Act 2007; Vic: DELWP 2021. Flora and Fauna Guarantee Act 1988 – Threatened List. Department of Environment, Land, Water and Planning, Victoria.

knowledge score of 59% or less, suggesting that knowledge to adequately manage the recovery of the species is limited (Koehn *et al.* 2020b).

*Table 2-1: Status of available knowledge for life stages of Murray Hardyhead. Available knowledge was scored as follows: 1: 0–19% of knowledge needed is available; 2: 20–39% of knowledge needed is available; 3: 40–59% of knowledge needed is available; 4: 60–79% of knowledge needed is available; 5: 80% of knowledge needed is available. Numbers in cells indicate median scores, and colours reflect these scores (green: high degree of knowledge; red: greatest knowledge gaps). Blank cells are not applicable to the particular life stage. Adapted from Koehn *et al.* (2020b).*

Knowledge categories	Eggs	Larvae	Juveniles	Adults
Spawning	2.5			3.0
Spawning conditions				3.0
Survival (recruitment)	2.0	2.0	2.0	2.0
Growth and condition		2.0	2.0	3.0
Movements		2.0	2.0	2.0
Physical habitat requirements	3.0	3.0	3.5	4.0
Water quality tolerances	2.0	2.0	3.0	3.5
Flows requirements	2.5	2.5	2.5	2.5

2.2 Southern Purple-spotted Gudgeon *Mogurnda adpersa*

2.2.1 Historic and current distribution

Historically, Southern Purple-spotted Gudgeon was widespread in most coastal drainages along the east coast and had a widespread but patchy distribution in the MDB (Bice *et al.* 2019; Pusey *et al.* 2004). It used to occur in the coastal drainages of the South Australian Gulf and was once widespread and common in wetland and fringing river habitats throughout the MDB, but has experienced severe declines in distribution and abundance in the Basin, especially the southern MDB (Lintermans 2023; Pusey *et al.* 2004). Along the east coast, it still occurs as far north as Normanby River, Cape York Peninsula in Queensland, south to the Clarence River in northern New South Wales (although only one remnant population is known in New South Wales) (Pusey *et al.* 2004).



NSW DPI Fisheries

In NSW, it has a patchy distribution and occurs in numerous small and isolated populations in tributaries of the Darling River (in the Macquarie, Gwydir and Border Rivers catchments) (Lintermans 2023; NSW DPI 2017). Recent reintroductions have been made to the Castlereagh, Macquarie, Lachlan and Murrumbidgee catchments, NSW (Lintermans 2023). Populations were also present near Dundas in the upper Severn River and in the upper Macintyre River around Inverell two decades ago, however none have been detected there recently. There is a possibility that some populations still exist in some of these (as well as in the Beardy River) (D. Gilligan, personal communication, 2020).

It was thought to be extinct in South Australia until a population was discovered in the Lower Murray between Murray Bridge and Mannum in 2002. By 2007, that site had dried completely due to heavy water use and prolonged drought conditions (Hammer *et al.* 2012). During the rapid wetland drying, fish were rescued and used to establish captive populations (Hammer *et al.* 2012). Fish were bred in captivity and surrogate dams and the population at the site in the Lower Murray has been maintained through regular reintroductions (Hammer *et al.* 2015; Whiterod *et al.* 2019). Reintroductions have also been undertaken to the River Torrens, Adelaide. The species was also presumed extirpated in Victoria until a population was rediscovered in the Kerang Lakes in 2019 (Lintermans 2023; Stoessel 2020). Environmental DNA results suggest that the species has a wider distribution in the Kerang region than previously thought (Stoessel *et al.* 2022).

2.2.2 Biological information

Southern Purple-spotted Gudgeon grows to a maximum size of ~150 mm total length but is more commonly between 60 and 120 mm in size (Lintermans 2023). It reaches sexual maturity at approximately six months of age. Breeding typically occurs between October and February and is thought to be induced by a combination of increasing temperatures and day length, abundance of food and availability of spawning sites (Llewellyn 2014; Pusey *et al.* 2004). The species has demersal, transparent eggs that have an adhesive disc and are attached in clusters of 100 to 1300 eggs to solid objects (Llewellyn 2014; Pusey *et al.* 2004). Eggs hatch within 3–9 days after fertilisation at temperatures of >18°C. It is a batch spawner with females capable of producing 7–10 broods over a spawning season (Llewellyn 2014; Pusey *et al.* 2004). Levels of fecundity depend on fish size and vary across the species' range (Pusey *et al.* 2004).



Southern Purple-spotted Gudgeon is a benthic species that inhabits slow moving or still waters in rivers, creeks, wetlands and billabongs, and is most abundant in habitat with fine to intermediate-sized substrate (e.g., sand, gravel and cobbles) and where aquatic macrophytes, filamentous algae, root masses and undercut banks are common (Hammer *et al.* 2015; Lintermans 2023; Pusey *et al.* 2004). While it is considered a freshwater species, it has also been recorded from estuarine habitats (Lintermans 2023; Pusey *et al.* 2004). Maxent species-distribution modelling indicates that Southern Purple-spotted Gudgeon in the northern MDB have a strong preference for small spring-fed streams (D. Gilligan, personal communication, 2020). It can tolerate a relatively wide range of temperatures (from ~10–34°C), moderately acidic to basic water conditions, elevated salinity levels and low dissolved-oxygen concentrations (Hammer *et al.* 2015; Pusey *et al.* 2004). It is a slow moving ambush predator that feeds on small fish, macroinvertebrates (such as freshwater prawns, dragonfly larvae and beetles), worms and tadpoles (Lintermans 2023; Pusey *et al.* 2004).

2.2.3 Conservation status

IUCN Red List⁴: *Least Concern*

EPBC Act⁵: Not listed (under assessment)

States⁶: *Critically Endangered* (Vic), *Critically Endangered* and *Protected* (SA), *Endangered* (NSW)

2.2.4 Key threats and knowledge gaps

Southern Purple-spotted Gudgeon has significantly declined in distribution and abundance. While the precise reasons for the declines remain unknown, it is likely that multiple, potentially interacting threats including intensive flow regulation and diversions, habitat degradation (loss of aquatic plants and increased sedimentation), drought, and predation and competition with alien species (such as Eastern Gambusia, Redfin Perch and Common Carp) are significant (Hammer *et al.* 2012; Hammer *et al.* 2009; Lintermans 2023; NSW DPI 2017). Recently, the species has been threatened by the 2018–19 drought and 2019–20 bushfires. Furthermore, populations are typically small, isolated and have low genetic diversity which makes them susceptible to catastrophic events such as drought, floods and pollution that might cause localised extirpation (Faulks *et al.* 2008; Lintermans 2023). Sites that experienced such localised extirpation might not be recolonised in the absence of rescue efforts due to the species' poor ability to disperse over long distances (NSW DPI 2017). Knowledge gaps exist regarding both biology and ecology (see Table 2–2 which provides a summary of knowledge status of this species in the MDB (Koehn *et al.* 2017). A better understanding of the specific requirements of the species would assist recovery planning (Hammer *et al.* 2009).

Table 2–2: Ecological knowledge of life stages of Southern Purple-spotted Gudgeon. Scores range from 1 to 10, with 1 indicating limited knowledge and 10 considerable knowledge. Adapted from Koehn *et al.* (2017).

Spawning	Eggs	Larvae	Juveniles	Adults
4	4	3	3	5

⁴ International Union for Conservation of Nature (IUCN) Red List of Threatened Species

⁵ Environment Protection and Biodiversity Conservation Act 1999

⁶ NSW: Fisheries Management Act 1994; SA: Action Plan for South Australian Freshwater Fishes 2009 and Fisheries Management Act 2007; Vic: DELWP 2021. Flora and Fauna Guarantee Act 1988 – Threatened List. Department of Environment, Land, Water and Planning, Victoria.

2.3 Olive Perchlet *Ambassis agassizii*

2.3.1 Historic and current distribution

Olive Perchlet was historically widespread but patchily distributed throughout much of the MDB in NSW, Queensland, South Australia and Victoria, and in coastal streams of northeastern NSW and southeastern Queensland (Allen and Burgess 1990). In the MDB, it was found broadly from both the northern (Darling River, Border Rivers, Bogan River, Clarence River and Condamine-Balonne, Nebine and Warrego River) and southern catchments (Lachlan River, Murrumbidgee River and Murray River downstream to the Lower Lakes) (Lintermans 2007). Although the species is still common within the rivers of coastal Queensland and NSW, the MDB population has declined and is now patchily distributed or absent (Lintermans 2023).



In the Gwydir River, the species was first detected in the mid-2010s from two wetlands, which subsequently dried and it has not been sampled since. It was considered extirpated from the southern MDB (e.g., last recorded in NSW in 1970; last recorded in SA in 1983; and last recorded in Vic in 1922) until it was rediscovered in large numbers (almost 5000 fish) from the Lachlan River Catchment in 2007 (McNeil *et al.* 2008). The rediscovered population is restricted to the weir pool upstream of Brewster Weir and a short distance downstream of Brewster Weir, as well as reaches within the lower end of Mountain Creek (the outlet channel for Lake Brewster) (McNeil *et al.* 2008).

Records suggest that it was always rare in SA with the last confirmed record from 1983, where it is now considered extinct (Hammer *et al.* 2009; Lintermans 2023). It was thought to be extinct in Victoria until the species was observed from Mullarro Creek (Vic) and Mendindee Lakes (NSW) following high flows in 2021/22 (Lintermans 2023).

Stocking was undertaken at in NSW at Lake Cargelligo weir pool, Washpen Creek (Euston) and Thegoa Lagoon (near Wentworth) in 2010/11, but unfortunately was unsuccessful (D. Gilligan, personal communication, 2020). More recently, fish were stocked in the Gwydir and Macquarie catchments and Nine Panel Lagoon, Millewa Forest, but it is not known yet whether these conservation efforts were successful. Bushfires in late 2019 impacted habitat in the Border Rivers area and ~700 fish were rescued to establish a captive population (Lintermans 2023). Captive surrogate sites now exist in four of the seven NRM regions (NCCMA, MCMA, MLLS & WLLS) and captive breeding is being attempted at Melbourne Sealife Aquarium. At Snobs Creek hatchery, 600 fish have been retained with a plan to breed some in spring 2024 and release into suitable habitats in conjunction with relevant CMAs.

Significant genetic differentiation is evident across the present range of the species, indicating four main groupings: southern coastal QLD, northern coastal NSW, southern MDB (Lachlan catchment) and northern MDB (Burnett, Warrego, Condamine, Macintyre, Gwydir and Bogan; P. Unmack, unpublished data). Separate management of the species across these four main groupings is currently recommended, however, evaluation of the validity of assisted gene flow is required and consequently management might require adaptation.

2.3.2 Biological information

Olive Perchlet is a small (max. total length 76 mm but typically up to 50 mm) oval, laterally compressed, olive to semitransparent fish, with brown margins on the scales (Lintermans 2007). It inhabits the vegetated edges of rivers, creeks, lakes, ponds, swamps, and wetlands, and in areas with little or no flow it is typically found amongst



aquatic vegetation and woody habitat (Lintermans 2023). During habitat preference trials, Olive Perchlet showed a preference for structure and submerged macrophytes (Hutchison *et al.* 2020). During the day, it aggregates in small, almost stationary schools that occupy areas close to instream cover (Allen and Burgess 1990; Lintermans 2023).

Both sexes mature at approximately one year of age and life expectancy ranges from two to four years, though females typically live slightly longer (Lintermans 2023). Spawning commences when water temperatures reach between 19–27°C, ceases at temperatures above 27°C and can occur once or twice a year (Lintermans 2007; Lintermans 2023; Llewellyn 2008; McNeil *et al.* 2008; Milton and Arthington 1985). Fecundity is usually 200–700 eggs, but can be as high as 10,000 eggs under captive breeding conditions (Llewellyn 2008). Eggs are small (0.7 mm diameter) and adhesive, which allows them to attach to aquatic plants and rocks on the stream bed. Hatching times range from one day at temperatures between 20–29°C (Llewellyn 2008) and five to seven days at 22°C, and larvae are approximately 3 mm long at hatching (Pusey *et al.* 2004). The species is a carnivore that feeds on microcrustaceans (e.g., copepods, cladocera), aquatic and terrestrial insects (e.g., mosquito wrigglers, small arachnids) and sometimes even small fish (Lintermans 2023).

2.3.3 Conservation status

IUCN Red List⁷: Least Concern

⁷ International Union for the Conservation (IUCN) Nature Red List of Threatened Species

EPBC Act⁸: Not listed

States⁹: *Extinct (Vic), Critically Endangered and Protected (SA), Endangered population (MDB population; NSW)*

2.3.4 Key threats and knowledge gaps

Although no individual threat has been attributed to the ongoing decline of the species, potential threats include impacts from alien fish (including predation by Redfin Perch, egg predation and resource competition with Eastern Gambusia and competition and habitat alteration by Common Carp), spawning and recruitment restrictions due to cold-water pollution, habitat loss and degradation (especially loss of macrophyte spawning habitat), rapid fluctuation in water levels due to river regulation leading to reduced reproduction and recruitment, and degradation in condition of wetlands (Lintermans 2007; Lintermans 2023; NSW DPI 2013a). Low levels of connectivity between lagoons and rivers due to river regulation reduces recruitment success and limits dispersal of juveniles. Drought and increased levels of sedimentation after bushfires can cause localised declines in populations (Lintermans 2023). Current knowledge of the ecology and requirements of Olive Perchlet is limited (Table 2-3) (Koehn *et al.* 2020b). The amount of available knowledge that exists for the species was summarised by Koehn *et al.* (2020b) indicating that typically less than 39% of knowledge that is needed is presently available (and in many cases <19%) (Table 2–3). While there are records of migration through tidal barrage fishways in coastal streams, there is limited knowledge of movement patterns of the MDB populations of the species (Lintermans 2007).

Table 2–3: Status of available knowledge for life stages of Olive Perchlet. Available knowledge was scored as follows: 1: 0–19% of knowledge needed is available; 2: 20–39% of knowledge needed is available; 3: 40–59% of knowledge needed is available; 4: 60–79% of knowledge needed is available; 5: 80% of knowledge needed is available. Numbers in cells indicate median scores, and colours reflect these scores (green: high degree of knowledge; red: greatest knowledge gaps). Blank cells are not applicable to the particular life stage. Adapted from Koehn *et al.* (2020b).

Knowledge categories	Eggs	Larvae	Juveniles	Adults
Spawning	2.0			2.0
Spawning conditions				2.0
Survival (recruitment)	1.0	1.0	1.0	1.5
Growth and condition		1.0	1.0	1.0
Movements		1.0	1.0	1.0
Physical habitat requirements	3.0	1.0	2.0	3.0
Water quality tolerances	1.0	1.0	1.0	1.0
Flows requirements	2.0	1.0	2.0	2.0

⁸ Environment Protection and Biodiversity Conservation Act 1999

⁹ NSW: Fisheries Management Act 1994; SA: Action Plan for South Australian Freshwater Fishes 2009 and Fisheries Management Act 2007; Vic: DELWP 2021. Flora and Fauna Guarantee Act 1988 – Threatened List. Department of Environment, Land, Water and Planning, Victoria.

2.4 Southern Pygmy Perch *Nannoperca australis*

2.4.1 Historic and current distribution

Southern Pygmy Perch historically occurred in the coastal catchments of southeastern SA and southern Victoria, the South Australian Gulf, northern Tasmania, King and Flinders Islands and the MDB. It used to be widespread across the southern MDB, including the headwaters of Lachlan Catchment, the Murrumbidgee and Murray catchments. In the Murray, it occurred in headwater streams, the mid-Murray and tributaries (Broken, Ovens, Goulburn and Kiewa rivers) and the lower Murray River (including the Lower Lakes and Mt Lofty tributaries). The species has experienced significant range reductions since European settlement, associated with the degradation and loss of wetland habitat and the impact of alien species (Lintermans 2007). The species remained widely distributed but persisted as fragmented subpopulations, which were further impacted by the Millennium Drought, with local extirpation occurring from mid- and headwater Murray River sites (including Barmah-Millewa, Normans Lagoon, Happy Valley Creek, Tallangatta Creek, Khancoban Lagoon, Oolong Creek and likely the lower Ovens River floodplain) as well as sites in Mount Lofty Ranges and Lake Alexandrina (and Hindmarsh Island). At this time, fish from Lake Alexandrina and surrounding areas (Turvey's Drain and Mundoo Island) were rescued to establish backup populations (initially captive maintenance and breeding facility) (Cole *et al.* 2016; Hammer 2008).



Over the past 10 years, the species has continued to decline across the MDB. In NSW, it persists in three catchments; the upper Lachlan drainage near Dalton (Blakney, Urumwalla, Oolong creeks); upper Billabong Creek near Holbrook; and Coppabella Creek near Albury (Lintermans 2023). The remaining populations include: 1) population in Blakney Creek (Lachlan catchment: discovered 2002; Lintermans and Osborne 2002) that has experienced recent range retraction; 2) Billabong Creek headwaters (e.g., Mountain Creek sub-catchment - experienced large recent range retraction); 3) Coppabella Creek (stable population); and 4) a reintroduced population in Pudman Creek (established, but only just persisting) (Pearce 2015; Pearce *et al.* 2018). Reintroductions were attempted in Thegoa Lagoon (near Wentworth) and Washpen Creek (near Euston) in May 2011 but despite short-term success (e.g., two individuals recaptured 20 days after release in Washpen Creek), the species did not establish.

In SA, despite declines, there are locally strong subpopulations in the Lake Alexandrina and tributary streams of the Mount Lofty Ranges (Whiterod *et al.* 2019). During the Millennium

Drought, the species almost disappeared from the Lower Lakes due to rising salinity levels and loss of fringing reedbed habitat (Lintermans 2023). Individuals were collected and captive bred fish were first reintroduced into the Lower Lakes in 2011. As part of these reintroductions, monitoring was undertaken annually in Autumn from 2011 to 2021, with a total of 278 surveys undertaken at sites suitable to support the Lower Lakes population (65 unique sites overall and 30 sites annually surveyed). Fish were first detected in 2012 and recorded every year during sampling. Recruitment success varied from moderate to high (YOY = 39–73%), and presented a successful self-sustaining population (Marshall *et al.* 2022).

In the Victorian MDB, it persists in Middle Creek, Mountain Creek, Avoca River catchment, Campaspe River catchment (Rose 2018), the Goulburn River catchment (Pranjip Creek, Castle Creek, Creightons Creek, Hughes Creek, Yea River), Broken River catchment (Broken River), and King River (P. Rose, personal communication, 2022). Releases were made into wetlands, dams and successful surrogate sites in Tahbilk and Mitchellstown, as well as more than 20 farm dams in the Loddon Catchment and more than 20 farm dams in the Greta Valley (Lintermans 2023; Raymond *et al.* 2019). Releases into Cameron's Creek (Gunbower Forest) and Sheepwash Creek (lower Campaspe catchment) have resulted in new populations establishing.

Although once considered to historically form one contiguous meta-population across the southern MDB, the species has now contracted to 14 genetically distinct subpopulations (Cole *et al.* 2016; Hammer 2008): 1) Angas River; 2) Finniss River; 3) Lake Alexandrina and surrounds: lower reaches of Tookayerta Creek, Turvey's Drain and Mundoo and Hindmarsh islands; 4) mid- to upper-reaches of Tookayerta Creek; 5) Avoca River; 6) Goulburn and Broken rivers; 7) upper Broken River; 8) Campaspe River; 9) Upper Murray (Norman Lagoon); 10) Coppabella Creek; 11) Kiewa River; 12) Ovens River; 13) Mitta Mitta River; and 14) Lachlan River. These genetic distinctions have been used to define conservation units, but in recognition of the negative impacts of fragmentation, a strategy of translocation (including genetic rescue) is recommended to enhance genetic diversity (Brauer and Beheregaray 2020; Brauer *et al.* 2016).

2.4.2 Biological information

Southern Pygmy Perch attains a maximum size of ~85 mm total length but is typically < 65 mm (Lintermans 2023). Both sexes reach sexual maturity within their first year (~30–33 mm total length) and life expectancy is up to 5 years



(Lintermans 2023). Populations are typically dominated by 0+ aged fish with a smaller proportion of 1+ and 2+ aged individuals (Humphries 1995). Spawning occurs from September to January with rising water temperatures (>16°C) and each females produce round, transparent and non-adhesive eggs. The eggs are deposited on the bottom substrate or on aquatic vegetation and hatching takes place after 2–4 days (Humphries 1995; Lintermans 2023).

Southern Pygmy Perch generally occurs in still and slow-flowing water, with abundant aquatic vegetation cover; it is rarely found in fast-flowing sections of streams. It is a poor disperser that has been recorded from small streams, irrigation channels, billabongs, wetlands and well-vegetated lakes. It is a carnivorous species that feeds on cladocerans, copepods, ostracods, and small insect larvae (e.g., chironomids, mayflies, water bugs, mosquitos) (Lintermans 2023).

2.4.3 Conservation status

IUCN Red List¹⁰: *Near Threatened*

EPBC Act¹¹: Not listed MDB pop has listing check

States¹²: *Endangered* (NSW), *Endangered and Protected* (SA), *Vulnerable population* (MDB lineage; Vic)

2.4.4 Key threats and knowledge gaps

River regulation, cold water pollution and associated habitat deterioration including loss of aquatic vegetation, floodplain alienation, cold-water pollution, water abstraction, seasonal flow changes/reduction as well as predation and competition with alien species (including Redfin Perch, Trout species, and possibly Eastern Gambusia, and competition with/habitat alteration by Common Carp) have contributed to population declines in Southern Pygmy Perch (Hammer *et al.* 2009; Lintermans 2023; NSW DPI 2013b). Extended drought h lead to the isolation of populations and drying of habitat, and subsequent flooding events can have severe impacts (Lintermans 2023). The Urumwalla Creek population was severely reduced by drought in 2019 (M. Lintermans, personal communication, 2020). Infection by parasitic nematode larvae might affect the health and fitness and consequently reduce growth, reproductive success and survival (Shamsi *et al.* 2023).

¹⁰ International Union for the Conservation (IUCN) Nature Red List of Threatened Species

¹¹ Environment Protection and Biodiversity Conservation Act 1999

¹² NSW: Fisheries Management Act 1994; SA: Action Plan for South Australian Freshwater Fishes 2009 and Fisheries Management Act 2007; Vic: DELWP 2021. Flora and Fauna Guarantee Act 1988 – Threatened List. Department of Environment, Land, Water and Planning, Victoria.

Knowledge gaps exist regarding the biology and ecology of this species (Lintermans 2007). Table 2-4 provides a summary of knowledge status of this species in the MDB with generally low levels of ecological knowledge available (<39% for most knowledge categories) (Koehn *et al.* 2020a).

*Table 2–4: Status of available knowledge for life stages of Southern Pygmy Perch. Available knowledge was scored as follows: 1: 0–19% of knowledge needed is available; 2: 20–39% of knowledge needed is available; 3: 40–59% of knowledge needed is available; 4: 60–79% of knowledge needed is available; 5: 80% of knowledge needed is available. Numbers in cells indicate median scores, and colours reflect these scores (green: high degree of knowledge; red: greatest knowledge gaps). Blank cells are not applicable to the particular life stage. Adapted from Koehn *et al.* (2020b).*

Knowledge categories	Eggs	Larvae	Juveniles	Adults
Spawning	2.5			3.0
Spawning conditions				3.0
Survival (recruitment)	2.0	2.0	2.0	2.0
Growth and condition		2.0	2.0	2.5
Movements		2.0	2.0	2.0
Physical habitat requirements	2.0	2.0	3.0	3.0
Water quality tolerances	2.0	2.0	2.5	3.0
Flows requirements	2.0	2.0	2.0	2.0

2.5 Flathead Galaxias *Galaxias rostratus*

2.5.1 Historic and current distribution



NSW DPI Fisheries

Flathead Galaxias is endemic to the Southern MDB but has experienced severe declines in distribution and abundance across much of its historic range (Lintermans 2023; New South Wales Fisheries Scientific Committee (NSW FSC) 2008; NSW DPI 2014). In Victoria the species was historically abundant in the Kerang Lakes, the Broken, Goulburn, Ovens, Kiewa and upper-Murray catchments and as far west as the Avoca River (Lintermans 2023). Populations are now only known from the Goulburn, Ovens, Kiewa and upper-Murray catchments (Raadik *et al.* 2024).

The species was likely broadly distributed in the River Murray in SA, as far downstream as Lake Alexandrina (Point Mcleay) (record collected by A. Zeitz in 1886, species confirmed by T. A. Raadik), and likely occurred more widely across floodplains, swamps and billabongs associated with the River Murray (Hammer *et al.* 2009; Lintermans 2023). It has not been recorded in SA since 1886 and is considered extinct in that state. In NSW, Flathead Galaxias was recorded from billabongs and the main river channel of the upper Murray River (near Albury; last sighting 2003), areas in the mid to lower Murrumbidgee River (last record 1995), a lagoon next to the Macquarie River near Bathurst (1881) and a single record from a site near Lake Brewster (Lachlan River; from 1972) (Lintermans 2023). It was historically considered widespread and common in rivers and wetlands of the Murrumbidgee and Murray catchments, however, it is now presumed to be locally extinct in NSW.

2.5.2 Biological information

The biology and ecology of Flathead Galaxias is poorly understood. It grows to a maximum total length of ~15 cm, has a life expectancy of 3 years and reaches sexual maturity by the end of its first year (Gilligan *et al.* 2019; Lintermans 2007). It spawns in August–September once surface and bottom water temperatures reach >10.5°C and females deposit from 2300–7000 eggs depending on body size (Lintermans 2023; Llewellyn 2005). The demersal and slightly adhesive eggs have been found to settle on the bottom and hatch after 8–9 days (Llewellyn 2005), though possibly also laid onto submerged aquatic vegetation (T. Raadik, personal communication, August 2024).

Flathead Galaxias is a highly vagile, fast swimming and schooling species that historically inhabited still or slow flowing waters in a range of habitats such as billabongs, small streams, lagoons lakes, swamps and rivers (Gilligan *et al.* 2019; Lintermans 2023; NSW DPI 2014). It is associated with aquatic vegetation and coarse sand or muddy substrate (NSW DPI 2014), in

clear to turbid waters (Raadik, unpublished data). While it generally aggregates in the mid-water, it has been observed to move into the oxygen-rich top layer at the water surface when oxygen levels in the habitat decline (Lintermans 2023). It is typically a carnivorous species that feeds on aquatic insects and some microcrustaceans (Lintermans 2023).

2.5.3 Conservation status

IUCN Red List¹³: *Critically Endangered*

EPBC Act¹⁴: *Critically Endangered*

States¹⁵: *Extinct (SA), Critically Endangered (NSW), Vulnerable – under review (Vic)*

2.5.4 Key threats and knowledge gaps

The precise reasons that have led to the decline in Flathead Galaxias populations remain unknown, however, they likely include reduced or lost connectivity between riverine and floodplain habitat, habitat loss and degradation, altered flow regimes and cold-water pollution leading to reduced reproductive success, predation and competition with alien fish such as Common Carp, Redfin Perch and Eastern Gambusia, loss of riparian and aquatic vegetation, and construction of barriers to movement and recolonisation (Lintermans 2023; New South Wales Fisheries Scientific Committee (NSW FSC) 2008). The ecology and biology of the species are not well understood, and further research is required.

¹³ International Union for the Conservation (IUCN) Nature Red List of Threatened Species

¹⁴ Environment Protection and Biodiversity Conservation Act 1999

¹⁵ NSW: Fisheries Management Act 1994; SA: Action Plan for South Australian Freshwater Fishes 2009 and Fisheries Management Act 2007; Vic: DELWP 2021. Flora and Fauna Guarantee Act 1988 – Threatened List. Department of Environment, Land, Water and Planning, Victoria.

2.6 Yarra Pygmy Perch *Nannoperca obscura*

2.6.1 Historic and current distribution

The historic distribution of Yarra Pygmy Perch is not well understood as records are limited, but it is likely that the species was historically more widespread



and abundant across its range in southern Australia (Saddler *et al.* 2013). It was previously found from the Bunyip River Basin (West Gippsland, Vic) east through southern Victoria and to southeastern South Australia. It has been observed as far west as Lake Alexandrina and the Finniss River (near the Murray River mouth, SA) (Saddler and Hammer 2010). Its current distribution is patchy and highly fragmented, and ranges from the Maribyrnong River system, Victoria, to the Henry Creek Catchment, South Australia (Saddler and Hammer 2010; Whiterod *et al.* 2019).

In Victoria, the species is considered extinct in the Yarra River and the Dandenong Creek (last records from 1872 and 1982, respectively) (Saddler and Hammer 2010). It is still found in reasonable numbers around Geelong and Torquay, but very few fish were recorded in the region around Lake Corangamite, where surveys are required to establish the continuing presence of the species (Department of Climate Change 2023). The Deep Creek (most easterly point of the distribution) and Henry Creek (most western part) populations are also at risk of extirpation with very low numbers of individuals observed in the past few years (Department of Climate Change 2023; Veale and Whiterod 2018).

In southeastern SA, the species was last recorded from Mosquito Creek, and Bool and Hacks Lagoons in 2012, and these populations are now considered extirpated (Veale and Whiterod 2018; Whiterod 2020; Whiterod 2022). In the MDB, it was only discovered in Lake Alexandrina (SA) in the early 2000s and was considered locally extinct by the later stage of the Millennium Drought. Falling water levels reduced the availability of the fringing reedbed refuge habitat and exposed fish to potential predators such as Redfin Perch (Beheregaray *et al.* 2021; Lintermans 2023; Wedderburn *et al.* 2019b; Wedderburn *et al.* 2022). Fish were rescued and placed into surrogate wetlands for later reintroductions into the wild. Translocations into Lake Alexandrina in 2012 to 2014 after the Millennium Drought broke were unsuccessful and the species remained extinct in the wild in the MDB (Beheregaray *et al.* 2021; Lintermans 2023; Wedderburn *et al.* 2022). Individuals are still maintained in surrogate sites for reintroductions and in 2023–2024, 9000 fish were reintroduced to the Lower Lakes. As few individuals were used to establish the source surrogate populations there are concerns regarding biological and genetic issues associated with maintaining Yarra Pygmy Perch in

surrogate refuges and genetic work is currently underway (Wedderburn *et al.* 2019b; Whiterod *et al.* 2021).

The remaining Yarra Pygmy Perch populations display low levels of genetic diversity due to habitat fragmentation, historic and recent local extinctions, poor dispersal ability and inbreeding (Brauer *et al.* 2013; Hammer *et al.* 2010). Three contemporary and one extinct in the wild geographically defined lineages, or Evolutionary Significant Units (ESUs), and 11 Conservation Management Units (CMUs), were identified using genetic analyses (Brauer *et al.* 2013; Hammer *et al.* 2010). The four ESUs are: 1) Murray–Darling Basin (considered extinct in the wild, but maintained in ex situ sites); 2) Central, including the Glenelg River Basin, Millicent Coast and Mount Emu Creek; 3) Merri, including and immediately surrounding the Merri Catchment; and 4) Eastern, including the Thompson, Waurm Ponds and Deep Creek subpopulations (Beheregaray *et al.* 2021; Brauer *et al.* 2013; Hammer *et al.* 2010; Wedderburn *et al.* 2019b). The status of reintroductions to Dandenong Creek (Vic) and the Central ESU requires further investigation (Department of Climate Change 2023; Saddler and Hammer 2010).

2.6.2 Biological information

Yarra Pygmy Perch is an obligate freshwater species that can grow to a maximum total length of 75 mm but is more usually less than 65 mm (Lintermans 2023). It likely reaches sexual maturity within its first year and life expectancy



is probably less than 4 years (Hammer *et al.* 2009). The following physio-chemical conditions were observed for this species: pH levels between 4–10, typical salinity levels of <1.6 parts per thousand (with juvenile growth increasing at moderate (2.5–7.5 parts per thousand) salinities), and dissolved oxygen levels > 2 mgL⁻¹ (Mahon *et al.* 2015; Veale *et al.* 2014). Breeding commences in spring when water temperatures are 16–24°C. It is primarily carnivorous and feeds on microcrustaceans, molluscs and aquatic insects (e.g., mosquito larvae) (Kuitert *et al.* 1996; Lintermans 2023). Yarra Pygmy Perch is usually found in small groups and often occurs with Southern Pygmy Perch (Kuitert *et al.* 1996; Saddler and Hammer 2010).

It is typically associated with the highly vegetated margins of slow flowing and still waters, and habitat includes wetlands, lakes, ponds, springs, creeks and drainage channels (Department of Agriculture 2020; Kuitert *et al.* 1996). Connectivity between permanent waterbodies is vital for the persistence of the species as a loss of connectivity leads to

fragmented populations thereby increasing the likelihood of local extinctions (Saddler and Hammer 2010).

2.6.3 Conservation status

IUCN Red List¹⁶: Endangered

EPBC Act¹⁷: Endangered

States¹⁸: Critically Endangered and Protected (SA), Vulnerable (Vic)

2.6.4 Key threats and knowledge gaps

The major threats to Yarra Pygmy Perch are wetland drainage and modification for agricultural, urban and industrial use, habitat degradation, alteration to hydrological regimes and reduced flooding, removal of instream and riparian habitat and disturbance through unregulated stock access, predation and/or competition with alien fish such as Redfin Perch, Eastern Gambusia and Common Carp, and climate change (Saddler and Hammer 2010; Saddler *et al.* 2013). Changes to flow regimes and natural flooding cycles reduce the levels of connectivity between wetlands and deeper and more permanent water bodies, which vital refuge habitat during dry periods and drought. Furthermore, the species has poor dispersal abilities and the reduced connectivity between populations means it is unlikely that natural recolonisation after population losses can take place (Brauer *et al.* 2013; Lintermans 2023). A combination of habitat degradation, especially the loss of fringing macrophyte refuge habitat, drought related impacts and predation by alien fish such as Redfin Perch is thought to have driven the species to local extinction in the MDB, and the presence of piscivore Redfin Perch is likely to hamper future reintroduction attempts (Wedderburn *et al.* 2022).

Knowledge gaps exist regarding both biology and ecology (see Table 2–6 which provides a summary of knowledge status of this species in the MDB (Koehn *et al.* 2017)). A better understanding of the species' life history, habitat dynamics and potential threats would assist recovery planning (Hammer *et al.* 2009).

Table 2–6: Ecological knowledge of life stages of Yarra Pygmy Perch. Scores range from 1 to 10, with 1 indicating limited knowledge and 10 considerable knowledge. Adapted from Koehn *et al.* (2017).

Spawning	Eggs	Larvae	Juveniles	Adults
3	4	3	3	5

¹⁶ International Union for the Conservation (IUCN) Nature Red List of Threatened Species

¹⁷ Environment Protection and Biodiversity Conservation Act 1999

¹⁸ NSW: Fisheries Management Act 1994; SA: Action Plan for South Australian Freshwater Fishes 2009 and Fisheries Management Act 2007; Vic: DELWP 2021. Flora and Fauna Guarantee Act 1988 – Threatened List. Department of Environment, Land, Water and Planning, Victoria.

3. Recovery approaches in-place

Broad guidance has been provided on the management actions needed to restore native fish in the MDB (Koehn *et al.* 2020a; MDBA 2020). The Native Fish Recovery Strategy, for instance, outlines five actions (across four outcomes) necessary to achieve four outcomes of (1) recovery and persistence of native fish; (2) identify and mitigate threats to native fish; (3) communities are actively involved in native fish recovery; and (4) recovery actions are informed by the best available knowledge (MDBA 2020). Similarly, Lintermans *et al.* (2020) provide nine recommendations to avert the extinction of threatened fish species. Koehn *et al.* (2020a) recommend 30 priority actions, relating to flow management, infrastructure and other restoration, and support and engagement, which are deemed as critical to ‘providing a legacy of native fish recovery in the MDB, rather than extinctions’.

National recovery plans have been developed for Murray Hardyhead (in draft) and Yarra Pygmy Perch (DELWP 2017; Saddler and Hammer 2010), which have an overarching objective of improving the conservation status of each species, with the ultimate long-term goal being the removal of species from the threatened species schedule (DELWP 2017). The original recovery plan for Murray Hardyhead, released in 2010 has been revised to detail seven recovery objectives (and 19 actions), including ‘*protect, maintain and monitoring presently known populations*’, ‘*increase area of occupancy*’ and ‘*establish emergency contingency*’.

Under the recently updated Conservation Advice for Yarra Pygmy Perch (In effect under the Environment Protection and Biodiversity Conservation Act 1999 from 15 November 2023), the main conservation objective was to ‘*Ensure ongoing survival of the Yarra pygmy perch by retaining and increasing known subpopulations and enhancing habitat quality and size*’. The main recovery objectives for Conservation and Management priorities included targeting *Human disturbance (habitat loss and fragmentation)*, *Climate change impacts*, *Invasive species impacts*, *Fires regimes that cause declines in biodiversity*, and *Ex situ recovery actions*, with further priorities targeting *Stakeholder engagement/community engagement*, *Survey and monitoring priorities* and *Information and research priorities*. A total of 34 actions are listed within all these priorities (DCCEEWW 2023).

In line with these plans, the Tri-State Alliance approach to recover species in the Murray Corridor is to:

- Protect existing populations;
- Collect broodstock;
- Intensive captive breeding to secure species;
- Reintroduce offspring into secure, predator free ‘surrogate’ sites (natural hatcheries);

- Translocate from surrogate sites to additional surrogate sites and to managed wild sites;
- Support dispersal from managed wild sites to other wild sites (e.g., through water for the environment).

For each of the six target fish species, the current status of each of the Tri-State recovery approaches is summarised in Sections 3.1 to 3.6.

Detailed information on **Ex situ maintenance and fish production**, **Conservation translocations** (Planning, translocation objectives, permitting and approvals, genetic management, accounting for climate change), **Implementation** (Identifying potential sites, site suitability criteria, site enhancement, release considerations, minimising transport-related stress, release considerations, biosecurity and disease, timing) and **Monitoring and evaluation** (Level 1: site-based seasonal monitoring, Level 2: site-based annual monitoring, Level 3: regional occupancy estimation (long-term), evaluation criteria) is provided in previous translocation plans for threatened fish species and should be utilised during conservation translocation projects adhere to the [SA translocation strategy](#) (Whiterod 2019) and the [NSW conservation translocation handbook](#) (Zukowski *et al.* 2021).

3.1 Murray Hardyhead *Craterocephalus fluviatilis*

- *Conservation listings and legal protection:* Federal and state (NSW, Vic, SA) conservation listings are in place, including listed as Endangered under the EPBC Act (1999). A national recovery plan is in place for the species (Backhouse *et al.* 2008). In NSW, there are penalties for harming, possessing, buying or selling Murray Hardyhead, and for damaging their habitat (NSW DPI 2016). In Victoria, the species is included in the Biodiversity On-Ground Action Icon Species Grants program (DEECA 2023). In SA, management of threatened populations and building a healthy, productive and resilient wetland system are part of the long-term management priorities for the Coorong, Lower Lakes and Murray Mouth (Department of Environment and Natural Resources 2009a). SA has also developed a Regional Management Guide specifically for Murray Hardhead (Whiterod *et al.* 2024, in review). The species is listed as a key native fish species in the Basin-Wide Environmental Watering Strategy (BWS), which sets out the environmental objectives for river flows and connectivity, native vegetation, waterbirds and native fish with the recovery of water for the environment and other complementary measures that improve flows (MDBA 2019).
- *Captive management:* Captive and surrogate populations have been established in SA (two are considered stable) (Whiterod 2019; Whiterod *et al.* 2021), North West Aquaculture near Mildura and Falla Dam on the Wimmera-Mallee Pipeline. Surrogate sites have been

established at the Australian Inland Botanic Gardens in Buronga and at Wingillie Station in NSW (Walker and Ellis 2023).

- *Reintroductions:* Fish were reintroduced across its range with varying success. Some populations such as Little Frenchman’s Creek (NSW), Lake Elizabeth (Vic), Lake Koorlong (Vic) and Lower Lakes region and Lake Albert (SA) show signs of establishment, while others appear unsuccessful (e.g., Lake Hawthorn and Brickworks Billabong (Vic)) (Ellis *et al.* 2020; Whiterod 2019; Whiterod *et al.* 2021). Genetic analyses have been conducted to guide the reintroduction strategy for the species (Marshall *et al.* 2022).
- *Other management actions:* Tailored environmental watering regimes have been adopted to support isolated populations at key sites (Bice *et al.* 2014; Ellis *et al.* 2013; Whiterod *et al.* 2021) and management of Lower Lakes for the species is occurring through water for the environment (DEW). A National Murray Hardyhead Recovery Working Group was established in 2022 with the help of the Commonwealth Department (DCCEEW) Threatened species strategy grants. The working group, driven by Nature Glenelg Trust, is still operational under a second stream of Threatened Species Strategy funding and alongside members of the Tri-State Alliance, guides Murray Hardyhead recovery across its range. A Regional Management Guide has been prepared specifically for Murray Hardyhead (Whiterod *et al.* 2024, in review).

3.2 Southern Purple-spotted Gudgeon *Mogurnda adspersa*

- *Conservation listings and legal protection:* Under assessment at the EPBC level. State (NSW, Vic, SA) conservation listings are in place. In NSW, there are penalties for harming, possessing, buying or selling Southern Purple-spotted Gudgeon, and for damaging their habitat (NSW DPI 2017). In Victoria, the species is included in the Biodiversity On-Ground Action Icon Species Grants program (DEECA 2023). In SA, management of threatened populations and building a healthy, productive and resilient wetland system are part of the long-term management priorities for the Coorong, Lower Lakes and Murray Mouth (Department of Environment and Natural Resources 2009b). The species is listed as a key native fish species in the Basin-wide environmental watering strategy (BWS) (Murray–Darling Basin Authority 2019).
- *Captive management:* Captive breeding facilities and surrogate dams have been established including two captive facilities established since 2019 for the Kerang Lakes region population (Vic) and four in SA (three considered stable and one non-functioning) (Whiterod 2019; Whiterod *et al.* 2021). There are self-sustaining surrogate populations at

the Australian Inland Botanic Gardens located in Buronga, NSW (Huntley 2024), and at 10 surrogate sites in central Victoria.

- *Reintroductions:* Translocations to historic and rediscovered sites were initiated in SA after the Millennium Drought broke with varying success. For example, reintroductions to historic sites were unsuccessful due to the site unexpectedly drying (Bice *et al.* 2014; Whiterod *et al.* 2021). The rediscovered population at Jury Swamp is not self-sustaining and is reinforced through regular translocations. Reintroduction to the River Torrens in SA were undertaken in 2023. In NSW, a population translocated to Adjungbilly Creek does not appear to have established and no fish were detected during subsequent surveys (Whiterod *et al.* 2021). While survival of stocked fish was observed at some sites in the Castlereagh, Macquarie, Lachlan and Murrumbidgee catchments, no recruitment was observed (Lintermans 2023; Zukowski *et al.* 2021). A translocated population was established at the Ornamental Lake in Mildura, Victoria with monitoring indicating multiple recruitments before the population dispersed and persisted during and post 2022-23 basin scale flooding (Huntley 2024). The species was stocked into Cameron's Creek (Gunbower Forest) in 2023 and recaptured in multiple surveys in early 2024. The species has also dispersed from a surrogate dam in Bendigo and established a population in Grassy Flat Creek.
- *Other management actions:* Supplementary management actions to be developed and reviewed at the two-year review of this plan.

3.3 Olive Perchlet *Ambassis agassizii*

- *Conservation listings and legal protection:* State (NSW, Vic, SA) conservation listings are in place. In NSW, there are penalties for harming, possessing, buying or selling Olive Perchlet, and for damaging their habitat (NSW DPI 2013a). The species is listed as a key native fish species in the BWS (Murray–Darling Basin Authority 2019).
- *Captive management:* Captive maintenance and breeding facilities have been established in the northern MDB. A captive insurance population was established using fish rescued after the species' habitat in the Border Rivers of the MDB was burnt in late 2019 (Lintermans 2023). In 2021, fish were stocked at two surrogate sites (permanent, managed wetlands with suitable habitat) in Mildura and Bendigo (Vic). While Olive Perchlet are surviving and showing strong recruitment at the Bendigo site, the presence of alien Eastern Gambusia, a predator of eggs and competitor for resources, at the Mildura site is of concern (North Central Catchment Management Authority 2023). Surrogate populations have been established from Bogan River sources and persist at the Australian

Inland Botanic Gardens in Buronga, NSW at a purpose-built surrogate dam at North West Aquaculture near Mildura, and 3 surrogate dams in north central Victoria.

- *Reintroductions:* Reintroductions have been undertaken but in the majority of cases were not successful. For example, populations reintroduced into Cargelligo weir pool (upstream of Brewster in the Lachlan) as well as the Thegoa Lagoon near Wentworth did not result in established populations (Whiterod *et al.* 2021). Attempts to establish a backup population in SA using fish from Queensland in the 1990s were also unsuccessful. In 2024, the species was reintroduced to Nine Panel Lagoon in Millewa Forest; the outcome of the stocking is yet to be assessed.
- *Other management actions:* Supplementary management actions to be developed and reviewed at the two-year review of this plan.

3.4 Southern Pygmy Perch *Nannoperca australis*

- *Conservation listings and legal protection:* The MDB population is listed under the EPBC. State (NSW, Vic, SA) conservation listings are in place. In NSW, there are penalties for harming, possessing, buying or selling Southern Pygmy Perch, and for damaging their habitat (NSW DPI 2013b). In SA, management of threatened populations and building a healthy, productive and resilient wetland system are part of the long-term management priorities for the Coorong, Lower Lakes and Murray Mouth (Department of Environment and Natural Resources 2009c). The species is listed as a key native fish species in the BWS (Murray–Darling Basin Authority 2019).
- *Captive management:* Rescue populations and captive breeding programs were established in SA using fish collected during the Millennium Drought from Lake Alexandrina and surrounding areas (Turvey’s Drain and Mundoo Island) (Whiterod *et al.* 2021). One population remains at a surrogate refuge site where the species has been able to establish, however, Southern Purple-spotted gudgeon have now colonised these ponds and co-exist (Whiterod 2019). Numerous backup populations were established in NSW including some in farm dams: two for the Lachlan River subpopulation; one for each of the Murrumbidgee River and Murray River subpopulations; and two for Coppabella Creek (Pearce *et al.* 2019; Whiterod *et al.* 2021). In Victoria, three captive maintenance and breeding facilities were established for Campaspe (two) and Avoca (one) populations, (Whiterod *et al.* 2021). Numerous populations have been established at farm dams (>20) in the Loddon catchment plus wetlands, dams and successful surrogate sites in Tahbilk Lagoon and North Central CMA (Lintermans 2023)

- *Reintroductions:* Reintroductions to historic sites showed mixed success. Fish were released into three sites around Lake Alexandrina in SA, but the population at only one site (Hindmarsh Island) showed persistence and recruitment (Whiterod *et al.* 2021). In NSW, reintroductions have occurred in Deniliquin Lagoons. In Victoria, fish were released into Sheepwash Creek, and multiple backup populations (including four in the Bendigo area) have been established (Whiterod *et al.* 2021). Reintroduction into Sandilong Creek, near Mildura appears unsuccessful at this time due to being heavily affected by 2022–23 basin scale flooding (Huntley and Whiterod 2022). Reintroductions into Cameron’s Creek in 2023 appear successful with recruitment detected in 2024.
- *Other management actions:* Management of water regimes is thought to have supported the persistence of populations in Lake Alexandrina (including Mundoo Island and Black Swamp) (Wedderburn *et al.* 2019a) and ongoing management of Lower Lakes for the species through water for the environment is being undertaken (DEW). Ongoing monitoring of wild populations in the Eastern Mount Lofty Ranges and the Lower Lakes is occurring. Genetic analyses has been conducted to inform conservation management of the remaining populations (Buckley *et al.* 2018).

3.5 Flathead Galaxias *Galaxias rostratus*

- *Conservation listings and legal protection:* Federal and state (NSW, Vic, SA) conservation listings are in place, including listed as Endangered under the EPBC Act (1999). In NSW, there are penalties for harming, possessing, buying or selling Flathead Galaxias, and for damaging their habitat (NSW DPI 2014). The species is listed as a key native fish species in the BWS (Murray–Darling Basin Authority 2019).
- *Captive management:* There is no captive breeding program yet, however Flathead Galaxias have been provided to the Conservation Hatchery at Snobs, and Middle Creek Farm for initial breeding exploration. So far these are only from the Goulburn River Catchment so they don't represent all extant populations. Fish have also been translocated to a farm dam in the Loddon catchment and will be monitored to determine if they breed naturally, if so, they will be restocked to the wild. The breeding program needs to include individuals from different populations (needs to be determined) to harness rare alleles and differing genetic diversity and mix these into the breeding program to stock out more genetically robust fish (T. Raadik, personal communication, August 2024).
- *Reintroductions:* While reintroductions are the goal for this species, it is important to first determine if and where other populations exist. Work is underway currently to establish the extent of newly discovered populations and ensuring captive breed fish stocks have

contributions from as many genetically diverse subpopulations as possible, as to create the most genetically robust fish for reintroductions. This will also validate field data on location and abundance of populations to guide where the captively bred stock are placed, and how many are released (T. Raadik, personal communication, August 2024).

- *Other management actions:* Targeted sampling in the NSW Murray River did not detect the species (Whiterod *et al.* 2021). In Victoria, recent targeted surveys across 60 sites found the species at four sites in the Goulburn and Upper Murray catchments (Lintermans 2023). Population genetic analysis has been undertaken across their Victorian range (T. Raadik, personal communication, August 2024).

3.6 Yarra Pygmy Perch *Nannoperca obscura*

- *Conservation listings and legal protection:* Natural and state (Vic, SA) conservation listings are in place, including listed as Endangered under the EPBC Act (1999). The species is listed as a key native fish species in the BWS (Murray–Darling Basin Authority 2019).
- *Captive management:* Captive facilities and surrogate refuges have been established with variable success and remain at low capacity. During the Millenium Drought, fish were rescued from three drying habitats at three sites in SA for captive maintenance and breeding (Whiterod 2019; Whiterod *et al.* 2021). The species persists in five backup populations in SA (two are stable, one is establishing and two are experiencing declines) (Whiterod 2019; Whiterod *et al.* 2021).
- *Reintroductions:* Reintroductions were attempted in 2012 and while initial short-term survival and recruitment were observed at some release sites, targeted surveys at reintroduction sites and sites of suitable habitat over recent years have failed to detect the species in SA (Whiterod *et al.* 2021). Over 9000 fish were released in 2023–2024 to the Lower Lakes.
- *Other management actions:* Genetic rescue approaches to increase genetic diversity in captive populations are being trialled to redress low reproductive output due to genetic deterioration (Whiterod 2019; Whiterod *et al.* 2021). Lower Lakes water for the environment (DEW). A national recovery plan for Yarra Pygmy Perch to guide conservation actions (Saddler and Hammer 2010), and recent Conservation Advice for Yarra Pygmy Perch (In effect under the Environment Protection and Biodiversity Conservation Act 1999 from 15 November 2023) (DCCEEWW 2023), have been developed.

4. Target numbers for managed surrogate and wild sites

Target numbers of managed surrogate and wild sites have been developed for the six fish species in each of the seven NRM regions in the Murray Corridor of the Tri-State Alliance to reduce extinction risk.

Managed surrogate backup sites are defined as ex situ surrogate refuges or captive facilities that support backup populations of the species. Managed wild sites are defined as remnant or reintroductions sites in the wild where the species maintains a presence over a 10-year period and achieves self-sustaining wild populations (Whiterod 2019; Zukowski *et al.* 2021). However, some managed wild sites will be shorter term with boom-and-bust species and have varying management requirements (i.e., Murray Hardyhead in a site that dries every four years).

This section has been compiled in consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders, with reference to existing plans and strategies (e.g., Basin Wide Watering Strategy, Threatened Species Recovery Plans, Action Statements and local fish recovery plans). These targets are set for 2024 to 2040, serving as goals while being open to revision based on external factors. It is recommended to review these targets biannually.

4.1 Murray Hardyhead *Craterocephalus fluviatilis*

The targets table below is based on recent consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders and in acknowledgement of existing plans and strategies (DEECA 2024; DELWP 2017; DSEWPC 2012; Hammer *et al.* 2009).

Region	Target # surrogate sites by 2040	Target # wild sites by 2040
Western LLS (NSW)	10	5
Murray LLS (NSW)	3	-
North Central CMA (Vic)	20	5
Mallee CMA (Vic)	10	5
Goulburn Broken CMA (Vic)	3	-
North East CMA (Vic)	3	-
Murraylands and Riverland LB (SA)	10	5
TOTAL	59	20

4.2 Southern Purple-spotted Gudgeon *Mogurnda adspersa*

The targets table below is based on recent consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders and in acknowledgement of existing advice (DEECA 2024; Hammer *et al.* 2009; NSW DPI 2017; Zukowski *et al.* 2024).

Region	Target # surrogate sites by 2040	Target # wild sites by 2040
Western LLS (NSW)	10	5
Murray LLS (NSW)	10	5
North Central CMA (Vic)	30	10
Mallee CMA (Vic)	10	5
Goulburn Broken CMA (Vic)	5	5
North East CMA (Vic)	20	10
Murraylands and Riverland LB (SA)	10	5
TOTAL	95	45

4.3 Olive Perchlet *Ambassis agassizii*

The targets table below is based on recent consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders and in acknowledgement of existing advice (DEECA 2024; Hammer *et al.* 2009; Zukowski *et al.* 2024; Zukowski *et al.* 2021).

Region	Target # surrogate sites by 2040	Target # wild sites by 2040
Western LLS (NSW)	10	5
Murray LLS (NSW)	10	5
North Central CMA (Vic)	15	5
Mallee CMA (Vic)	5	5
Goulburn Broken CMA (Vic)	5	5
North East CMA (Vic)	5	-
Murraylands and Riverland LB (SA)	5	3
TOTAL	55	28

4.4 Southern Pygmy Perch *Nannoperca australis*

The targets table below is based on recent consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders and in acknowledgement of existing advice (DEECA 2024; Hammer *et al.* 2009; Zukowski *et al.* 2024; Zukowski *et al.* 2021).

Region	Target # surrogate sites by 2040	Target # wild sites by 2040
Western LLS (NSW)	10	5
Murray LLS (NSW)	10	5
North Central CMA (Vic)	60	10
Mallee CMA (Vic)	5	3
Goulburn Broken CMA (Vic)	10	15
North East CMA (Vic)	10	3
Murraylands and Riverland LB (SA)	10	10
TOTAL	115	51

4.5 Flathead Galaxias *Galaxias rostratus*

The targets table below is based on recent consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders and in acknowledgement of existing advice (DEECA 2024; Hammer *et al.* 2009; TSSC 2016; Whiterod *et al.* 2021).

Region	Target # surrogate sites by 2040	Target # wild sites by 2040
Western LLS (NSW)	3	1
Murray LLS (NSW)	3	1
North Central CMA (Vic)	25	5
Mallee CMA (Vic)	3	1
Goulburn Broken CMA (Vic)	10	15
North East CMA (Vic)	20	10
Murraylands and Riverland LB (SA)	3	1
TOTAL	67	34

4.6 Yarra Pygmy Perch *Nannoperca obscura*

The targets table below is based on recent consultation with NRM managers, fisheries agencies, fish experts and other relevant stakeholders and in acknowledgement of existing advice (DCCEEW 2023; DEECA 2024; Hammer *et al.* 2009; Zukowski *et al.* 2024).

Region	Target # surrogate sites by 2040	Target # wild sites by 2040
Western LLS (NSW)	3	-
Murray LLS (NSW)	1	-
North Central CMA (Vic)	1	-
Mallee CMA (Vic)	3	-
Goulburn Broken CMA (Vic)	1	-
North East CMA (Vic)	1	-
Murraylands and Riverland LB (SA)	10	5
TOTAL	20	5

4.7 Target summary

The targets outlined here are preliminary and should be reviewed after two years. At that time, the plan is recommended to be reassessed and new findings and recommendations incorporated.

Some NRM regions do not currently have wild reintroduction targets. It may not be realistic to expect every region to be able to develop sites for all species for wild reintroduction. However, contributing to the broader species range by using suitable surrogate sites is an achievable goal at present. For example, while the Murray Hardyhead range is currently confined to four of the seven NRM regions, it was formally known from the Murrumbidgee system in the Western LLS (NSW). Through site investigations for all species, sites that align with the Murray Hardyhead suitability criteria can be flagged and developed for surrogacy in the NRM regions that fall outside the current species range. These sites can initially support the species through translocations within the species range and eventually contribute to new reintroductions to expand the species range, which is a key outcome for threatened species recovery (MDBA 2020).

A modified approach to reintroduction is suggested for the more cryptic and less progressed species in this plan, such as the Flathead Galaxias and the Yarra Pygmy Perch. As the species range is not yet fully understood, it is important to ensure the genetic viability of fish sourced for breeding and surrogacy, to avoid swamping potentially undiscovered genetic subpopulations. The primary aim in the case of Flathead Galaxias, is to harness genetic

diversity, by determining where other populations are and bringing some of these into captive breeding programs. By mixing these populations into the breeding program, more genetically robust fish are produced and able to be stocked back out into the wild (T. Raadik, personal communication, 2024).

5. Potential reintroduction sites

Central to the implementation of conservation translocations is the ability to release enough evolutionarily viable individuals to allow population establishment and persistence. In consultation with NRM managers, fisheries agencies, experts, and other stakeholders, a comprehensive table has been compiled for each of the six target fish species, for each NRM region within the Murray corridor (Tables 5-1 to 5-6). The tables include current known population locations (along with its status), as well as potential new managed surrogate and wild sites (such as wetland complexes or floodplain areas; these will generally receive environmental water). The tables also include the relevant land managers and stakeholders (although not listed for every site, it can be assumed that relevant state-based fisheries agencies and private hatcheries are also key stakeholders across the sites), and necessary management actions (if known) for potential new sites to establish a suitable habitat for the threatened fish species.

This list is intended as a brief outline of sites and stakeholders and is not intended to be exhaustive (i.e., other sites or stakeholders could be added in the future, or listed sites later removed should future investigations reveal that they are not suitable).

5.1 Murray Hardyhead *Craterocephalus fluviatilis*

Murray Hardyhead		
Murray Local Land Services (NSW)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Nil	Locally extinct	N/A
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Nil	N/A	N/A
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Nine-Panel Large Lagoon - Millewa Forest	Aquatic revegetation, pest fish control - Eastern Gambusia, Oriental Weatherloach and some Carp (recent Carp control), ongoing Carp management required	NSW NPWS (land manager), NSW DPI (REF holder/manager), First Nations communities inc. YYNAC, Bangerang, Cumeragunja LALC and Moama LALC, Environmental Trust NSW and LLS (reveg grants), NCCMA (ecological expertise and fish), Environmental water managers at NSW DCCEEW (environmental water allocations and flows), the Millewa Icon Site projects and staff (funded by the MDBA TLM program)
Nine-Panel Small Lagoon - Millewa Forest		
Fishermans Bend - Millewa Forest		
Pinchgut Lagoon - Millewa Forest		
Burial Lagoon - Millewa Forest		
Horseshoe Lagoon - Millewa Forest	Aquatic revegetation, hydrological investigations and communication with environmental water	
Western Local Land Services (NSW)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Little Frenchmans Creek (Wild site)	Not recorded since Feb 2023 (monitored quarterly), unconfirmed post flood	Hazel Henry Nature Farmland Reserves, NSW DPI, Millewa Pumping, NGT, Commonwealth environmental Water Office, MDWWG
Australian Inland Botanic Gardens Pond 3 (Surrogate sites)	Viable (thriving), 224 Catch per 20 net hours (monitored quarterly)	AIBG Committee of Management, NSW DPI, NGT
Wingillie holding tanks (Holding facility)	Viable (ad-hoc monitoring)	Hazel Henry Nature Farmland Reserves
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Australian Inland Botanic Gardens - Pond 4	Water delivery infrastructure, potential water donations from MDWWG or CEWO	AIBG Committee of Management
Wingillie Station - Dams	Secure water delivery approvals and allocations	Hazel Henry Nature Farmland Reserves
Limbaree Dam	Secure water delivery approvals and allocations	Millewa Pumping
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Boeill Lagoon/Creek	Minor regulator to control Murray inflows, secure funding, water delivery approvals & allocations	Hazel Henry Nature Farmland Reserves private landowners, NSW DPI, Millewa Pumping, NGT
Tareena Billabong	Minor regulator to control Murray inflows	Crown Lands, SA Water

Murray Hardyhead		
Brilka/Mungo Creek Complex (Wingillie Station)	Minor regulator to control Murray inflows, pumping infrastructure to allow top-up, secure funding, water delivery approvals & allocations	Hazel Henry Nature Farmland Reserves, NSW NPWS, Barkindji Title Group
North East CMA (Vic)		
Nil known, potential surrogate or potential wild populations		
Goulburn Broken CMA (Vic)		
Nil known, potential surrogate or potential wild populations		
North Central CMA (Vic)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Round Lake	Stable	NCCMA, GMW, Wamba Wamba TO, VEWH
Lake Elizabeth	Stable	NCCMA, PV, GMW, Wamba Wamba TO, VEWH
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Falla Dam	Translocations (where habitat & water quality suitable)	NCCMA, VEWH, private landholder
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Barr Creek	Aquatic revegetation; pest fish control	Wetland Working Group, NCCMA, GMW, Barapa Barapa TO
Gunbower Creek/Camerons Creek	To be investigated	NCCMA, PV, YYNAC, Barapa Barapa TO, DEECA, VEWH
Sand Hill	To be investigated	MDWWG, NCCMA, PV
Mallee CMA (Vic)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Lake Koorlong	Viable, adults recorded in Spring 2023	Lower Murray Water, MCMA, NGT
NW Aquaculture	Translocated and establishing	NW Aquaculture, NGT
Brickworks Billabong	Historic translocation site. Currently undergoing a dry management stage for translocations in spring 2024	MCMA, PV, NGT
Lake Hawthorn	Fish released in 2018, not established.	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Millewa-Mallee Pipeline dams	Engagement with land holders/managers, receiving waters risk assessments (habitat, current fish populations)	MCMA, NGT
Kirby Lagoon	Constructed wetland	MCMA, NCCMA, Mildura Rural City Council, Tati Tati TO, NGT
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Psyche Lagoon	To be investigated	MCMA, PV, NGT

Murray Hardyhead		
Brickworks Billabong	Drying and removal of carp, followed by refill and habitat improvement and eventual translocation	MCMA, PV, NGT
Cardross Lakes	Historically recorded prior and during the Millenium drought, potential for renewed effort to reestablish the species here	MCMA, Lower Murray Water, PV, NGT, ARI
Murraylands and Riverland Landscape Board (SA)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Beyond wetlands	Population stable, 2 wetlands	Alexandrina Council, NGT, Beyond Today, M&RLB, H&FLB
Lake Albert	14,200 fish released between 2016–2019, not established, no fish sampled in 2024	M&RLB, University of Adelaide, NGT, Big Little 4 Working Group
Lake Alexandrina	No fish sampled in 2024	M&RLB, University of Adelaide, NGT, Big Little 4 Working Group
Munday Dam	Stable, 1 wetland, 2010–present	Private dam land holders, NGT
Rocky Gully Wetland	No fish sampled in 2024	M&RLB, NGT
Berri Evaporation Basin	20 fish sampled in 2024	DEW, SA NPWS, M&RLB, CEWO, NGT
Disher Creek	No fish sampled in 2024	DEW, SA NPWS, M&RLB, CEWO, NGT
Lyrup Lagoon	No fish sampled in 2024	DEW, SA NPWS, M&RLB, CEWO, NGT
Shadows lagoon, Hindmarsh Island	1 fish sampled in 2024	DEW, SA NPWS, private landowner, University of Adelaide, M&RLB, CEWO NGT, M&RLB
Noora Basin	1 fish sampled in 2024	M&RLB, NGT, DEW
Mundoo Island Channel	7000 fish released in 2012	DEW, SA NPWS, private landowner, University of Adelaide, M&RLB, CEWO, NGT, M&RLB, University of Adelaide, NGT
Hunters Creek	520 fish released in 2012	DEW, SA NPWS, SARDI, University of Adelaide, M&RLB, CEWO, NGT
Gurra Gurra Wetland Complex	135 released in 2010, initially not established but self-sustaining population detected in 2019	
Boggy Creek	7520 fish released, status unknown	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
WL - mid Murray 'Yarra' Martins Bend	To be investigated	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Clark's Lagoon	To be investigated	M&RLB, CEWO, SA Water, DEW, private landowners, NGT
Lyrup Flat	To be investigated	M&RLB, CEWO, SA Water, DEW, private landowners, NGT
Narrung Wetland (boom/bust site)	Acceptance of hydrograph requirements (i.e., wetting and drying) and alternate priorities (i.e., shorebird habitat)	M&RLB, Raukkan Council, Narrung Community, Ngarrindjeri Aboriginal Corporation
Yarra Creek Lagoon	To be investigated	
Depending on distribution: Sugar Shack Wetland Complex, Morgans Lagoon (perhaps more appropriate for SPP, YPP and SPSS than MHH)	Further investigation required, including liaising with landholders. Acceptance of hydrograph requirements (i.e., wetting and drying regimes) and alternate conservation priorities already established at sites.	M&RLB, Mannum Aboriginal Community Association Inc., Sugar Shack Aboriginal Corporation, DEW Water Infrastructure and Operations, Landholders

Murray Hardyhead		
Salt Lagoon	Pending site investigation; including liaising with landholders	Landholders; M&RLB

5.2 Southern Purple-spotted Gudgeon *Mogurnda adspersa*

Southern Purple-spotted Gudgeon		
Murray Local Land Services (NSW)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Barham Lake Small Bodied Fish Nursery	1,000 released in May 2024 from Gippsland hatchery	WMLIG, Club Barham, Murray LLS and NCCMA support
Deniliquin lagoons	Persisting, no recruitment detected yet.	Deniliquin Lagoons Committee, Yarkuwa, Edward River Council, Deniliquin High School, EWAA, WMLIG, Landcare NSW, RGA ECP, JIG, MLLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW, Edward Kolety Lagoons Landcare
Nine-Panel Large Lagoon - Millewa Forest	Recently reintroduced - 126 adult fish released 11 April 2024. Future releases are currently being planned and are dependent on source fish availability and seasonal conditions.	NSW NPSW, ARI, NSW DPI, NGT
Nine-panel lagoon small lagoon - Millewa Forest (wild)	1000 fish released 11 April 2024 - to be monitored by NSW NPWS. Future releases are currently being planned and are dependent on source fish availability and seasonal conditions	NSW NPWS, ARI, NSW DPI, NGT
Adjungbilly Creek	Fish released in 2004–2005. Not established	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Moulamein Lake	Stage 1: habitat / snagging for small bodied fish provided for by Murray LLS. Stage 2: needs to be identified	Moulamein Lake Committee, Murray River Council, EWAA, WMLIG, Landcare NSW, RGA ECP, JIG, Murray LLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Barham Federation Reserve Landcare plot demo site	Pipeline / water / ewater allocation (Feds/ State / philanthropic offered by Duxton Water)	Club Barham, Barham Landcare, WMLIG, Landcare NSW, Barham High School, Barapa, EWAA, Moama LALC, JIG, MLLS, Barham Angling Club, Tri-State NRM Alliance, environmental / philanthropic water holders, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW?
Jerilderie Lake		Local Council, EWAA. JIG, Murray LLS, Landcare NSW, Tri-state NRM Alliance, Jerilderie High School, YACTAC, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Finley Lake	To be investigated	Local Council, EWAA. JIG, Murray LLS, Tri-State NRM Alliance, Finley High School, YACTAC, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW

Southern Purple-spotted Gudgeon		
Moama Lake - Killkerin Management Plan	To be investigated	Moama LALC, JIG, MLLS, EWAA, WMLIG, Local residents / Site mgt plan committee, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Moama town lakes - other	To be investigated	Moama LALC, MLLS, Murray River Council, JIG, Local residents, EWAA, Landcare NSW, Moama High School, WMLIG, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Perricoota Vines Estate	To be investigated	Perricoota Vines Estate owners, JIG, Moama LALC, MLLS, EWAA, High School/s, Landcare NSW, WMLIG, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Lower Toupna Ck	To be investigated	MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Seven Mile Ck	To be investigated	MLLS, JIG, Local residents, EWAA, Landcare NSW, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Bullatale Ck	To be investigated	MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Werai Forest	To be investigated	Werai Land and Water Aboriginal Council, MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Millewa Forest (6 sites) - Nine-panel small lagoon, Nine-panel large lagoon, Fisherman's Bend, Pinchgut Lagoon, Burial Lagoon, Horseshoe Lagoon.	Refer to Millewa Fish Recovery Strategy. Revegetation of aquatic plants, hydrological investigations (for water supply in drought), ongoing management of pest fish (as sites connect with Gulpa Creek in high water), water quality monitoring (esp. warm months).	NSW NPWS, fisheries NSW, first nations communities (inc. Yorta Yorta Nations Aboriginal Corporation, Bangerang, Cummeragunja LALC and Moama LALC), Environmental Trust NSW and LLS, NCCMA, Environmental water managers at NSW DCCEEW, Millewa Icon Site (funded through the MDBA TLM program).
Pollack Lagoon / Swamp	Carp removal funding	Forestry Corporation of NSW, private landholders, Moama LALC, JIG, Barapa, WMLIG, Landcare NSW, KPA, Pollack Community Group, MLLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
KP Forest wetlands (Swan Lagoon and downstream wetlands, Little Forest, Inlet Channel and wetlands downstream).	Environmental water delivery from Goulburn River (Swan Lagoon) at commence to flow of 17,000ML/day. E-water from Murray system U/S for inlet channel and other KP Forest wetlands to support restocking.	Forestry Corporation of NSW, Moama LALC, JIG, Barapa, WMLIG, Landcare NSW, KPA, EWAA, KP Community Group, MLLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Lake Agnus	To be investigated	Private landholders, NSW DPI, MLLS, CEWH, WMLIG, EWAA, Moama / Deniliquin LALC, OZFish, NSW BC&S, NSW DCCEEW, MDWWG
Thule Creek and wetlands	To be investigated	Various landholders, NSW DPI, EWAA, CEWH, WMLIG EWAA Moama LALC, Barapa Nation, JIG, Murray LLS, OZFish, NSW BC&S, NSW DCCEEW, MDWWG, Koondrook Perricoota Alliance

Southern Purple-spotted Gudgeon		
Eagle Creek	Connectivity with Meran Ck system / fish friendly infrastructure. Community visioning process completed	Eagle Creek Pumping Syndicate / various individual landholders, Barham Angling Club, EWAA, WMLIG, Landcare NSW, Barham Landcare, JIG, Moama LALC, MLLS, Environmental water holders, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW, MDWWG
Merran Creek	To be investigated	Little Merran Creek Irrigation Trust / Landholders, WMLIG, Landcare NSW, EWAA, Wemba Wemba Nation / JIG, MLLS Environmental water holders, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW, MDWWG
Tallys Lake	To be investigated	Dunns, WMLIG, EWAA, Wemba Wemba Nation / JIG, Environmental water holders, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Wilson's Lake	To be investigated	Private landholders, WMLIG, EWAA, Landcare NSW, MLLS, Wemba Wemba Nation / JIG, Environmental water holders, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Sheepwash lagoon (off Merran Ck system)	Environmental water allocation	Private landholders, WMLIG, Landcare NSW, State environmental water holders, CEWH, Philanthropic water, JIG, EWAA, MDWWG
Speewa Creek	To be investigated	Landholders / WMLIG, EWAA, MLLS, Wemba Nation, JIG, Environmental water holders, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Western Local Land Services (NSW)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Wingillie Surrogate Tanks	Viable	Hazel Henry Nature Farmland Reserves
Australian Inland Botanic Gardens Pond	Viable	AIBG Committee of Management
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Wingillie Station - Dams	Secure water delivery approvals and allocations	Hazel Henry Nature Farmland Reserves
Limbaree Dam (MPC Directors)	Secure water delivery approvals and allocations	MPC Directors
Coomealla Golf Course	Carp and Gambusia exclusion/control, aquatic revegetation (esp. Vallisneria sp. and Eleocharis), permanent water security	Coomealla Golf Club
Barham Lakes		WMLIG, Club Barham, MLLS
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Henry Creek/Lake	Pump-screen infrastructure to exclude Gambusia and Carp eggs, supplementary aquatic revegetation, secure backup population (Wingillie Tanks)	Hazel Henry Nature Farmland Reserves
Bingerra Creek	Continue Winter water delivery timing to continue the exclusion of Carp and Gambusia	NSW EHG, Bingerra Farms

Southern Purple-spotted Gudgeon		
North East CMA (Vic)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Farm dam at Hansonville	Yet to be re-surveyed	NECMA, ARI, Greta Valley Landcare, private landholder
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Expansion of Landcare surrogate program could yield suitable sites across the NE catchment and Lower Ovens Floodplain	Funding to improve habitat quality and/or control pest fish (Gambusia or other exotics) in farm dams, desktop analysis via aerial imagery of drought years to reduce risk of low water security (Warby Range spring-fed dams may be an option)	PV, NECMA, private landholders, Landcare Victoria, TO
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Lower reaches of the Ovens River, including King & Reedy Ck Floodplain North of Freeway. All sites at high likelihood of floodplain connection annually.	Habitat assessments, pre-survey (particularly for existing assemblages of exotics)	PV, NECMA, private landholders, Landcare Victoria, TO
Goulburn Broken CMA (Vic)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Private dams (x4) - Limestone - reintroduction site	Approx. 1000 released in 2024 - follow up monitoring planned for later this year	Private landholders, PV, DEECA, TO groups, ARI & Research Institutes, Local Fishing Groups / NFA, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state Alliance
Goulburn wetlands - near Seymour (McLartys) - reintroduction site	632 released in Aug 2023 - follow up monitoring in 2024 did not detect presence	
Private Dam – Merrijig – reintroduction site	Approx. 150 released in 2024	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Private dams (x 2) - Flowerdale	Enhance to improve available food	Private landholders, PV, DEECA, TO groups, ARI & Research Institutes, Local Fishing Groups / NFA, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state Alliance
Private dams - Yea	In-dam vegetation improvements (close to being suitable)	
Private dam (3 in chain) -Yarck	Increase habitat (close to being suitable)	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Mid & Lower Goulburn River	<i>Note – guidance for species & site suitability will be sought from ARI fish ecologists</i>	Private landholders, PV, DEECA, TO groups, ARI & Research Institutes, Local Fishing Groups / NFA, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state alliance
Goulburn River wetlands (e.g. Loch Garry)		
Broken River (mid - lower)		
Upper Broken Creek		
Lower Broken Creek		
Broken wetlands		
Barmah Forest		

Southern Purple-spotted Gudgeon		
North Central CMA (Vic)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Kerang Lakes (Middle Reedy, Racecourse, Kangaroo)	Requires assessment (may have been impacted by 2022 floods)	NCCMA, GMW, Barapa Barapa and Wamba Wamba TO
Camerons Creek	Establishing (recaptures 6 months post-stocking)	NCCMA, PV, YYNAC
Grassy Flat Creek (Bendigo)	Small recruiting population (dispersed from Harcourt Park wetlands)	City of Greater Bendigo Council
Surrogate farm dams and urban wetlands (x 8)	7 sites stable and recruiting; 1 site with persistence but no recruitment	NCCMA, City of Greater Bendigo Council, private landholders, Native Fish Australia (Vic), Australia New Guinea Fishes Association
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Atkinson Park wetland (Kerang)	Draining, install screen, aquatic revegetation, habitat addition (rocks / timber)	NCCMA, Barapa Barapa TO, Gannawarra Shire Council
Milloo St Wetlands (Swan Hill)	Habitat addition (logs / rock), Gambusia control	NCCMA, Swan Hill Rural City Council, Wamba Wamba TO
Farm dams near Bendigo (x 2)	To be investigated	NCCMA, private landholders, Australia New Guinea Fishes Association, Native Fish Australia (Vic)
Along Wimmera-Mallee pipeline wetlands	Engagement with land holders/managers, receiving waters risk assessments (habitat, current fish populations)	NCCMA, VEWH, private landholders
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Kerang Weir Pool	Aquatic revegetation, pest fish control	NCCMA, PV, Barapa Barapa TO
The Bannacher wetland	Water delivery / EWMP	NCCMA, VEWH, GMW, Barapa Barapa TO, private landholders
Reedy Lagoon (Gunbower Forest)	Reset, then stocking	NCCMA, VEWH, DEECA, Barapa Barapa TO
Black Charlie Lagoon (Gunbower Forest)	Aquatic revegetation, pest fish control, woody habitat addition	NCCMA, PV, YYNAC
Gunbower Creek (d/s Cohuna)	To be investigated	NCCMA, VEWH, DEECA, Barapa Barapa TO
Axe Creek	To be investigated	NCCMA, City of Greater Bendigo, Strathfield and districts community enterprise and FOSSALs group, Native Fish Australia (Vic), Australia New Guinea Fishes Association
Ghow Swamp	To be investigated	NCCMA, YYNAC, GMW
Little Murray River (weir pools and backwaters)	To be investigated	NCCMA, Wamba Wamba TO
Campaspe River (secondary channels b/w Eppalock and Elmore)	To be investigated	NCCMA, Djaara, VEWH
Mallee CMA (Vic)		
Current known population locations	Current population status	Relevant stakeholders/land managers

Southern Purple-spotted Gudgeon		
Ornamental Lake (Nowingi Place)	Stable and monitored, multiple recruitment events recorded pre and post 2022-23 flooding; Dispersal recorded from the lake to downstream Brickworks Billabong	Lower Murray Water, MCMA, NGT, Swan Hill Rural City Council, OzFish, First People of the Millewa Mallee Aboriginal Corp.
Cowanna and Brickworks Billabong	Dispersed from Ornamental Lake – Brickworks now dry (management phase) but Cowanna has continued to hold water – monitoring to confirm presence	MCMA, PV, NGT
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Millewa-Mallee Pipeline dams	Engagement with land holders/managers, receiving waters risk assessments (habitat, current fish populations)	MCMA, NGT, private landholders
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Cowanna Billabong	Monitored and assessed; Requires screening when filling from the Murray River but supports aquatic macrophytes	MCMA, PV, NGT
Murraylands and Riverland Landscape Board (SA)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Beyond wetlands	Established 2013, Population stable, 3 wetlands	Alexandrina Council, NGT, Beyond Today, M&RLB, H&FLB
Greenlands Drive Reserve Wetland, Murray Bridge	Population stable, 1 wetland	Murray Bridge Council, M&RLB
Urrbrae Wetlands	Low numbers sampled 2024	Urrbrae High School, NGT
Various schools	9 schools	Various Schools in South Australia
Torrens River (out of MDB)	2 fish sampled 2024	City of Adelaide, NGT, Green Adelaide
Oaklands Wetland (out of MDB)	33 fish sampled 2024	City of Marion, NGT, Green Adelaide
Patawalonga Creek (out of MDB)	6 fish sampled 2024	City of West Torrens, NGT, Green Adelaide
Lower Finniss River	1120 fish released between 2011–2013, not established	Private landholders, NGT
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Monarto Zoo	Revegetation	Zoos SA
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Sugar Shack Wetland Complex – (multi basin rotating)	To be investigated. Requires acceptance of hydrograph requirements (i.e. wetting and drying regimes). Would require intensive monitoring to move fish from wetland to wetland within complex within the current hydrological management. <i>*May be more aligned with boom/bust species than SPSG</i>	M&RLB, Mannum Aboriginal Community Association Inc. (MACAI), Sugar Shack Aboriginal Corporation, DEW Water Infrastructure and Operations, Landholders
Mid murn Cluster	To be investigated	
North Purnong	Acceptance of hydrograph requirements (i.e., wetting and drying) <i>*May be more aligned with boom/bust species than SPSG</i>	Private landholders, M&RLB, DEW WIO

Southern Purple-spotted Gudgeon		
Murbko South	Further investigation is required, including liaising with landholders. Acceptance of hydrograph requirements (i.e. wetting and drying regimes). <i>*May be more aligned with boom/bust species than SPSG</i>	Private landholders, M&RLB, DEW WIO
Morgan's Lagoon (South of Blanchetown)	Further investigation is required, including liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes). Assess substrate during proposed wetland dry (2024). <i>*May be more aligned with boom/bust species than SPSG</i>	Private landholders, M&RLB
Teal Flat Hut	Further investigation is required, including liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes). Assess substrate during proposed wetland dry (2024). <i>*May be more aligned with boom/bust species than SPSG</i>	Private landholders, M&RLB, DEW WIO
Tauwitchere Station	Further investigation is required, including liaising with landholders. Acceptance of hydrograph requirements (i.e. wetting and drying regimes), and alternate priorities (i.e., shorebird habitat). Assess substrate during proposed wetland dry (2025). <i>*May be more aligned with boom/bust species than SPSG</i>	Private landholders, M&RLB

5.3 Olive Perchlet *Ambassis agassizii*

Olive Perchlet		
Murray Local Land Services (NSW)		
Current known population locations	Current population status	Relevant stakeholders/land managers
Moulamein Lake	5,000 released May 2024 by NSW DPI Fisheries (also released Western Carp Gudgeon, M-D Rainbow Fish and Australian Smelt)	Moulamein Angling Association Club, Moulamein Lake Committee, Murray River Council, EWAA, WMLIG, JIG, MLLS
Deniliquin Lagoons	To be investigated	Edward Kolety Lagoons Landcare & EWAA, Deniliquin Lagoons Committee, Edward River Council, Yarkuwa, Deniliquin High School, EWAA, WMLIG, Landcare NSW, RGA ECP, JIG, MLLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Nine-Panel Small Lagoon - Millewa Forest	600 fish released 11 April 2024. Future releases are currently being planned and are dependent on source fish availability and seasonal conditions. To be monitored	NSW NPWS, YYNAC

Olive Perchlet		
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Moulamein Lake	Carp control, continued monitoring, 1st stage habitat / snagging for small-bodied fish (provided for by Murray LLS). Stage 2 needs to be investigated	Moulamein Angling Association Club
Barham Lakes (Barham Lake Small Bodied Fish Nursery)	Carp and Gambusia exclusion/control, aquatic reveg (esp. Vallisneria sp. and Eleocharis), water security (permanent). Actions (NCCMA Contract) to create infrastructural needs for a fish nursery (currently underway). Habitat enhancement and community engagement est. \$50K. Large pop. Eel Tailed Catfish (could be translocated)	WMLIG, CluBarham, WMLIG, Barham Landcare, High School, Barham and Koondrook Lions Club, Barapa, Moama LALC, JIG, MLLS, Barham Angling Club, Tri-State Alliance, NSW environmental water holders.
Barham Federation Reserve Landcare plot demo site	Pipeline, water, environmental water allocation	Federal/ State Government / philanthropic offered by Duxton Water, cluBarham, Barham Landcare, WMLIG, Barham High School, Barapa, Moama LALC, JIG, MLLS, Barham Angling Club, Tri-State Alliance, environmental / philanthropic water holders
Jerilderie Lake	To be investigated	Local Council, EWAA, JIG, MLLS, Landcare NSW, Tri-State NRM Alliance, Jerilderie High School, YACTAC, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Finley Lake	To be investigated	Local Council, EWAA, JIG, MLLS, Tri-State NRM Alliance, Finely High School, YACTAC, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Moama Lake - Killkerin Mgt Plan	To be investigated	Moama LALC, JIG, MLLS, EWAA, Western Murray Land Improvement Group, Local residents / Site mgt plan committee, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Moama town lakes - other	To be investigated	Moama LALC, MLLS, Murray River Council, JIG, Local residents, EWAA, Landcare NSW, Moama High School, WMLIG, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Perricoota Vines Estate	To be investigated	Perricoota Vines Estate owners, JIG, Moama LALC, MLLS, EWAA, High School/s, Landcare NSW, WMLIG, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Millewa Forest (5 sites) - Nine-panel large lagoon, Fisherman's Bend, Pinchgut Lagoon, Burial Lagoon, Horseshoe Lagoon.	Aquatic revegetation, hydrological investigations (for water supply in drought), ongoing management of pest fish (as sites connect with Gulpa Creek in high water), water quality monitoring (esp. warm months). Refer to Millewa Fish Recovery Strategy	NSW NPWS, NSW DPI, first nations communities (inc. YYNAC Bangerang, Cumeragunja LALC and Moama LALC), Environmental Trust NSW and LLS, NCCMA, Environmental water managers - NSW DCCEEW, Millewa Icon Site (funded through the MDBA TLM program).
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Lower Toupna Ck	To be investigated	MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Seven Mile Ck	To be investigated	
Bullatale Ck	To be investigated	

Olive Perchlet		
Werai Forest	To be investigated	Werai Land and Water Aboriginal Council, MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Millewa	To be investigated	MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW, NSW NPWS
Pollack Lagoon / Swamp	Pest fish control (Carp) funding required	Forestry Corporation of NSW, Graham and Tanya Heffer, Moama LALC, JIG, Barapa, WMLIG, KPA, Pollack Community Group, MLLS
KP Forest wetlands (Swan Lagoon and downstream wetlands, Little Forest, Inlet Channel and wetlands downstream).	Environmental water delivery from Goulburn River (Swan Lagoon) at commence to flow of 17,000ML/day, E water from Murray system U/S for inlet channel and other KP Forest wetlands	Forestry Corporation of NSW, Moama LALC, JIG, Barapa, WMLIG, KPA, EWAA, KP Community Group, MLLS
Lake Agnus	To be investigated	Landholders Mathew and Jes Russ, NSW DPI, MLLS, CEWH, WMLIG, EWAA
Thule Ck and wetlands	To be investigated	Various landholders, NSW DPI Water, EWAA, CEWH, WMLIG EWAA Moama LALC, Barapa Nation, JIG, MLLS
Eagle Creek	Connectivity with Meran Ck system / fish friendly infrastructure. Community visioning process completed	Eagle Creek Pumping Syndicate / various landholders, Barham Angling Club, EWAA, WMLIG, Barham Landcare, JIG, Moama LALC, MLLS, Environmental water holders
Merran Creek	To be investigated	Little Merran Creek Irrigation Trust / Landholders, WMLIG, EWAA, Wemba Wemba Nation / JIG, MLLS, Environmental water holders
Tallys lake	To be investigated	Private landholders, WMLIG, EWAA, Wemba Wemba Nation / JIG, Environmental water holders
Wilsons Lake	To be investigated	Private landholder, WMLIG, EWAA, Wemba Wemba Nation / JIG, Environmental water holders
Sheepwash Lagoon (off Merran Ck system)	Environmental water allocation	Private landholders, WMLIG, State and Federal environmental holders, Philanthropic water, JIG, EWAA
Speewa Creek	To be investigated	Private landholders / WMLIG, EWAA, MLLS, Wemba Nation, JIG, Environmental water holders
Western Local Land Services (NSW)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Australian Inland Botanic Gardens - Pond 2 (surrogate)	Released April 2024 (monitored quarterly)	AIBG Committee of Management
Holding facility - Wingillie holding tanks	Present (ad-hoc monitored)	Hazel Henry Nature Farmland Reserves
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Wingillie Station - Dams	Secure water delivery approvals and allocations	Hazel Henry Nature Farmland Reserves

Olive Perchlet		
Limbaree Dam	Secure water delivery approvals and allocations	MPC Directors
Coomealla Golf Course	Carp and Gambusia exclusion/control, aquatic revegetation (emphasis on Vallisneria sp.), water Security (permanent)	Coomealla Golf Club
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Henry Lake/Creek	Carp and Gambusia exclusion/control, aquatic revegetation (emphasis on Vallisneria sp.), water Security (permanent and dispersal mechanism)	Hazel Henry Nature Farmland Reserves
North East CMA (Vic)		
No known current populations or potential surrogate or wild populations		
Goulburn Broken CMA (Vic)		
No known current populations or potential surrogate or wild populations		
North Central CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Harcourt Park wetland no. 3 (surrogate)	Recruiting	NCCMA, City of Greater Bendigo Council
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Haasal Dam (near Heathcote)	Translocations; addition of woody habitat	NCCMA, VFA, private landholder
Larni Girangiland Wetland (Bendigo)	Translocations; addition of woody habitat	NCCMA, City of Greater Bendigo, Djaara, VFA
Harcourt Park Dam 1 (Crook St)	Translocations; addition of woody habitat	NCCMA, City of Greater Bendigo, Djaara, VFA, Native Fish Australia (Vic), ANGFA
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Black Charlie Lagoon (Gunbower Forest)	To be investigated	NCCMA, PV, YYNAC
Cameron's Creek (Gunbower Forest)	To be investigated	NCCMA, PV, YYNAC
Reedy Lagoon (Gunbower Forest)	To be investigated	NCCMA, VEWH, DEECA, Barapa Barapa TO
Mallee CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
North West Aquaculture Dam Mildura (Surrogate)	1000 released into surrogate dam in June 2024	NW Aquaculture, NGT, VFA, MCMA, NCCMA
Tafe ponds	Potentially not successful, no recruitment detected	Sunitafe, NC CMA, NGT, Mallee CMA
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Along Wimmera-Mallee pipeline wetlands	Engagement with land holders/managers, receiving waters risk assessments (habitat, current fish populations)	MCMA, NGT, private landholders

Olive Perchlet		
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Cowanna Billabong	Monitored and assessed; Requires screening when filling from the Murray River but supports aquatic macrophytes	MCMA, PV, NGT
Murraylands and Riverland Landscape Board (SA)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Nil	Extinct in SA	N/A
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Beyond Wetlands	To be investigated	Alexandrina Council, NGT, Beyond Today
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
North Purnong	Acceptance of hydrograph requirements (i.e., wetting and drying) <i>*May be more aligned with classic boom/bust species</i>	Private landowners, M&RLB, DEW Water Infrastructure and Operations
Teal Flat Hut	Further investigation, liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes). Assess substrate during proposed wetland dry (2024). <i>* May be more aligned with classic boom/bust species</i>	Private landowners, M&RLB, DEW Water Infrastructure and Operations
Sugar Shack Complex	To be investigated. Requires acceptance of hydrograph requirements (i.e. wetting and drying regimes). Would require intensive monitoring to move fish from wetland to wetland within complex within the current hydrological management. <i>*May be more aligned with classic boom/bust species</i>	M&RLB, Mannum Aboriginal Community Association Inc. (MACAI), Sugar Shack Aboriginal Corporation, DEW Water Infrastructure and Operations, private landowners
Morgan's Lagoon (South of Blanchetown)	Further investigation is required, liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes). Opportunities to assess substrate during proposed wetland dry (2024). <i>*May be more aligned with classic boom/bust species</i>	Private landowners, M&RLB

5.4 Southern Pygmy Perch *Nannoperca australis*

Southern Pygmy Perch		
Murray Local Land Services (NSW)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Nine panel lagoon (wild)	Released April 2024 - to be monitored	NSW NPWS
Basin Creek (wild)	Declining due to exotic species incursion	NSW NPWS
Coppabella Creek (wild)	Stable	NSW NPWS
Upper Billabong Creek (wild)	Stable	NSW NPWS
Mountain Creek (wild)	Stable	NSW NPWS
Spring Creek (wild)	Stable	NSW NPWS
Yarra Yarra Creek (wild)	Stable	NSW NPWS
Ten Mile Creek (wild)	Stable	NSW NPWS
Woomargarma Station Dam (surrogate)	Status unknown	
Deniliquin lagoons (Championed by Edward Kolety Lagoons Landcare & EWAA)	To be investigated	Deniliquin Lagoons Committee, Edward River Council, Deniliquin High School, Yarkuwa, EWAA, WMLIG, Landcare NSW, RGA ECP, JIG, MLLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Barham Lakes	Carp and Gambusia exclusion/control, aquatic revegetation (emphasis on Vallisneria sp. and Eleocharis), water Security (permanent), dedicated surrogate site \$30K.	WMLIG, CluBarham
Moulamein Lake	1st stage habitat / snagging for small bodied fish provided for by Murray LLS. Stage 2 needs to be determined.	Moulamein Lake Committee, Murray River Council, EWAA, Landholders, WMLIG, JIG, MLLS
Barham Federation Reserve Landcare plot demo site	Pipeline / water / ewater allocation (Feds/ State / philanthropic offered by Duxton Water)	CluBarham, Barham Landcare, WMLIG, Barham High School, Barapa, Moama LALC, JIG, MLLS, Barham Angling Club, Tri-State Alliance, environmental / philanthropic water holders
Jerilderie Lake, Finley Lake, Moama Lake - Killkerin Mgt Plan, Moama town lakes – other, Perricoota Vines Estate	To be investigated	Local Council, EWAA, JIG, MLLS, Landcare NSW, Tri-State Alliance, Jerilderie High School, YACTAC, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW, Local residents / Site mgt plan committee, WMLIG, Perricoota Vines Estate owners
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Lower Toupna Ck, Seven Mile Ck, Bullatale Ck	To be investigated	MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW, Landcare NSW
Werai Forest	To be investigated	Werai Land and Water Aboriginal Council, MLLS, JIG, Local residents, EWAA, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW

Southern Pygmy Perch		
Pollack Lagoon / Swamp	Carp removal funding	Forestry Corporation of NSW, Graham and Tanya Heffer, Moama LALC, JIG, Barapa, WMLIG, KPA, Pollack Community Group, MLLS
KP Forest wetlands (Swan Lagoon and downstream wetlands, Little Forest, Inlet Channel and wetlands downstream).	Environmental water delivery from Goulburn River (Swan Lagoon) at commence to flow of 17,000ML/day, E water from Murray system U/S for inlet channel and other KP Forest wetlands	Forestry Corporation of NSW, Moama LALC, JIG, Barapa, WMLIG, KPA, EWAA, KP Community Group, MLLS
Lake Agnus?	To be investigated	Private landowners, NSW DPI, MLLS, CEWH, WMLIG, EWAA
Thule Ck and wetlands	To be investigated	Private landowners, NSW DPI, EWAA, CEWH, WMLIG EWAA Moama LALC, Barapa Nation, JIG, MLLS
Eagle Creek	Connectivity with Meran Ck system / fish friendly infrastructure. Community visioning process completed	Eagle Creek Pumping Syndicate / private landowners, Barham Angling Club, EWAA, WMLIG, Barham Landcare, JIG, Moama LALC, MLLS, Environmental water holders
Merran Creek	To be investigated	Little Merran Creek Irrigation Trust / private landowners, WMLIG, EWAA, Wemba Wemba Nation / JIG, MLLS Environmental water holders
Tallys lake	To be investigated	Private landowners, WMLIG, EWAA, Wemba Wemba Nation / JIG, Environmental water holders
Wilsons Lake	To be investigated	Private landowners, WMLIG, EWAA, Wemba Wemba Nation / JIG, Environmental water holders
Sheepwash lagoon (off Merran Ck system)	Environmental water allocation	Private landowners, WMLIG, State and Federal environmental holders, Philanthropic water, JIG, EWAA
Speewa Ck	To be investigated	Private landowners, WMLIG, EWAA, MLLS, Wemba Nation, JIG, Environmental water holders
Millewa Forest (6 sites) - Nine-panel small lagoon, Nine-panel large lagoon, Fisherman's Bend, Pinchgut Lagoon, Burial Lagoon, Horseshoe Lagoon.	Refer to Millewa Fish Recovery Strategy. Revegetation of aquatic plants, hydrological investigations (for water supply in drought), ongoing management of pest fish, water quality monitoring (esp. warm months).	NSW NPWS, NSW DPI, first nations communities (inc. YYNAC, Bangerang, Cumeragunja LALC and Moama LALC), Environmental Trust NSW and MLLS, Environmental water managers at NSW DCCEEW, Millewa Icon Site (funded through the MDBA TLM program).
Western Local Land Services (NSW)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Australian Inland Botanic Gardens Pond 1 & 2 (surrogate)	Present in low numbers, but not recruiting (monitored quarterly)	AIBG Committee of Management, NSW DPI
Wingillie holding tanks (holding facility)	Present (ad-hoc monitored)	Hazel Henry Nature Farmland Reserves, NSW DPI
Paika Lake - Reedbeds Reserve (surrogate)	Not detected since 2023	NSW EHG, NSW DPI, private landholders

Southern Pygmy Perch		
Thegoa Lagoon	700 fish released 2011, 4500 fish released 2011. Not established	NSW EHG, NSW DPI, MDWWG
Washpen Creek	4500 fish released in 2011. Not established.	NSW EHG, NSW DPI
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Wingillie Station - Dams	Secure water delivery approvals and allocations	Hazel Henry Nature Farmland Reserves, NSW DPI
Limbaree Dam (MPC Directors)	Secure water delivery approvals and allocations	Millewa Pumping, NGT, NSW DPI
Coomealla Golf Course	Pest fish control/exclusion (Carp and Gambusia), aquatic revegetation (esp. on Vallisneria sp.), permanent water security	Coomealla Golf Club, MDWWG, NSW DPI
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Henry Lake/Creek	Pest fish exclusion/control (Carp and Gambusia), aquatic revegetation (esp. Vallisneria sp.), water Security (permanency and dispersal mechanism)	Hazel Henry Nature Farmland Reserves
North East CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
King Valley: Fosang's Creek, Queens Creek, Stoney Creek, King River main channel near Moyhu/Docker, Edi Upper (Farm Dam), Lower Ovens wetlands	Recorded within last 5 years; Appear to be locally stable and reasonably abundant. Have been used for establishing translocation surrogate pops. Lower Ovens wetlands - small numbers found in 2023.	NECMA, ARI, MDB Tri-State Murray Corridor program, Greta Valley Landcare Group, private landholders
Ovens - GVLC farm dams	Surrogate, multiple sites	
Ovens – Mullinmur billabong	Surrogate, work to improve aquatic vegetation, e-water available	
Ovens - Ovens deep refuge wetlands	Oct 23, small number of SPP found in last WetMAP survey	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Farm Dams across the North East region (10-15 sites, expand Greta Valley Landcare Group extensive translocation/surrogate program, part funded by the MDB Tri-State Murray Corridor program)	Funding to improve habitat quality and/or control Gambusia (or other exotics), desktop analysis via aerial imagery of drought years to reduce risk of low water security. Extended survey across floodplain wetlands in the King Valley to better understand the natural extent and strength of wild pops. Assumption is that genetics should be OK due to number of individuals/pops, but evidence of gene flow between pops within the King Valley would be extremely beneficial (Raymond <i>et al.</i> 2019).	NECMA, ARI, MDB Tri-State Murray Corridor program, Greta Valley Landcare Group, other landcare groups, Bangerang Aboriginal Corporation, Boorhaman landcare
Sumsion Gardens, Wodonga	To be investigated	NECMA, ARI, MDB Tri-State Murray Corridor program, Greta Valley Landcare Group, other landcare groups, Bangerang Aboriginal Corporation, Boorhaman Landcare
Kiewa - Sandy Creek Streamside Reserve	To be investigated	

Southern Pygmy Perch		
Kiewa - Upper Sandy Creek Rec Reserve?	To be investigated	
Ovens - Bonthrambo or other TFN sites	To be investigated	
Ovens - Black Swamp	To be investigated	
Ovens - Other Boorhaman wetlands, old sand quarry sites/dragline holes	To be investigated	
Ovens - Fosters Lake, Glenrowan	To be investigated	
Murray d/s Hume - Ryans Lagoons	E-water available via pumping. Carp control	
Mitta - Billabong off Omeo Rd	To be investigated	
Mitta - Billabong off Yabba rd	To be investigated	
Mitta - Billabong - Tom Patton	To be investigated	
Mitta - Billabong - Leigh Bowran	To be investigated	
Upper Murray - Cudgewa Rec reserve wetland	To be investigated	
Upper Murray - Tintalra	Exact location TBD	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Lower reaches of the Ovens River, including King & Reedy Ck Floodplain nth of Freeway.	Pre-survey to determine if already present (determine if we have e-DNA for SPP); all site have a high likelihood of floodplain connection annually.	NECMA, PV, DEECA, Rural City of Wangaratta, GMW, MDBA, Wodonga City Council, private landholders, Landcare, TO, Parklands Albury Wodonga.
Ovens - Black Swamp	To be investigated	
Goulburn Broken CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Goulburn wetlands - near Seymour (Mc Lartys) - reintroduction site	2553 released between Sept 2021 and Aug 2023, follow up monitoring in 2024 did not detect presence	
Private Dam – Merrijig – reintroduction site	40 released in 2024	
Tahbilk Lagoon (Goulburn River) - reintroduction site	Approximately 100 released in 2019	
Seven Creeks (above Gooram Falls)	2 captured in 2021 native fish survey	
Hughes Creek	55 captured in 2021 native fish survey	
King Parrot Creek	11 captured in 2021 native fish survey	
Castle Creek	Detected – ‘good numbers’ surveyed in 2024	
		Private landholders, PV, DEECA, TO groups, ARI, Research Institutes, Local Fishing Groups, Native Fish Australia, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state alliance
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Private dams (x2) - Flowerdale	Enhance to improve available food	
Private dams - Yea	In-dam veg improvements - close to being suitable	Private landholders, PV, DEECA, TO groups, ARI, DEECA, VFA, Local Fishing Groups, MDBA, TO (YYNAC/TLaWC), Snobs Creek

Southern Pygmy Perch		
Private dam (3 in chain) -Yarck	Increase habitat - close to being suitable	Fish Hatchery, Arcadia Native Fish Hatchery, Local Government, Landcare Groups, CEWH, VEWH, NSW and SA partners, Research Institutes
Private dams (x4) -Koonda	Suitable now	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Mid & Lower Goulburn River	<i>Note – guidance for species & site suitability will be sought from ARI fish ecologists</i>	Private landholders, PV, DEECA, TO groups, ARI, DEECA, VFA, Local Fishing Groups, MDBA, TO (YYNAC/TLaWC), Snobs Creek Fish Hatchery, Arcadia Native Fish Hatchery, Local Government, Landcare Groups, CEWH, VEWH, NSW and SA partners, Research Institutes
Goulburn River wetlands		
Broken River (mid - lower)		
Upper Broken Creek		
Lower Broken Creek		
Broken wetlands		
Barmah Forest		
North Central CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Middle Creek (Avoca)	Present, recruiting.	DEECA, private landholders, Djaara
Jews Harp Creek & Pipers Creek (Campaspe)	To be investigated. Present, strong population	DEECA, private landholders, Djaara
Timor Creek (Loddon)	Detected in eDNA	DEECA, private landholders, Djarra
Back Creek (Loddon)	Detected in eDNA	DEECA, private landholders, Djarra
Camerons Creek	Stocked and recruiting	PV, YYNAC
Grassy Flat Creek (Bendigo)	Present, recruiting	City of Greater Bendigo, private landholders, Djaara
Sheepwash Creek (Bendigo)	Stocked and recruiting	City of Greater Bendigo, private landholders, Djaara
Mclvor Creek (Tooberac)	May be extirpated following 2019 drought – requires monitoring	DEECA, private landholders, TLaWC
Approximately 20 surrogate sites (at Bendigo Creek and Middle Creek)	Farm dams and urban wetlands (assessed, stocked and monitored)	NCCMA, City of Greater Bendigo Council, private landholders, ANGFA, Native Fish Australia (Vic), Djaara
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Housing Development Wetlands	To be investigated	Local councils
Waste Water Treatment Plants	To be investigated	Coliban Water
Water Authority Storages	To be investigated	GMW
Ornamental lakes (golf course, Crusoe, Sandhurst, Lake Neangar, Lake Tom Thumb, etc.)	To be investigated	Private landholders, golf clubs, City of Greater Bendigo, TO
Private dams with suitable conditions	To be investigated	Private landholders
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers

Southern Pygmy Perch		
Axe Creek	To be investigated	City of Greater Bendigo, Strathfield and districts community enterprise and FOSSALS group, Native Fish Australia (Vic), Australian New Guinea Fishes Association
Campaspe River (vegetated secondary channels)	To be investigated	VEWH, TLaWC, Djaara
Kerang weir pool	To be investigated	PV, Barapa Barapa TO
"The Bannacher" wetland	To be investigated	Private Landholders, GMW
Reedy Lagoon (Gunbower Forest)	To be investigated	DEECA, Barapa Barapa TO
Black Charlie Lagoon (Gunbower Forest)	To be investigated	PV, YYNAC
Twelve Mile Creek and 'flood runners'	To be investigated	Private landholders
Nine Mile Creek wetland	To be investigated	Private landholders
Gunbower Creek (d/s Cohuna)	To be investigated	DEECA, Barapa Barapa TO, GMW
Ghow Swamp	To be investigated	GMW, YYNAC
Mallee CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Sandilong Creek	1400 released into surrogate dam in August 2022, Major flooding in summer 2022-23 heavily effected the site and requires monitoring to determine if they still persist.	MCMA, NGT, NCCMA, Riverside Golf Club
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Along Wimmera-Mallee pipeline wetlands	Engagement with land holders/managers, receiving waters risk assessments (habitat, current fish populations)	MCMA, NGT, private landholders
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Cowanna Billabong	Monitored and assessed. Requires screening when filling from the Murray River but supports aquatic macrophytes.	MCMA, PV, NGT
Murraylands and Riverland Landscape Board (SA)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Beyond wetlands	Population stable, 2 wetlands	Private landholders, Alexandrina Council, NGT, Beyond Today, H&FLB, M&RLB, BL4
Mount Compass	3 fish sampled 2024, stream	H&FLB, NGT
Middle Creek junction, EMLR	4 fish sampled in 2024	H&FLB, NGT
Turveys drain, EMLR	24 fish sampled in 2024	H&FLB, NGT
Willowburn Road, Tookayerta Creek, EMLR	16 fish sampled in 2024	H&FLB, NGT
Teague Property, WMLR	1 fish sampled in 2024	Private landholders, NGT, H&FLB, BL4

Southern Pygmy Perch		
Thorn Dairy, EMLR	4 fish sampled in 2024	Private landholders, NGT, H&FLB, BL4
Shadows lagoon, Hindmarsh Island	Few sampled in 2024	Private landholders, NGT, H&FLB, M&RLB, BL4, TO, DEW
Hindmarsh island	Very low numbers (Flood decreased habitat availability)	Private landholders, NGT, H&FLB, M&RLB, BL4, TO, DEW
Sallys lagoon, Mundoo Island	45 fish sampled in 2024	Private landholders, NGT, H&FLB, M&RLB, BL4, TO
Lake Alexandrina	1350 fish released between 2011–2012, established	Private landholders, NGT, H&FLB, M&RLB, BL4, TO, DEW
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Nil	N/A	N/A
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
More potential Lawari / Lucerne / Ewe IS	To be investigated	Private landholders, NGT, M&RLB, NPWS
Pelican Lagoon	To be investigated	Private landholders, NGT, H&FLB, M&RLB, BL4, TO, DEW
Teal Flat Hut	Further investigation is required, liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes).	Private landholders, M&RLB, DEW WIO
Morgan's lagoon (Sth. Blanchetown)	Further investigation is required, liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes).	Private landholders, M&RLB
Salt Lagoon	Pending site investigation; liaising with landholders	Private landholders, M&RLB
Paiwalla	Better regulating structure (being assessed currently)—acceptance of hydrograph requirements (i.e. wetting and drying regimes).	Wetlands Habitat Trust Inc., M&RLB

5.5 Flathead Galaxias *Galaxias rostratus*

Flathead Galaxias		
Murray Local Land Services (NSW)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Nil	Considered locally extinct	N/A
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Moulamein Lake	Stage 1 - habitat / snagging for small bodied fish provided for by Murray LLS. Stage 2 needs to be determined	Moulamein Lake Committee, Murray River Council, EWAA, Lan, WMLIG, JIG, MLLS
Barham Lake	To be investigated	cluBarham, WMLIG, Barham Landcare, High School, Barham and Koondrook Lions Club, Barapa, Moama LALC, JIG, MLLS, Barham Angling Club, Tri-State Alliance, Environmental water holders
Deniliquin Lagoons	To be investigated	Deniliquin Lagoons Committee, Edward River Council, Deniliquin High School, Yarkuwa, EWAA, WMLIG, Landcare NSW, RGA ECP, JIG, MLLS, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Finley Lake	To be investigated	Local Council, EWAA, JIG, MLLS, Tri-State NRM Alliance, Finely High School, YACTAC, NSW DPI, OZFish, NSW BC&S, NSW DCCEEW
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Millewa Forest (6 sites) - Nine-panel small lagoon, Nine-panel large lagoon, Fisherman's Bend, Pinchgut Lagoon, Burial Lagoon, Horseshoe Lagoon.	Refer to Millewa Fish Recovery Strategy. Aquatic revegetation, hydrological investigations (for water supply in drought), ongoing management of pest fish, water quality monitoring (esp. warm months)	NSW NPWS, NSW DPI, first nations communities (inc. YYNAC, Bangerang, Cumeragunja LALC and Moama LALC), Environmental Trust NSW and LLS, NCCMA, Environmental water managers at NSW DCCEEW, Millewa Icon Site (funded through the MDBA TLM program).
Western Local Land Services (NSW)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Nil	N/A	N/A
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Wingillie Station - Dams	Secure water delivery approvals and allocations	
Limbaree Dam (MPC Directors)	Secure water delivery approvals and allocations	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Nil	N/A	N/A
North East CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers

Flathead Galaxias		
Recent surveys identified some FHG in lower Mitta/Kiewa area also Murray floodplain wetlands between Lake Hume and Lake Mulwala (Lake Moodemere and Ryans Lagoons). Historical references in Upper Murray.	Small, patchy	NECMA, PV, DEECA, Rural City of Wangaratta, GMW, MDBA, Wodonga City Council, private landholders, Landcare, TO, Parklands Albury Wodonga.
Kiewa - Baker Lane Billabong, Killara	Mar-22 (Need to confirm if wild)	
Murray d/s Hume - Lake Moodemere	Mar-22 (surrogate), stable water levels at present for recreation and irrigation. Consider e-water if reconfiguration project goes ahead	
Murray d/s Hume - Ryans Lagoons	e-water available via pumping. Surrogate, Mar-22	
Mitta - Billabong off Omeo Rd	Mar-22 (surrogate)	
Mitta - Billabong off Yabba Rd	Mar-22 (surrogate)	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Farm Dams/swamps/wetlands on private property across the Boorhams/Browns Plains extending from Bowser, east of the Ovens River and northwards to the Murray, Lower Kiewa floodplain/fam dams.	Desktop analysis of aerial imagery during dry years to gauge water security, ground-truthing with landholders/assessing for habitat quality and connectivity	NECMA, PV, DEECA, Rural City of Wangaratta, GMW, MDBA, Wodonga City Council, private landholders, Landcare, TO, Parklands Albury Wodonga.
Kiewa - Sandy Creek Streamside Reserve	Need to confirm if managed by PV	
Kiewa - Upper Sandy Creek Rec Reserve	To be investigated	
Ovens - GVLC farm dams	Multiple sites (note - need to get master list)	
Ovens - Mullinmur	Improve aquatic vegetation, e-water available. Surrogate and wild?	
Ovens - Bonthrambo or other TFN sites	To be investigated	Bangerang Aboriginal Corporation
Ovens - Black Swamp		
Ovens - Other Boorhaman wetlands	Consult with stakeholders	Boorhaman Landcare
Ovens - Fosters Lake, Glenrowan	To be investigated	
Mitta - Billabong - Tom Patton	ARI to assess for FHG March 24	
Mitta - Billabong - Leigh Bowran	ARI to assess for FHG March 24	
Upper Murray - Cudgewa Rec reserve wetland	To be investigated	
Upper Murray - Tintaldra	Exact location TBD	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers

Flathead Galaxias		
Boundary Creek, Warby - Ovens National Park	Extended/continued Surveys	NECMA, PV, DEECA, Rural City of Wangaratta, GMW, MDBA, Wodonga City Council, private landholders, Landcare, TO, Parklands Albury Wodonga.
Ovens/King/Reedy floodplain north of Hume freeway (4 sites)	Extended/continued Surveys	
Ryans Lagoon	Extended/continued Surveys	
Sumsion gardens	Extended/continued Surveys	
Lake Moodemere	Extended/continued Surveys	
Lower Mitta Floodplain (4)	Extended/continued Surveys	
Lower Kiewa Floodplain (2)	Extended/continued Surveys	
Lower Cudgewa Creek Floodplain (2)	Extended/continued Surveys	
Ovens - Mullinmur	Work to improve aquatic vegetation, e-water available.	
Goulburn Broken CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Goulburn wetlands - near Alexandra	Present - sparse	Land Managers (incl. private landholders, PV, DEECA, TO groups), ARI & Research Institutes, Local Fishing Groups / NFA, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state alliance
Goulburn wetlands - Sandy Creek near Mitchellstown	Present, sufficient for some conservation translocations	
Faithful creek – near Euroa	Present in 2024 fish survey	
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Private dams (x2) - Flowerdale	Enhance to improve available food	Land Managers (incl. private landholders, PV, DEECA, TO groups), ARI & Research Institutes, Local Fishing Groups / NFA, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state alliance
Private dams (x4) - Merijig	Suitable now - consider altitude and temperatures for species selection (note – property already has 2 surrogate dams)	
Private dams - Yea	In-dam veg improvements - close to being suitable	
Private dam (3 in chain) -Yarck	More habitat - close to being suitable	
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Mid & Lower Goulburn River	Note – guidance for species & site suitability will be sought from ARI fish ecologists	Land Managers (incl. private landholders, PV, DEECA, TO groups), ARI & Research Institutes, Local Fishing Groups / NFA, MDBA, TO (YYNAC & TLaWC), VFA - Snobs Creek, Arcadia hatcheries, Private hatcheries e.g. Middle Creek Native Fish Hatchery, Landcare Groups, CEWH & VEWH, Tri-state alliance
Goulburn River wetlands		
Broken River (mid - lower)		
Upper Broken Creek		
Lower Broken Creek		
Broken wetlands		
Barmah Forest		

Flathead Galaxias		
North Central CMA (Vic)		
No known current populations or potential surrogate or wild populations		
Mallee CMA (Vic)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
No known current populations		
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Potential for surrogate sites along Wimmera-Mallee pipeline wetlands	Engagement with land holders/managers, receiving waters risk assessments (habitat, current fish populations)	MCMA, NGT, private landholders
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
No planned wild reintroductions yet due to species recently rediscovered, focus on breeding enough stock numbers through surrogate sites		
Murraylands and Riverland Landscape Board (SA)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Nil	Extinct in SA	N/A
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers
Beyond Wetlands	Established surrogate site for other threatened species	Private landholders, Alexandrina Council, NGT, Beyond Today, H&FLB, M&RLB, BL4
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Sugar shack, Morgans Lagoon (depending on distribution)	Likely more sites, as we learn more. May be good candidates for wetting-drying sites. To be investigated. Requires acceptance of hydrograph requirements (i.e. wetting and drying regimes). Would require intensive monitoring to move fish from wetland to wetland within complex within the current hydrological management	M&RLB, Mannum Aboriginal Community Association Inc. (MACAI), Sugar Shack Aboriginal Corporation, DEW Water Infrastructure and Operations, private landholders

5.6 Yarra Pygmy Perch *Nannoperca obscura*

Yarra Pygmy Perch		
Murray Local Land Services (NSW)		
No known current populations or potential surrogate or wild populations, focus on breeding enough stock numbers through surrogate sites		
Western Local Land Services (NSW)		
No known current populations or potential surrogate or wild populations, focus on breeding enough stock numbers through surrogate sites		
North East CMA (Vic)		
No known current populations or potential surrogate or wild populations, focus on breeding enough stock numbers through surrogate sites		
Goulburn Broken CMA (Vic)		
No known current populations or potential surrogate or wild populations, focus on breeding enough stock numbers through surrogate sites		
North Central CMA (Vic)		
No known current populations or potential surrogate or wild populations, focus on breeding enough stock numbers through surrogate sites		
Mallee CMA (Vic)		
No known current populations or potential surrogate or wild populations, focus on breeding enough stock numbers through surrogate sites		
Murraylands and Riverland Landscape Board (SA)		
Current known pop. locations	Current population status	Relevant stakeholders/land managers
Price Dam	2018–present, persist in low numbers, 1 wetland, initial population numbers 200 from captive source populations	Private landholders, NGT, M&RLB, H&FLB, BL4
Softfoot Dam	Persist in low numbers, 1 wetland	Private landholders, NGT, M&RLB, H&FLB, BL4, Flinders University
Grist Dam	Persist in low numbers, 1 wetland	Private landholders, NGT, M&RLB, H&FLB, BL4
Crouch Dam	Population stable, 1 wetland	Private landholders, NGT, M&RLB, H&FLB, BL4
Harper (Oster) Dam (surrogate)	2008-present, initial population numbers 70 from captive source population, persist in low numbers	Private landholders, NGT, M&RLB, H&FLB, BL4
Cleland Wildlife Park (surrogate)	2008–present, population numbers 10s	Cleland Wildlife Park, NGT
Flinders University (captive breeding)	2010–present, initial population numbers 77 from captive source populations, persist in low numbers	Flinders University, BL4
Lower Murray region	5850 fish released across five sites from 2010–2011, not established. 9000 fish released 2024	Private Landholders, TO, NGT, M&RLB, H&FLB Uni of Adelaide, BL4, DEW
Hindmarsh Island	900 fish released in 2015, not established.	Private Landholders, TO, NGT, M&RLB, H&FLB Uni of Adelaide, BL4, DEW
Potential new surrogate sites	Key management actions required	Relevant stakeholders/land managers

Yarra Pygmy Perch		
Monarto Zoo Dam	Aquatic revegetation	Royal Zoological Society of South Australia (ZoosSA), M&RLB, H&FLB, NGT, BL4
Gemtree winery Dam	Aquatic revegetation	Private landholders, NGT, M&RLB, H&FLB, BL4
Eco tour Dam (McLaren Flat)	Aquatic revegetation	Private landholders, NGT, M&RLB, H&FLB, BL4
Potential new wild sites	Key management actions required	Relevant stakeholders/land managers
Shadow's Lagoon (Hindmarsh Island)	To be investigated	Private Landholders, TO, NGT, M&RLB, H&FLB Uni of Adelaide, BL4, DEW
Mundoo Channel	To be investigated	Private Landholders, TO, NGT, M&RLB, H&FLB Uni of Adelaide, BL4, DEW
Amanda Burgers land (Hindmarsh Island)	To be investigated	Private Landholders, TO, NGT, M&RLB, H&FLB Uni of Adelaide, BL4, DEW
Lucerne Island	To be investigated	SA NPWS, Private Landholders, TO, NGT, M&RLB, H&FLB, Uni of Adelaide, BL4, DEW
Morgan's Lagoon (South of Blanchetown)	Further investigation is required, liaising with landholders—acceptance of hydrograph requirements (i.e. wetting and drying regimes).	Private landholders, M&RLB, TO
Boggy Creek (Lucerne Island side)	M&RLB to survey site in SP 2024	SA NPWS, M&RLB, TO
Ti Tree Anabranh, Hindmarsh island	To be investigated. Need to monitoring pools throughout the warmer months- at risk of drying.	M&RLB, TO

6. Key knowledge gaps and recommendations

6.1 Key knowledge gaps

While progress has been made on some of the target species, many knowledge gaps remain around their specific ecological and biological requirements (Section 2). While greater understanding of these species-specific requirements will increase our ability to manage individual subpopulations, knowledge gaps exist at a broader scale that will have a larger impact on all species across the Murray corridor. Including;

- Altered hydrology – are natural or man-made hydrographs sufficient enough to provide connectivity for dispersal (temporally and spatially)?

At what rate do the target species survive dispersal events, what is the scale and duration of flow events sufficient to promote successful dispersal and subsequent colonisation of new wetland habitats;

- Undetected populations

What populations exist in the wild that we are currently unaware of? Are these contributing to new populations during dispersal events or are they isolated;

- Climate change

How will a changing climate affect habitat availability? At what scale will water and habitat availability be impacted with increased frequency and protracted extreme weather events, such as droughts, bushfires and floods? If we can recreate appropriate hydrographs for dispersal, is there enough water to do so;

- Number and scale of resilient, self-sustaining (connected) populations required for recovery? How many, how often?
- Utility of metapopulation models to assess strategies for reintroductions including optimal stocking strategies, and number of connected populations required to sustain metapopulations? (i.e., Reintroduction strategies for Southern Pygmy Perch to Gunbower Island wetlands using a metapopulation model, Todd *et al.* 2023)

One of the challenges in developing this plan was consensus on setting site number targets for each species in each NRM region. This illustrate that there is still work to be done in understanding how many sites are required (targets), how often (temporal) and how connected (spatial)? While some ground has been gained in establishing surrogate and captive breeding sites to ensure good stock numbers (such as MHH in the Southern Basin, SPSG and SPP in the North Central CMA region) we are still unsure of the number and scale

of resilient, self-sustaining populations required for recovery. This plan is to act as a guide to encourage NRM regions to strive for the 2040 targets (Section 4), but it is understood that these targets need to be adaptive to external pressures (such as fish stock or water availability, climate, etc.) and thus can be updated and revised (Whiterod 2019). The ultimate goal will be to establish the 'optimal stocking strategy' (Lintermans *et al.* 2015), which this plan will endeavor to work towards.

6.2 Recommendations

There are well recognised recommendations regarding the management actions required to protect and restore native fish in the MDB (Koehn *et al.* 2020a; Lintermans *et al.* 2020; MDBA 2020). Strongly aligning with these, Zukowski *et al.* (2021) sets out recommendations relating to undertaking successful long-term conservation actions (namely reintroductions and conservation translocations) which were reviewed during the Tri-State Murray NRM Regional Alliance workshop (Winton Wetlands, 2024) and with direct contact with each of the seven Murray NRM regions for the development of this plan. These are summarised below including priority actions to guide progress towards achieving each:

- Consider habitat suitability under a changing climate
 - ACTION: Enhancement of site management, including provision of water for the environment, that considers impacts under a changing climate
 - ACTION: Site enhancement including habitat management and reduction of impacts (predation and competition by alien fish)
- Ensure legislative requirements do not impede ability to implement recovery actions
 - ACTION: Cross boarder/jurisdiction fish sharing agreements (Whiterod 2019), memorandum of understanding between states
 - ACTION: streamline multi-jurisdictional (where necessary) permit and approval processes
 - ACTION: lobby (open letter) for simplification of permit and approval processes for established threatened fish recovery actions
- Acknowledge long-term commitment (2040) necessary to achieve threatened fish recovery
 - ACTION: commit sufficient multi-year resources. Commitment from all levels of government (local, state and federal) to provide funding and support for on ground actions.

-
- ACTION: create a vast network of wild and surrogate subpopulations as to not rely on captive breeding and maintenance
 - Maintenance and continuity of whole-of-range strategies to achieve appropriate scale of actions (Tri-State Murray NRM Regional Alliance)
 - ACTION: engage relevant stakeholders and encourage knowledge sharing through the Alliance
 - ACTION: ensure appropriate funding is available to coordinate and share knowledge and outcomes for fish recovery along the Murray Corridor
 - ACTION: ensure fish production through use of *in situ* surrogate sites and captive breeding (*ex situ*)
 - Ensure reintroductions are guided by appropriate genetic management
 - ACTION: Development and implementation of adaptive genetic framework for each target species
 - ACTION: build robust genetic subpopulations through informed genetic analysis (especially for potentially isolated subpopulations)
 - Routinely obtain information on status of each target species (especially annual and short-lived species) and sites
 - ACTION: targeted field surveys of translocated subpopulations to determine status and identify necessary follow-up actions
 - ACTION: development of a translocation site database including stocking efforts – where have fish come from and where they went
 - Timely compilation of new knowledge as it becomes available
 - ACTION: ensure conservation advice and or listing status are up to date or developed, i.e., Develop conservation advice and potential EPBC listing for Olive Perchlet which are currently not federally listed with no conservation advice developed.
 - ACTION: biennial revision of this plan and its targets (next revision in 2026)
-

7. Conclusion

Across Australia, many threatened freshwater fish face the risk of extinction in the medium-term future without substantial intervention. In the southern MDB Murray Corridor, six target freshwater fishes (that are the focus on this Reintroduction Plan) are either absent or persisting as small, fragmented populations across contracted parts of their historical range. It is clear that urgent wide-ranging and collaborative conservation recovery actions are required to redress these declines and affect recovery of threatened freshwater fishes (Koehn *et al.* 2020a; Whiterod 2019; Zukowski *et al.* 2021).

In the southern MDB Murray Corridor, small-bodied native fish species where once common but have suffered extensive range and distribution declines. It is imperative that recovery is aimed to create resilient self-sustaining populations at a sufficient scale to ensure species persist long term. The Tri-State Murray Regional Alliance aims to recover populations and prevent the extinction of threatened native fish species in the southern MDB. This Reintroduction Plan aligns with the objectives of the Tri-State Murray Regional Alliance and provides a synthesis of knowledge, obtained through extensive collaboration and consultation, of six target threatened floodplain specialist fish species in the Murray Corridor to guide best-practice recovery actions.

For each species, species summaries (historic and current distribution, biological information, conservation status, population status, key threats and knowledge gaps), recovery approaches in-place, target numbers of managed surrogate and wild site, potential reintroduction sites, key knowledge gaps and recommendations are provided.

The Reintroduction Plan should not be viewed as standalone, rather as a supporting document that aligns with the objectives of the Tri State Murray NRM Regional Alliance, species-specific (e.g., national recovery plans) and fish-specific planning documents (e.g., The NSW Freshwater Fish Stocking Fishery Management Strategy, The Native Fish Recovery Strategy) as well as other strategies (e.g., Basin-wide environmental watering strategy), regional fish recovery plans, and translocation plans (e.g., Whiterod 2019; Zukowski *et al.* 2021). It should be viewed as a 'live' Plan that is routinely updated as new knowledge is gained.

8. References

- Adams M., Raadik T. A., Burrige C. P., Georges A. (2014). Global biodiversity assessment and hyper-cryptic species complexes: more than one species of elephant in the room? *Systematic Biology* **63**, 518-533.
- Allen G. R., Burgess W. E. (1990). A review of the glassfishes (Chandidae) of Australia and New Guinea. *Records of the Western Australian Museum Supplement* **34**, 139-207.
- Arthington A. H., Dulvy N. K., Gladstone W., Winfield I. J. (2016). Fish conservation in freshwater and marine realms: status, threats and management. *Aquatic Conservation: Marine and Freshwater Ecosystems* **26**, 838-857.
- Backhouse G., Lyon J., Cant B. (2008). 'National recovery plan for the Murray Hardyhead *Craterocephalus fluviatilis*.' State of Victoria Department of Sustainability and Environment, Melbourne, Vic.
- Balcombe S. R., Sheldon F., Capon S. J., Bond N. R., Hadwen W. L., Marsh N., Bernays S. J. (2011). Climate-change threats to native fish in degraded rivers and floodplains of the Murray–Darling Basin, Australia. *Marine and Freshwater Research* **62**, 1099-1114.
- Beheregaray L., Attard C., Brauer C., Whiterod N., Wedderburn S., Hammer M. (2021). 'Conservation breeding and reintroduction of pygmy perches in the lower Murray–Darling Basin, Australia: two similar species, two contrasting outcomes.' IUCN SSC Conservation Translocation Specialist Group, Environment Agency – Abu Dhabi and Calgary Zoo, Canada., Gland, Switzerland.
- Bice C., Gilligan D., Raadik T., Unmack P. (2019). '*Mogurnda adspersa*. The IUCN Red List of Threatened Species 2019: e.T13609A123378372.'
- Bice C., Whiterod N., Wilson P., Zampatti B., Hammer M. (2012). 'The critical fish habitat project: reintroductions of Threatened fish species in the Coorong, Lower Lakes and Murray Mouth region in 2011/12.' South Australian Research and Development Institute, Department of Primary Industry and Regions, Adelaide.
- Bice C., Whiterod N., Zampatti B. (2014). 'The Critical Fish Habitat Project: assessment of the success of reintroductions of threatened fish species in the Coorong, Lower Lakes and Murray Mouth region 2011-2014.' SARDI Aquatic Sciences, Adelaide.
- Brauer C. J., Beheregaray L. B. (2020). Recent and rapid anthropogenic habitat fragmentation increases extinction risk for freshwater biodiversity. *bioRxiv*.
- Brauer C. J., Hammer M. P., Beheregaray L. B. (2016). Riverscape genomics of a threatened fish across a hydroclimatically heterogeneous river basin. *Molecular Ecology* **25**, 5093-5113.
- Brauer C. J., Unmack P. J., Hammer M. P., Adams M., Beheregaray L. B. (2013). Catchment-scale conservation units identified for the threatened Yarra Pygmy Perch (*Nannoperca obscura*) in highly modified river systems. *PLoS one* **8**, e82953.
- Buckley S. J., Domingos F. M., Attard C. R., Brauer C. J., Sandoval-Castillo J., Lodge R., Unmack P. J., Beheregaray L. B. (2018). Phylogenomic history of enigmatic pygmy perches: implications for biogeography, taxonomy and conservation. *Royal Society Open Science* **5**, 172125.
- Byrne A., Thomas G., Steelcable A. (2013). 'Kerang Lakes Fauna Assessment. Report for North Central Catchment Management Authority.' Biosis, Melbourne.
- Cole T. L., Hammer M. P., Unmack P. J., Teske P. R., Brauer C. J., Adams M., Beheregaray L. B. (2016). Range-wide fragmentation in a threatened fish associated with post-European settlement modification in the Murray–Darling Basin, Australia. *Conservation Genetics* **17**, 1377-1391.
- Crowley L., Ivantsoff W. (1990). A review of species previously identified as *Craterocephalus eyresii* (Pisces: Atherinidae). In 'Proceedings of the Linnean Society of New South Wales' pp. 87-103. (Linnean Society of New South Wales.)
- Darwall W., Bremerich V., et al. (2018). The Alliance for Freshwater Life: A global call to unite efforts for freshwater biodiversity science and conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems* **28**, 1015-1022.
- Darwall W., Freyhof J. (2016). Lost fishes, who is counting? The extent of the threat to freshwater fish biodiversity. In 'Conservation of freshwater fishes'. (Eds G. Closs, M. Krkosek and J. Olden) pp. 1–36. (Cambridge University Press: Cambridge)
- DCCEEW (2023). 'Conservation Advice for *Nannoperca obscura* (Yarra pygmy perch).' Department of Climate Change, Energy, the Environment and Water, Canberra.
- DCCEEW (2023). 'Conservation Advice for *Nannoperca obscura* (Yarra pygmy perch).' Department of Climate Change, Energy, the Environment and Water, Canberra.

- DEECA (2023). 'Icon Species 2023-25 - Guidelines.' Victorian Department of Energy, Environment and Climate Action, Melbourne.
- DEECA (2024). 'Flora and Fauna Guarantee Act 1988 – Threatened List.' Victorian Department of Energy, Environment and Climate Action, Melbourne.
- DELWP (2017). 'Draft National Recovery Plan for the Murray Hardyhead *Craterocephalus fluviatilis*.' Victorian Department of Environment, Land, Water and Planning for the Australian Government Department of the Environment and Energy, Canberra.
- Department of Agriculture, Water and the Environment (2020). 'Conservation Advice for the Karst springs and associated alkaline fens of the Naracoorte Coastal Plain Bioregion.' Australian Government Department of Agriculture, Water and the Environment, Canberra.
- Department of Climate Change, Energy, the Environment and Water, (2023). 'Conservation Advice for *Nannoperca obscura* (Yarra pygmy perch).' Department of Climate Change, Energy, the Environment and Water, Canberra.
- Department of Environment and Natural Resources (2009a). 'Murray Hardyhead - Murray Futures, Lower Lakes and Coorong Recovery, Fact Sheet.'
- Department of Environment and Natural Resources (2009b). 'Southern purple-spotted gudgeon - Murray Futures, Lower Lakes and Coorong Recovery, Fact Sheet.'
- Department of Environment and Natural Resources (2009c). 'Southern pygmy perch - Murray Futures, Lower Lakes and Coorong Recovery, Fact Sheet.'
- Díaz S., Settele J., *et al.* (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science* **366**, eaax3100.
- DSEWPC (2012). Approved Conservation Advice for *Craterocephalus fluviatilis* (Murray hardyhead). In. (Ed. E. Department of Sustainability, Water, Population and Communities). (Canberra, ACT)
- Dudgeon D., Arthington A. H., *et al.* (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews* **81**, 163-182.
- Ebner B., Raadik T., Ivantsoff W. (2003). Threatened fishes of the world: *Craterocephalus fluviatilis* McCulloch, 1913 (Atherinidae). *Environmental Biology of Fishes* **68**.
- Ellis I. (2005). 'Ecology and breeding seasonality of the Murray hardyhead *Craterocephalus fluviatilis* (McCulloch), family Atherinidae, in two lakes near Mildura, Victoria.' Report prepared for the Mallee Catchment Management Authority. Murray-Darling Freshwater Research Centre Lower Basin Laboratory, Mildura.
- Ellis I., Whiterod N., Nias D. (2020). 'Short-term intervention monitoring associated with the translocation of Murray Hardyhead into Little Frenchmans Creek, Wingillie Station NSW.' Technical report to The Commonwealth Environmental Water Office, Canberra.
- Ellis I. M., Stoessel D., Hammer M. P., Wedderburn S. D., Sutor L., Hall A. (2013). Conservation of an inauspicious endangered freshwater fish, Murray hardyhead (*Craterocephalus fluviatilis*), during drought and competing water demands in the Murray–Darling Basin, Australia. *Marine and Freshwater Research* **64**, 792-806.
- EPBC Act (1999). 'Environment Protection and Biodiversity Conservation (EPBC) Act.' Commonwealth Government of Australia.
- Faulks L. K., Gilligan D. M., Beheregaray L. B. (2008). Phylogeography of a threatened freshwater fish (*Mogurnda adspersa*) in eastern Australia: conservation implications. *Marine and Freshwater Research* **59**, 89-96.
- Galego de Oliveira A., Bailly D., Cassemiro F. A., Couto E. V. d., Bond N., Gilligan D., Rangel T. F., Agostinho A. A., Kennard M. J. (2019). Coupling environment and physiology to predict effects of climate change on the taxonomic and functional diversity of fish assemblages in the Murray-Darling Basin, Australia. *PloS one* **14**, e0225128.
- Garcia-Moreno J., Harrison I. J., Dudgeon D., Clausnitzer V., Darwall W., Farrell T., Savy C., Tockner K., Tubbs N. (2014). Sustaining freshwater biodiversity in the Anthropocene. *The global water system in the Anthropocene: Challenges for science and governance*, 247-270.
- Gilligan D., Pearce L., Raadik T. (2019). '*Galaxias rostratus*. The IUCN Red List of Threatened Species 2019: e.T8814A129041409.'
- Gonzalez D., Scott A., Miles M. (2011). 'Assessing the vulnerability of native vertebrate fauna under climate change, to inform wetland and floodplain management of the River Murray in South Australia.'

- Department for Environment and Natural Resources and South Australian Murray-Darling Basin Natural Resources Management Board, South Australian Government, Adelaide.
- Graham R., Harris J. H. (2005). Floodplain inundation and fish dynamics in the Murray-Darling Basin. *Current concepts and future research: a scoping study. CRC for Freshwater Ecology* **51**.
- Hammer M. (2008). A molecular genetic appraisal of biodiversity and conservation units in freshwater fishes from southern Australia. PhD thesis, University of Adelaide.
- Hammer M., Barnes T., Piller L., Sortino D. (2012). Reintroduction plan for the purplespotted gudgeon in the southern Murray-Darling Basin. *MDBA Publication*.
- Hammer M., Wedderburn S., van Weenan J. (2009). 'Action Plan for South Australian Freshwater Fishes.' Native Fish Australia (SA) Inc., Adelaide.
- Hammer M., Wedderburn S., Westergaard S. (2002). Freshwater fishes. In 'A Biological Survey of the Murray Mouth Reserves, South Australia'. (Ed. R. Brandle) pp. 54–61. (Department of Environment and Heritage: Adelaide)
- Hammer M. P., Bice C. M., Hall A., Frears A., Watt A., Whiterod N. S., Beheregaray L. B., Harris J. O., Zampatti B. (2013). Freshwater fish conservation in the face of critical water shortages in the southern Murray-Darling Basin, Australia. *Marine and Freshwater Research* **64**, 807-821.
- Hammer M. P., Goodman T. S., Adams M., Faulks L. F., Unmack P. J., Whiterod N. S., Walker K. F. (2015). Regional extinction, rediscovery and rescue of a freshwater fish from a highly modified environment: the need for rapid response. *Biological Conservation* **192**, 91-100.
- Hammer M. P., Unmack P. J., Adams M., Johnson J. B., Walker K. F. (2010). Phylogeographic structure in the threatened Yarra pygmy perch *Nannoperca obscura* (Teleostei: Percichthyidae) has major implications for declining populations. *Conservation Genetics* **11**, 213-223.
- Harrison I., Abell R., Darwall W., Thieme M. L., Tickner D., Timboe I. (2018). The freshwater biodiversity crisis. *Science* **362**, 1369-1369.
- Humphries P. (1995). Life history, food and habitat of southern pygmy perch, *Nannoperca australis*, in the Macquarie River, Tasmania. *Marine and Freshwater Research* **46**, 1159-1169.
- Huntley S. (2024). 'The Southern Purple-spotted gudgeon of Ornamental Lake – Reestablishing threatened small-bodied native fish in the Victorian Mallee.' A report to the Tri-State Murray NRM Regional Alliance. Nature Glenelg Trust, Mildura.
- Huntley S., Whiterod N. (2022). 'Reestablishing threatened small-bodied native fish in the Victorian Mallee, phase 2.' Aquasave-Nature Glenelg Trust, Victor Harbor.
- Hutchison M., Norris A., Nixon D. (2020). Habitat preferences and habitat restoration options for small-bodied and juvenile fish species in the northern Murray-Darling Basin. *Ecological Management & Restoration* **21**, 51-57.
- IUCN (2024). 'The IUCN Red List of Threatened Species. Version 2024-1. www.iucnredlist.org'
- Ivantsoff W., Crowley L. E. L. M. (1996). Family Atherinidae - Silver sides or hardyheads. In 'Freshwater fishes of south-eastern Australia'. (Ed. R. M. McDowall) pp. 123–133. (Reed Books: Sydney)
- Koehn J., Balcombe S., Zampatti B. (2017). 'Prioritising fish research for flow management in the Murray-Darling Basin.' Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria.
- Koehn J. D. (2022). Key steps to improve the assessment, evaluation and management of fish kills: lessons from the Murray-Darling River system, Australia. *Marine and Freshwater Research* **73**, 269-281.
- Koehn J. D., Balcombe S. R., et al. (2020a). What is needed to restore native fishes in Australia's Murray-Darling Basin? *Marine and Freshwater Research* **71**, 1464-1468.
- Koehn J. D., King A. J., Beesley L., Copeland C., Zampatti B. P., Mallen-Cooper M. (2014). Flows for native fish in the Murray-Darling Basin: lessons and considerations for future management. *Ecological Management & Restoration* **15**, 40-50.
- Koehn J. D., Raymond S. M., et al. (2020b). A compendium of ecological knowledge for restoration of freshwater fishes in Australia's Murray-Darling Basin. *Marine and Freshwater Research* **71**, 1397-1463.
- Kuiter R., Humphries P., Arthington A. (1996). Family Nannoperidae – Pygmy Perches. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. R. McDowall). (AH & AW Reed Pty Ltd: Sydney)
- Lintermans M. (2007). 'Fishes of the Murray-Darling Basin: An Introductory Guide.' (Murray-Darling Basin Commission: Canberra, Australia)
- Lintermans M. (2013). A review of on-ground recovery actions for threatened freshwater fish in Australia. *Marine and Freshwater Research* **64**, 775-791.

- Lintermans M. (2023). 'Fishes of the Murray–Darling Basin.' (Australian River Restoration Centre: Canberra)
- Lintermans M., Geyle H. M., *et al.* (2020). Big trouble for little fish: identifying Australian freshwater fishes in imminent risk of extinction. *Pacific Conservation Biology* **26**, 365-377.
- Lintermans M., Lutz M., *et al.* (2024). 'Troubled Waters in the Land Down Under: Pervasive Threats and High Extinction Risks Demand Urgent Conservation Actions to Protect Australia's Freshwater Fishes.'
- Lintermans M., Lyon J. P., Hammer M. P., Ellis I., Ebner B. C. (2015). Underwater, out of sight: lessons from threatened freshwater fish translocations in Australia. In 'Advances in Reintroduction Biology of Australian and New Zealand Fauna'. (Eds D. Armstrong, M. Hayward, D. Moro and P. Seddon) pp. 237-254. (CSIRO Publishing: Canberra)
- Lintermans M., Osborne W. (2002). 'Wet and Wild: A Field Guide to the Freshwater Animals of the Southern Tablelands and High Country of the ACT and NSW.' (Environment ACT: Canberra)
- Llewellyn L. (2014). Breeding and development of the endangered Purple-spotted Gudgeon *Mogurnda adspersa* population from the Murray Darling. *Australian Zoologist* **33**, 480-510.
- Llewellyn L. C. (2005). Breeding biology, and egg and larval development of *Galaxias rostratus* Klunzinger, the Murray Jollytail from inland New South Wales. *Australian Zoologist* **33**, 141-165.
- Llewellyn L. C. (2008). Observations on the breeding biology of *Ambassis agassizii* Steindachner, 1867 (Teleostei: Ambassidae) from the Murray Darling Basin in New South Wales. *Australian Zoologist* **34**, 476-498.
- Lloyd L., Walker K. (1986). Distribution and conservation status of small freshwater fish in the River Murray, South Australia. *Transactions of the Royal Society of South Australia (Australia)*.
- Mahon H. C., Hammer M. P., Harris J. O. (2015). Effect of salinity on growth of juvenile Yarra pygmy perch (*Nannoperca obscura*: Percichthyidae). *Environmental Biology of Fishes* **98**, 1491-1500.
- Marshall I., Brauer C. J., Wedderburn S., Whiterod N. S., Hammer M. P., Barnes T. C., Attard C. R., Moller L. M., Beheregaray L. B. (2022). Longitudinal monitoring of neutral and adaptive genomic diversity in a reintroduction. *Conservation Biology*, doi: 10.1111/cobi.13889.
- McNeil D., Wilson P., Hartwell D., Pellizzari M. (2008). 'Olive perchlet (*Ambassis agassizii*) in the Lachlan River: population status and sustainability in the Lake Brewster region. Report to the Lachlan Catchment Management Authority. SARDI Publication F2008/00846-1.' SARDI Aquatic Sciences, West Beach, Adelaide.
- MDBA (2019). 'Basin-wide environmental watering strategy.' Murray-Darling Basin Authority, Canberra.
- MDBA (2020). 'The Native Fish Recovery Strategy – Working together for the future of native fish.' Murray–Darling Basin Authority, Canberra.
- Milton D. A., Arthington A. H. (1985). Reproductive strategy and growth of the Australian smelt, *Retropinna semoni* (Weber) (Pisces: Retropinnidae), and the olive perchlet, *Ambassis nigripinnis* (De Vis) (Pisces: Ambassidae), in Brisbane, south-eastern Queensland. *Australian Journal of Marine and Freshwater Research* **36**, 329-341.
- Murray–Darling Basin Authority (2019). 'Basin-Wide Environmental Watering Strategy.' MDBA, Canberra, ACT.
- New South Wales Fisheries Scientific Committee (NSW FSC) (2008). 'Final determination: *Galaxias rostratus* – flathead galaxias. July 2008, Ref. No FD 39.' New South Wales Department of Primary Industries.
- North Central Catchment Management Authority (2023). 'Establishing populations of Olive perchlet in northern Victorian surrogate sites.' North Central Catchment Management Authority, Huntly, Victoria.
- NSW DPI (2006). 'Proposed determination – *Craterocephalus fluviatilis* – Murray Hardyhead.' Department of Primary Industries Fisheries, Nelsen Bay.
- NSW DPI (2013a). 'Olive Perchlet (western population) - *Ambassis agassizii*. November 2013, Primefact 176, Second edition.' Fisheries Ecosystems Unit, Port Stephens Fisheries Institute; Threatened Species Unit, Department of Primary Industries, Crows Nest, NSW.
- NSW DPI (2013b). 'Southern Pygmy Perch, *Nannoperca australis*, November 2013 Primefact 190 Second Edition.' Fisheries Ecosystems Unit, Port Stephens Fisheries Institute; Threatened Species Unit, Department of Primary Industries, Crows Nest, NSW.
- NSW DPI (2014). 'Flathead Galaxias – *Galaxias rostratus*, December 2014 Primefact 880 First Edition.' Aquatic Ecosystems Unit, Port Stephens Fisheries Institute; Threatened Species Unit, Department of Primary Industries, Crows Nest, NSW.

- NSW DPI (2016). 'Murray Hardyhead – *Craterocephalus fluviatilis*. May 2016, Primefact 180, Third Edition.' Threatened Species Unit, Port Stephens Fisheries Institute, Department of Primary Industries, Nelson Bay, NSW.
- NSW DPI (2017). 'Southern Purple Spotted Gudgeon – *Mogurnda adspersa*. July 2017, Primefact 1275, Second Edition.' Threatened Species Unit, Department of Primary Industries, Crows Nest, NSW.
- Pearce L. (2015). 'Surveys, Monitoring and Conservation Status of Southern Pygmy Perch (*Nannoperca australis*) within Blakney and Pudman Creeks.' NSW Department of Primary Industries, Albury.
- Pearce L., Bice C., Whiterod N., Raadik T. (2019). '*Nannoperca australis*. The IUCN Red List of Threatened Species 2019: e.T123358579A123382811.'
- Pearce L., Silva L. G. M., Mabon S., Horta A., Duffy D., Ning N., Baumgartner L. J. (2018). 'Finding forgotten fishes, the search for two endangered species in the NSW Murray Catchment.' Institute for Land, Water and Society, Charles Sturt University., Thurgoona.
- Pusey B., Kennard M. J., Arthington A. H. (2004). 'Freshwater fishes of north-eastern Australia.' (CSIRO publishing)
- Raadik T. A., Stoessel D. J., Murphy N., Unmack P., Rose P. (2024). 'Detection and management of the threatened Flatheaded Galaxias (*Galaxias rostratus*): Testing eDNA and physical sampling, and analysis of population genetics. Arthur Rylah Institute for Environmental Research Technical Report Series.' Arthur Rylah Institute for Environmental Research, Department of Energy, Environment and Climate Action, Heidelberg, Victoria.
- Raymond S., Ryall J., Day S., Campbell A., Berry K. (2019). 'Translocation of a threatened native fish from the wild to private farm dams and wetlands: helping recover Southern Pygmy Perch in north eastern Victoria.' Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria.
- Rose P. (2018). Prediction of Fish Assemblages in Eastern Australian Streams Using Species Distribution Models: Linking Ecological Theory, Statistical Advances and Management Applications. Griffith University.
- Saddler S., Hammer M. (2010). 'National Recovery Plan for the Yarra Pygmy Perch *Nannoperca obscura*.' Department of Sustainability and Environment, Melbourne.
- Saddler S., Koehn J. D., Hammer M. P. (2013). Let's not forget the small fishes—conservation of two threatened species of pygmy perch in south-eastern Australia. *Marine and Freshwater Research* **64**, 874-886.
- Sayer C. A., Fernando E., *et al.* (in review). Under water, under threat: extinction risk of the world's freshwater fauna. *Biological Conservation*.
- Shamsi S., Pearce L., Zhu X. (2023). Characterisation of nematode larvae found in a vulnerable native Australian fish, the southern pygmy perch, *Nannoperca australis* Günther. *Marine and Freshwater Research* **74**, 1095-1101.
- Stoessel D. (2010). 'Review of Murray hardyhead (*Craterocephalus fluviatilis*) biology and ecology, and the environmental data for two key populations in the Kerang region.' Unpublished report No 2010/30 prepared for the Department of Sustainability and Environment, Statewide Services. Department of Sustainability and Environment, Heidelberg, Victoria.
- Stoessel D. (2012). 'Status of Lake Kelly, Round Lake, and Woorinen North Lake Murray hardyhead (*Craterocephalus fluviatilis*) populations, and assessment of potential translocation sites in north-central Victoria. Unpublished report prepared for the Department of Sustainability and Environment, Regional Services.' Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg.
- Stoessel D. (2020). 'Survey for Southern Purple-spotted Gudgeon (*Mogurnda adspersa*) in the Reedy Lakes complex, Kerang.' Unpublished Client Report for Loddon-Mallee Fire, Forestry and Regions, and Water and Catchment Group, Department of Environment, Land, Water and Planning (DELWP). Arthur Rylah Institute for Environmental Research, DELWP, Heidelberg, Victoria.
- Stoessel D., Ellis I. M., Whiterod N., Gilligan D., Wedderburn S. D., Bice C. (2019). '*Craterocephalus fluviatilis*. The IUCN Red List of Threatened Species 2019: e.T40692A123379212.'
- Stoessel D., Fairbrother P., Fanson B., Raymond S., Raadik T., Nicol M., Johnson L. (2020). Salinity tolerance during early development of threatened Murray hardyhead (*Craterocephalus fluviatilis*) to guide environmental watering. *Aquatic Conservation: Marine and Freshwater Ecosystems* **30**, 173-182.
- Stoessel D. J., Raadik T. A., Adams M., Shelley J., Hatley T. A., Iervasi D., Rose P., Russell A., Murphy N. (2022). 'Status of Southern Purple-spotted Gudgeon (*Mogurnda adspersa*) in the Kerang region, Victoria.

- Arthur Rylah Institute for Environmental Research. Technical Report Series No. 343.' Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Thiele S., Adams M., Hammer M., Wedderburn S., Whiterod N. S., Unmack P. J., Sasaki M., Beheregaray L. B. (2020). Range-wide population genetics study informs on conservation translocations and reintroductions for the endangered Murray hardyhead (*Craterocephalus fluviatilis*). *Aquatic Conservation: Marine and Freshwater Ecosystems* **30**, 1959-1974.
- Thoms M. C., Sheldon F. (2000). Lowland rivers: an Australian introduction. *Regulated Rivers: Research & Management: An International Journal Devoted to River Research and Management* **16**, 375-383.
- Todd C. R., Wootton H. F., Koehn J. D. (2023). 'Reintroduction strategies for Southern Pygmy Perch to Gunbower Island wetlands using a metapopulation model. Arthur Rylah Institute for Environmental Research Technical Report Series No. 374.' Arthur Rylah Institute for Environmental Research, Heidelberg.
- TSSC (2016). 'Conservation Advice *Galaxias rostratus* flathead galaxias.' Department of the Environment, Canberra.
- Unmack P. (2018). Australian Freshwater Fishes. Available from www.peter.unmack.net/biogeog/fish.html. In. (accessed 10 October 2018)
- Veale L., Whiterod N. (2018). 'Status of freshwater fish in the Mosquito Creek and Bool and Hacks Lagoons, spring 2017. A report by the South Australian South East Natural Resources Management Board.' Aquasave – Nature Glenelg Trust, Mount Gambier.
- Veale L., Whiterod N., Bachmann M. (2014). 'Translocation Feasibility Assessment and Action Plan for the Yarra Pygmy Perch in the South East of South Australia. Draft report to the SA Department of Environment, Water and Natural Resources.' Aquasave-Nature Glenelg Trust, Mount Gambier, South Australia.
- Walker J., Ellis I. (2023). 'Monitoring to inform threatened fish management in priority wetlands in western NSW.' An annual report prepared for the Commonwealth Environmental Water Holder. NSW DPI Fisheries, Buronga, NSW.
- Wedderburn S., Barnes T. (2012). 'Condition monitoring of threatened fish species at Lake Alexandrina and Lake Albert (2011–2012).' University of Adelaide, Adelaide.
- Wedderburn S., Barnes T. (2018). 'Condition Monitoring of Threatened Fish Populations in Lake Alexandrina and Lake Albert.' The University of Adelaide, Adelaide.
- Wedderburn S., Furst D., Barnes T. (2019a). 'A model to help predict responses of threatened fish populations to water level scenarios in Lake Alexandrina, South Australia.' The University of Adelaide, Adelaide.
- Wedderburn S., Shiel R., Hillyard K., Brookes J. (2010). 'Zooplankton response to watering of an off-channel site at the Lower Lakes and implications for Murray hardyhead recruitment. Report to the Murray-Darling Basin Authority and the South Australian Murray-Darling Basin Natural Resources Management Board.' The University of Adelaide, Adelaide.
- Wedderburn S., Sutor L. (2012). 'South Australian River Murray regional wetlands fish assessment 2003–2012.' University of Adelaide, Adelaide.
- Wedderburn S., Walker K., Zampatti B. (2007). Habitat separation of *Craterocephalus* (Atherinidae) species and populations in off-channel areas of the lower River Murray, Australia. *Ecology of Freshwater Fish* **16**, 442-449.
- Wedderburn S., Whiterod N., Gwinn D. C. (2019b). Determining the status of Yarra Pygmy Perch in the Murray–Darling Basin. *The University of Adelaide and Aquasave-Nature Glenelg Trust, Adelaide*.
- Wedderburn S. D., Whiterod N. S., Vilizzi L. (2022). Occupancy modelling confirms the first extirpation of a freshwater fish from one of the world's largest river systems. *Aquatic Conservation: Marine and Freshwater Ecosystems* **32**, 258-268.
- Whiterod N. (2019). 'A translocation strategy to ensure the long-term future of threatened small-bodied freshwater fishes in the South Australian section of the Murray-Darling Basin.' A report to Natural Resources, SA Murray-Darling Basin and the Riverine Recovery Project. Aquasave-Nature Glenelg Trust, Goolwa Beach.
- Whiterod N. (2020). 'Simplification and decline: the present status of fish communities across Mosquito Creek Catchment.' A report for the South East Natural Resources Management Board, Government of South Australia. Aquasave–Nature Glenelg Trust, Victor Harbor.

- Whiterod N. (2022). '2022 update on the status of fish communities across Mosquito Creek Catchment. A report for the Limestone Coast Landscape Board, Government of South Australia.' Aquasave–Nature Glenelg Trust, Victor Harbor, South Australia.
- Whiterod N., Hammer M., Vilizzi L. (2015). Spatial and temporal variability in fish community structure in Mediterranean climate temporary streams. *Fundamental and Applied Limnology* **187**, 135-150.
- Whiterod N., Wedderburn S. D., Zukowski S., Huntley S. (2024). 'Management guide for Murray hardyhead (*Craterocephalus fluviatilis*) in the Riverland region of South Australia.' A report to South Australian Department for Environment and Water. Nature Glenelg Trust, Victor Harbor.
- Whiterod N., Zukowski S., *et al.* (2021). 'A 2021 update on the status of key small-bodied threatened freshwater fishes in the southern Murray-Darling Basin. A report to the Tri-State Murray NRM Regional Alliance.' Aquasave–Nature Glenelg Trust, Victor Harbor.
- Whiterod N., Zukowski S., Ellis I., Pearce L., Raadik T., Rose P., Stoessel D., Wedderburn S. (2019). 'The present status of key small-bodied threatened freshwater fishes in the southern Murray-Darling Basin, 2019.' A report to the Tri-State Murray NRM Regional Alliance. Aquasave–Nature Glenelg Trust, Goolwa Beach.
- WWF (2022). 'Living Planet Report 2022- Building a nature-positive society.' World Wide Fund For Nature, Gland, Switzerland.
- Zukowski S., Lutz M., Whiterod N. (2024). 'Green Adelaide Freshwater Fish Translocation Plan for Urban Wetlands.' A report to Green Adelaide and the Department for Environment and Water. Nature Glenelg Trust, Victor Harbor.
- Zukowski S., Whiterod N., *et al.* (2021). 'Conservation translocation handbook for New South Wales threatened freshwater fishes.' A report to the Department of Primary Industries Fisheries. Aquasave-NGT, Victor Harbor.