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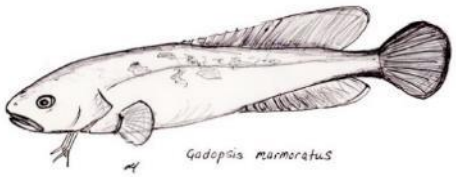

Ecology, Monitoring, Conservation

The present status of key small-bodied threatened freshwater fishes in the southern Murray-Darling Basin, 2019

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Section 1 BACKGROUND

Native small-bodied freshwater fishes – those obtaining a maximum total length (TL) of less than 150 mm – are under threat across the Murray-Darling Basin (MDB). These small fishes possess traits, such as limited dispersal, short longevity and small ranges, that make them inherently at risk (Kopf *et al.* 2017; Liu *et al.* 2017; Olden *et al.* 2007). Thus threats such as habitat loss and degradation, invasive species, over-exploitation, water abstraction and flow alteration have led to historical declines in range and abundance for these species (Dudgeon *et al.* 2006; Arthington *et al.* 2016). Furthermore, small fishes are particularly vulnerable to drought impacts (Chessman 2013; Crook *et al.* 2010) and historical declines were further compounded by the prolonged and extreme Millennium Drought. Indeed, local and regional extinctions of some species are now being realised throughout the southern MDB and regional concerted actions are critically important to prevent species loss.

This report focuses on six small fishes historically found throughout the southern MDB, which are now under threat and require urgent conservation actions. These are Murray Hardyhead (*Craterocephalus fluviatilis*), Southern Purple-spotted Gudgeon (*Mogurnda adspersa*), Southern Pygmy Perch (*Nannoperca australis*), Yarra Pygmy Perch (*Nannoperca obscura*), Olive Perchlet (*Ambassis agassizii*), and Flathead Galaxias (*Galaxias rostratus*). This report provides a summary of the present status of each species in terms of:

- Conservation status;
- Background information (i.e. pre-drought status);
- Post-drought status;
- Genetic conservation units;
- Known threats and knowledge gaps; and
- Overall summary.

The impact of the millennium drought on populations was considerable. Thus, the sections have been divided to separately cover the pre-drought status (background information) and post drought status of each species. The report considers both wild and backup populations, which can be both captive facilities and surrogate refuges. Some of the information provided here is expanded on a recent translocation strategy (Whiterod 2019) and it is hoped that both reports will guide future conservation efforts directed toward these threatened species.

Section 2 SUMMARY OF SPECIES

2.3 Flathead Galaxias (*Galaxias rostratus*)

2.3.1 Conservation status

International (IUCN)	National (EPBC)	VIC (FFG Act)	SA (2009 Action Plan)	NSW
Vulnerable	Critically Endangered	Threatened (Vulnerable)	Extinct in Wild	Critically Endangered

2.3.2 Identification guide

Given its rarity and similarity with other species, the identification of Flathead Galaxias can be problematic. It has olive-green back and sides, a silver undercarriage and can grow up to 146 mm in length but are more often found at or below 100 mm (Lintermans 2007; McDowall and Frankenberg 1981). It has a forked tail, flattened top part of the head and large mouth in which the gape extends to below the eye. The origin of the anal and dorsal fins aligns but the anal fin extends slightly further back towards the tail than the dorsal fin (Lintermans 2007). It can be confused with Common Galaxias (*Galaxias maculatus*) and Obscure Galaxias (*Galaxias oliros*) but there are several identification differences, including its flattened head, and larger mouth and eyes.

2.3.3 Background

Flathead Galaxias was historically widely but patchily recorded across the southern MDB (Lintermans 2007). In NSW, it was once common from Murray and Murrumbidgee catchments and there were single records from the upper-Macquarie and mid-Lachlan catchments (Llewellyn 2005). In Victoria, it is known from Kerang Lakes as well as mid-to upper-catchments, including the Broken, Goulburn, Ovens, Kiewa and upper-Murray catchments and as far west as Avoca River (Lintermans 2007; Tarmo Raadik, ARI, unpublished data). In South Australia, there are only a handful of historical (1800s) records as far as Murray Bridge (Hammer *et al.* 2009). Whilst there is no quantitative information on population trends in the species, it is evident that it has experience substantial declines in distribution and abundance, much of which occurred prior to the Millennium Drought. It is presumed locally

extinct from Lachlan and Murrumbidgee catchments as well as the lower- to mid-Murray Catchment. The status in other regions was unclear.

The ecology of the species is poorly known but is it believed to prefer still to low flow habitats, including wetlands, swamps, lakes and rivers (Lintermans 2007). It spawns at water temperatures over 10.5°C generally in August to September and is believed to become sexually mature at one year and live for ~3 years.

2.3.4 Post-drought status

Whilst there has not been any greater insight provided on the status of Flathead Galaxias since the Millennium Drought, it is suspected that it continues to decline. Indeed, there have been four records in New South Wales since 2003, with only one being post-2012. In Victoria, there are post-drought records in the Goulburn River Catchment, in Cornella Creek (Dion Iervasi, unpublished data), and a farm dam in the Spring Creek Catchment near Mitchellstown (Tarmo Raadik, ARI, unpublished data). It is acknowledged that it may persist in patchy and isolated habitats across the southern MDB but limited focus (e.g. surveys) and problematic identification hamper the ability to gain an updated assessment of its status.

Targeted surveys for Flathead Galaxias were undertaken at all of the site where they had recently been detected within the NSW Murray, these surveys included intensive techniques known to successfully capture the species in the past at 12 locations. Despite this intensive targeted sampling no Flathead Galaxias were detected, given these surveys and other general fish surveys that have been carried out within the region it appears quite likely that Flathead Galaxias may be locally extinct within the NSW Murray region or at the very least persisting in very low abundances (Pearce *et al.* 2018) There have not been any backup populations established for the species.

2.3.5 Genetic conservation units

There has not been a genetic assessment for Flathead Galaxias, so the species is managed as a single conservation unit.

2.3.6 Known threats and identified knowledge gaps

Due to limited information about this species, the exact threats that have contributed to its decline are poorly known. However, competition with and predation by alien species such as Trout, Eastern Gambusia and Redfin Perch, competition and habitat alteration by Common Carp, effects of river regulation (altered river regime) and cold water pollution on reproduction success, loss of habitat connectivity between streams and loss and degradation of habitat especially loss of aquatic vegetation through agricultural practices all may have been associated with their demise (Lintermans 2007). Knowledge gaps about the biology and ecology of Flathead Galaxias, causes for decline, factors preventing recovery, movement patterns and habitat requirements exist.

2.3.7 Overall summary

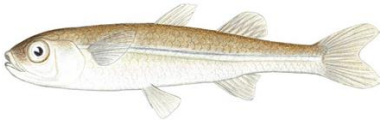
Flathead Galaxias has declined whilst out of sight; and is now presumed extinct across much of its former range and only irregularly recorded in very low numbers in other areas. It is important to focus attention on this species, by undertaking target surveys of its present status, improving ecological knowledge and identifying and mitigating threats to its long-term viability. Equally important is the establishment of backup populations. Without this increased effort, it is anticipated to continue to decline and become extinct from the southern MDB.

2.1 Murray Hardyhead (*Craterocephalus fluviatilis*)

2.1.1 Conservation status

International (IUCN)	National (EPBC)	VIC (FFG Act)	SA (2009 Action Plan)	NSW
Endangered	Endangered	Threatened	Critically Endangered	Critically Endangered

2.1.2 Identification guide



Murray Hardyhead grow up to 100 mm, have a small protruding mouth, large silvery eye; moderately rounded snout; two small and short-based dorsal fins; forked tail; and pectoral fins positioned high on the body (Lintermans 2007). The species is often confused with several species across its range, including Smallmouthed Hardyhead (*Atherinosoma microstoma*) and Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*) but can be distinguished by the shape and colour of the dorsal surface scales. Murray Hardyhead scales are generally roundish with pigment around the margin, while Unspecked Hardyhead and Smallmouthed Hardyhead scales appear diamond shaped and are arranged in uniform rows, with pigment through the scale as well as around the margin (Ellis and Kavanagh 2014).

2.1.3 Background

The Murray Hardyhead is a short-lived (<2 years) species that is endemic to the lowland floodplains of the Murray and Murrumbidgee rivers where is was historically common (Ellis *et al.* 2013; Lintermans 2007; Stoessel 2010). With river regulation and the deterioration and loss of the shallow saline, and vegetated (namely submerged *Myriophyllum* and *Ruppia*) wetland habitats, the species experienced significant declines (DELWP 2017; Ellis et al. 2013; Hammer et al. 2013). The impacts of river regulation were exacerbated by critical water shortages during the Millennium Drought. During the drought (or shortly after), populations were lost from some sites (e.g. Lake Albert, Lake Elizabeth, Woorinen North Lake, Lake Hawthorn), while others experienced dramatic declines in abundance (DELWP 2017). Yet, a number of key sites were maintained with environmental watering, including the Cardross Lakes, Berri Evaporation Basin and Disher Creek (mid-Murray) and Boggy Creek (Lower Murray); and Round Lake and Woorinen North Lakes (Kerang Lakes) (Bice *et al.* 2014; Ellis *et*

al. 2013; Wedderburn *et al.* 2014). Fish rescues were undertaken during this period for wild-to-wild reintroductions as well as establishing backup populations (Ellis *et al.* 2013; Hammer *et al.* 2013).

2.1.4 Post-drought status

The post-drought conservation of Murray Hardyhead has benefited from the establishment of backup populations. This included the Murray-Darling Freshwater Research Centre (MDFRC) captive facility, which housed and bred fish sourced from nine sites across four of the regional populations before closing in 2011 (Ellis *et al.* 2013; Hammer *et al.* 2013). Additionally, in 2011, a total of 300 fish from Boggy Creek (Lower Murray population) were used to establish a captive facility at Flinders University; these fish were bred over one season and utilised for wild release (to Hindmarsh and Mundoo islands) before closure of the facility. In 2015, the Lake Elizabeth subpopulation was reestablished using fish from Lake Kelly. More recently in 2017, captive maintenance and breeding occurred at Arthur Rylah Institute, which demonstrated out of season production of fish and allowed for salinity tolerance testing (Dan Stoessel, Arthur Rylah Institute, unpublished data). These fish were subsequently used to reinforce Round Lake and Lake Elizabeth subpopulations (Dan Stoessel, Arthur Rylah Institute, unpublished data). During 2010 and 2011, a surrogate refuge (Munday Dam) was successfully established using fish sourced from various sites across the Lower Murray. More recently, another Lower Murray surrogate refuge was established.

Since the end of the drought, there has been some fragmented recovery of wild populations in part due to active management (environmental watering and reintroductions) (Bice *et al.* 2014; Ellis *et al.* 2013; Wedderburn *et al.* 2014). In the South Australian Lower Lakes region, the species has seen limited recovery attributed to the persistence of the Boggy Creek site with environmental water and reintroduction of 7520 fish (Bice *et al.* 2014). Reintroductions have also helped the species persist in the Rocky Gully wetland (Whiterod *et al.* 2019). Unfortunately, reintroductions of 14,200 fish to three sites

across Lake Albert on four occasions between 2016 and 2019 do not appear to have facilitated the successful reestablishment of the species.

Subpopulations in the South Australian Riverland mid-Murray (including Berri Evaporation Basin and Disher Creek) have been maintained, whilst the species was recently rediscovered in Gurra Gurra Wetland Complex (Whiterod and Gannon 2019).The species also persists as a translocated population in Koorlong Lake (fish sourced from the MDFRC captive maintenance facility) and Brickworks Billabong (wild-wild transfers from Koorlong Lake, Berri Evaporation Basin and Disher Creek (Dan Stoessel, ARI, unpublished data; Whiterod and Wood 2019). Murray Hardyhead were also released into Little Frenchman's Creek in NSW in late 2018, with monitoring demonstrating survival and subsequent breeding in situ representing the first record of the species in NSW for more than 13 years (Ellis *et al.* 2018). Attempted reintroductions to Lake Hawthorn appear unsuccessful (Dan Stoessel, ARI, unpublished data; Whiterod and Wood 2019). In the Kerang Lakes region, the species persists in Round Lake but has not been detected from Woorinen North Lake and Lake Elizabeth for some time. The species persisted in channel systems associated with Lake Kelly but were subsequently extirpated. Post drought reintroduction to Lake Elizabeth, supported by environmental water, have fortunately been successful.

2.1.5 Genetic conservation units

Presently, the species is managed as five conservation units on the basis of genetic distinction (Adams *et al.* 2011; DELWP 2017; Ellis *et al.* 2013; Stoessel 2010), these being the (1) Lower Murray: lower reaches of the Murray River and Lower Lakes; (2) mid-Murray: subpopulations the Riverland and Sunraysia regions; (3) Kerang Lakes: Round Lake and Lake Kelly; (4) Woorinen North Lake (believed to be extinct); and (5) Lake Elizabeth. Recent population genetic analyses identifies two (regional) meta-populations (i.e. Lower Murray and the mid-Murray) for which there are nine partially isolated subpopulations (Thiele 2018). The separate management of subpopulations may be reinforcing genetic isolation, thus managing more broadly (e.g. meta-population level) may be more appropriate.

2.1.6 Known threats and identified knowledge gaps

The species has experienced rapid and ongoing decline, attributed to multiple, compounding threats (DELWP 2017; Ellis *et al.* 2013; Hammer *et al.* 2013). These include the impact of river regulation and water abstraction that have contributed to the deterioration and loss of the floodplain wetlands and changing of salinity regime as well as the impact of alien species. (Ellis *et al.* 2013; Hammer *et al.* 2013; Wedderburn *et al.* 2017). Many of these threats relate to the deterioration and loss of the shallow saline, and vegetated (namely submerged *Myriophyllum* and *Ruppia*) wetland habitats preferred by Murray Hardyhead (Wedderburn *et al.* 2007). These habitats have been impacted by river regulation for decades, but more recently habitat degradation increased during critical water shortages during the Millennium Drought. In fact, populations at many sites became extinct during the drought, while others experienced dramatic declines in abundance (DELWP 2017). Recent research has determined the salinity tolerance of various life stages to inform environmental watering of known (and reintroduction) sites (Dan Stoessel, ARI, unpublished data). Table 1 summarises the level of knowledge that exists on the ecology of the species.

Table 1.Status of knowledge of the biology and ecology for life stages of Murray Hardyhead (low (1–3); moderate (4–7), and high (7–10) knowledge: adapted from Koehn et al. (2017)).

Spawning	Eggs	Larvae	Juveniles	Adults
Moderate	Moderate	Low	Low	Moderate

2.1.7 Overall summary

Murray Hardyhead is persisting in the wild with rediscovery and reintroductions acting to improve regional status, which has also benefited from strategic environmental watering. In Lake Alexandrina, the species occurs at multiple locations, but has not been detected in Lake Albert since 2008 despite reintroductions. Across the mid-Murray population, the Berri Evaporation Basin and Disher Creek subpopulations appear secure although these populations do exhibit variability in abundance. The rediscovery at Gurra Gurra Wetland Complex provides further security for the species in the mid-Murray. In NSW, the reintroduced Little Frenchman's Creek population has demonstrated successful recruitment In Victoria, isolated subpopulations persist in Koorlong Lake, Brickworks Billabong and Lake Elizabeth (all translocated), Round Lake and potentially Reedy Lake and Tutchewop Main Drain (i.e. remnants of the Lake Kelly population). Backup populations (surrogate refuges)

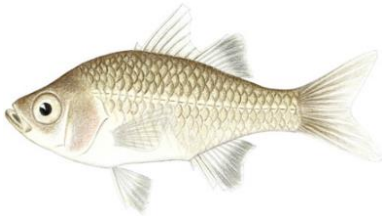
provide an opportunity to contribute to future reintroductions should appropriate sites be determined. Continued active management and reintroductions are required to continue the regional recovery of the species.

2.2 Olive Perchlet (*Ambassis agassizii*)

2.2.1 Conservation status

International (IUCN)	National (EPBC)	VIC (FFG Act)	SA (2009 Action Plan)	NSW
Data Deficient	Vulnerable	Regionally Extinct	Endangered	Endangered

2.2.2 Identification guide



Olive Perchlet have an oval laterally compressed olive to semitransparent body with brown margins on the scales and grow up to 76 mm but more often are found around 50 mm (Lintermans 2007). It has a large eye and mouth, a single prominent dorsal fin and a forked tail.

2.2.3 Background

The species was once widespread throughout the MDB and coastal streams in north eastern NSW and south eastern Queensland (Allen and Burgess 1990). In the southern MDB, it was found in the Darling, mid-Murray and Lower Murray as far downstream as Lake Alexandrina (Hammer *et al.* 2009). The species has experienced widespread historical decline and is now considered extinct in Victoria (last record 1922) and South Australia (last record in 1983). It was considered absent from the NSW section of the southern MDB, before it was rediscovered (after 47 year absence) in large numbers (almost 5,000 fish) from several locations (Mountain Creek and Lake Brewster) in the Lachlan River Catchment (McNeil *et al.* 2008). Fish where collected from this population in an attempt to create a backup population at the Narrandera Fisheries Centre (NFC), the population persisted for a number of years with at least one successful production year, however this population subsequently crashed to the point where it was no longer viable. The progeny of the successful breeding year was released into Thegoa Lagoon at Wentworth in 2011, it appears that the population did not establish with no subsequent recaptures. In the 1990s, attempts were made to establish a backup population in SA, using fish sourced from Queensland, but it was unsuccessful as subsequent monitoring failed to detect the specie (Hammer 2008a).

Olive Perchlet often reside in large schools inhabiting aquatic vegetation in creeks, wetlands, swamps and rivers and are generally found in low flow areas (Allen and Burgess 1990). Both sexes reach sexual maturity at one year of age, live between two and four years and commence spawning at water temperatures between 22–23°C (Lintermans 2007; McNeil *et al.* 2008).

2.2.4 Post-drought status

The majority of the decline of Olive Perchlet in the southern MDB occurred prior to the Millennium Drought. The rediscovered population in the Lachlan River Catchment appears to be persisting and is of conservation priority as the only known southern MDB population. The species still occurs in the coastal streams and the northern MDB.

2.2.5 Genetic conservation units

Although no genetic studies have been completed, the species has been separated into eastern (coastal streams) and western (Murray-Darling) populations. Furthermore, the southern MDB population (in the Lachlan River Catchment) appears genetically distinct from populations in the northern MDB, thus should be considered a separate conservation unit (Peter Unmack, University of Canberra, unpublished data).

2.2.6 Known threats and identified knowledge gaps

There is little historical information and reasons for decline related to the species. Potential threats include predation by introduced fish including Redfin Perch and Eastern Gambusia, competition and habitat alteration by Common Carp, spawning and recruitment restrictions and habitat loss and degradation caused by cold water pollution and river regulation (Lintermans 2007).

There is limited ecological knowledge on the species (Table 2). There are records of migration through tidal barrage fishways in coastal streams but there is limited knowledge of movement patterns for this species in the southern MDB (Lintermans 2007).

Table 2. Status of knowledge of the biology and ecology for life stages of Olive Perchlet (low (1–3); moderate (4–7), and high (7–10) knowledge: adapted from Koehn et al. (2017)).

Spawning	Eggs	Larvae	Juveniles	Adults
low	moderate	low	low	moderate

2.2.7 Overall summary

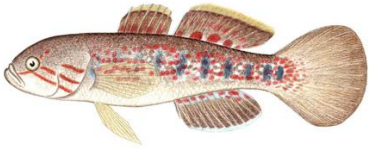
Olive Perchlet is now considered extirpated from the southern MDB other than one remnant population within the Lachlan River Catchment. There are large knowledge gaps about this species relating to basic ecology and the threats that contributed to population declines. There is a need to act urgently to conserve the known population and recover the species across areas where it has been lost.

2.3 Southern Purple-spotted Gudgeon (*Mogurnda adspersa*)

2.3.1 Conservation status

International (IUCN)	National (EPBC)	VIC (FFG Act)	SA (2009 Action Plan)	NSW
-	-	Threatened	Critically Endangered	Endangered

2.3.2 Identification guide



Southern Purple-spotted Gudgeon reaches a maximum total length of 150 mm but is typically found between 60 and 120 mm. It has a rounded head, small mouth, rounded tail and two dorsal fins (Lintermans 2007). The species has several distinguishing markings; a row of darkish blotches present on the sides from the start of the second dorsal fin to the start of the caudal fin, surrounded by numerous red and white spot and, at times, series of iridescent blue blotches toward the tail. The species also has brown to purple facial strips (3–4 in males; two in females), which differentiate it from other freshwater gudgeons, like Flathead Gudgeon (*Philypnodon grandiceps*) that it coexists with.

2.3.3 Background

Southern Purple-spotted Gudgeon is a benthic and sedentary wetland specialist with a strong preference for dense physical (woody structure and rocks) and aquatic vegetation cover (Hammer *et al.* 2015; Lintermans 2007). Historically, it was broadly distributed across coastal areas of Queensland and New South Wales as well as patchily occurring in the MDB. In the southern MDB, it was once widespread and common in wetland and fringing river habitats. Specifically, it was known from Murrumbidgee, Lachlan and Murray catchments, including the Lower Murray (Cardross Lakes and SA section). Whilst still common in coastal QLD, it has experienced substantial declines across the MDB. In the

southern MDB, it is now considered extinct from Cardross Lakes (last records in 1990s) and was declared extinct in South Australia in the early 1990s; following the last verified record of them in 1973 (Hammer *et al.* 2009). However, in 2002, the species was recorded from a single wetland, Jury Swamp near Murray Bridge, signaling its rediscovery after 30 years (Hammer *et al.* 2015). Just as the species was rediscovered, flows and water availability began to decline associated with the Millennium Drought. As conditions deteriorated, fish were rescued into three captive breeding facilities, with the view of establishing surrogate populations to help safeguard the species (Hammer 2007b). By spring 2009, Jury Swamp had completely dried, with presumed local, and regional extinction of the species (Hammer *et al.* 2015). At this stage, fish rescued at the height of the Millennium Drought were used to establish captive populations in private breeding facilities (Hammer *et al.* 2013). This species is most likely locally extinct from the NSW Southern MDB, with the last record from 1996.

2.3.4 Post-drought status

Fish rescued at the height of the Millennium Drought were used to establish backup populations (Hammer *et al.* 2013). Three captive maintenance and breeding facilities were established and have continued to produce moderate numbers (100s) of fish annually. Additionally, the establishment of a surrogate refuge for the species has been successful with high numbers (population estimated at >10,000 fish) and regular spawning and recruitment observed. These backup populations enabled the reintroduction of fish to occur in the attempt to reestablish the species. Initially, over 2011 and 2012, 1120 fish were reintroduced into a historical site with several recaptures (n=15) before the site unexpectedly dried (Bice *et al.* 2014). Considerably more fish (5043 fish) were reintroduced to the rediscovery site (Jury Swamp) over 2014 to 2019. The species is regularly detected at the site in low numbers (most recently in February 2019, one fish was detected), but the reestablishment of self-sustaining populations has not occurred (Whiterod 2019). In NSW, active captive maintenance and breeding for this species occurred at the NFC in the early 2000s with fish produced from this program stocked into a number of locations. The only

location were the species was reintroduced within the Southern MDB was Adjungbilly Creek near Gundagai; this population does not appear to have established as subsequent sampling has not detected the species at the release site or elsewhere in the system.

2.3.5 Conservation units

The MDB population is one of three genetic lineages of the species (Sasaki *et al.* 2016). Further, the southern MDB sub-population is considered genetically distinct from those of the northern MDB (Hammer *et al.* 2015; Sasaki *et al.* 2016). As such, the southern MDB sub-population of the species is considered a separate conservation unit.

2.3.6 Known threats and identified knowledge gaps

The species has declined profoundly due to intensive flow regulation and diversions resulting in habitat alteration and loss as well as predation and competition with alien species. Knowledge gaps exist on biology, ecology and movement patterns. Table 3 provides a summary of knowledge status of this species in the southern MDB.

Table 3.Status of knowledge of the biology and ecology for life stages of Southern Purple-spotted Gudgeon (low (1–3); moderate (4–7), and high (7–10) knowledge: adapted from Koehn et al. (2017).

Spawning	Eggs	Larvae	Juveniles	Adults
Moderate	Moderate	Low	Low	Moderate

2.3.7 Overall summary

The future of the species remains precarious in the southern MDB. It is only known from few locations, which have resulted from reintroductions. In the Lower Murray, it does persist but has yet to reestablish a self-sustaining population. In NSW, reintroductions have not been successful with the Southern MDB, however there has been the successful establish of an additional population within the Castlereagh River in the Northern MDB. Encouragingly, healthy backup populations are maintained for the species. Identification of priority sites for the species, which considered localised threats, environmental water and reintroductions are required to reestablish a network of sites across the southern MDB.

2.4 Southern Pygmy Perch (*Nannoperca australis*)

2.4.1 Conservation status

International (IUCN)	National (EPBC)	VIC (FFG Act)	SA (2009 Action Plan)	NSW
Not listed	Not listed	Threatened	Critically Endangered Protected	Endangered

2.4.2 Identification guide

Southern Pygmy Perch are a small freshwater perch attaining a maximum size of ~85 mm. The species has a slightly rounded head, small mouth that extends to just in front of eye and a rounded tail (Lintermans 2007). The body colour is cream to gold to greenish-brown. These features, along with a round pupil, distinguish the species from the Yarra Pygmy Perch, with which it is often confused. Additionally, male Southern Pygmy Perch develop bright red fins during spawning, whereas the fins of a breeding male Yarra Pygmy Perch are black.

2.4.3 Background

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. Historically, it occurred in the coastal catchments of south-east South Australia and southern Victoria, the South Australian Gulf, the north of Tasmania, and King and Flinders Islands and the southern MDB. In the southern MDB, it was formally found in the lower Murrumbidgee and Murray catchments, including tributaries (Broken, Ovens, Goulburn, Kiewa, Mitta Mitta) and the lower reaches (Lower Lakes and Mt Lofty tributaries). The species has experienced significant range reductions since European settlement associated with the degraded and loss of wetland habitat and impact of alien species (Lintermans 2007). At this stage, the species remained widely distributed but persisted as fragmented subpopulations. These subpopulations were further impacted by the Millennium Drought, with local

extirpation occurring from mid- and upland Murray Catchment 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 surrounds areas (Turvey's Drain and Mundoo Island) were rescued to establish backup populations (initially captive maintenance and breeding facility) (Cole *et al.* 2016; Hammer 2008b).

2.4.4 Post-drought status

Since the Millennium Drought, the species continues to persist and although there has been some localised recovery, it continues to decline across the southern MDB. In Lake Alexandrina and surrounding areas (Wedderburn and Barnes 2017; Wedderburn and Barnes 2018; Wedderburn *et al.* 2019) and Mt Lofty Ranges tributaries (Wedderburn and Barnes 2012; Wedderburn and Barnes 2013; Wedderburn and Barnes 2014; Whiterod and Hammer 2014), locally strong subpopulations persist, including in the Tookayerta, Finniss and Angas catchments. Reintroductions of Southern Pygmy Perch focused on three sites around Lake Alexandrina (Turvey's Drain, Hindmarsh Island and Mundoo Island). During spring and autumn of 2011 and 2012 approximately 1350 individuals were released (Bice *et al.* 2014). Post-release monitoring detected the species at all three sites, but only the Hindmarsh Island site has demonstrated persistence and recruitment in subsequent years (although the species was recently redetected at Turvey Drain) (Whiterod 2018). Reintroductions (over 2007–2010) aiming at establishing the species in Pudman Creek, have been successful with abundance and distribution increasing over time.

In Victorian and NSW, subpopulations in Middle Creek, Mountain Creek (Victoria), Mountain Creek (New South Wales), Coppabella Creek, Blakney Creek and Spring Creek have severely reduced the area of occupancy (Pearce 2015). It is still known from Avoca River and Campapse River catchments (Rose 2018). Other sites have been lost since the Millennium Drought (Brauer *et al.* 2016) with some occurring as habitats dried over the most recent summer.

Limited backup populations of the species persist. The Lower Lakes captive maintenance and breeding facility (Attard *et al.* 2016a; Attard *et al.* 2016b) was used to establish a surrogate refuge in 2014, which has persisted with low numbers over time (Whiterod 2019). In NSW,

multiple backup populations have been established over time (Table 4); two for the Lachlan River subpopulation and one for each of the Murrumbidgee River (and Murray River subpopulations). More recently, an emergency drought rescue of fish from Coppabella Creek have been used to establish two surrogate refuges (Table 4). In Victoria, captive maintenance and breeding has been established for two Campapse and one Avoca subpopulations (Rose 2018).

Table 4.Summary of fish rescue, translocation and environmental watering for Southern Pygmy Perch over the past seven years.

Location	Year	Action	Number of fish rescued or released	Notes
Coppabella Creek	2007	Drought rescue into surrogate refuge	122	Stocked into surrogate refuge (earthen pond) at NFC
	2008	Fish release	69	
	2009	Drought rescue into surrogate refuge	2000	1800 Stocked into earthen pond at NFRC, 200 kept at a holding facility Tumut
	2019	Drought rescue into surrogate refuge	400	200 stocked into a pond at NFC, 200 temporarily into Pearce maintenance facility, then Middle Creek Farm
Toupna Creek	2006	Environmental watering	-	Project with OEH and NSW State Forests. No subsequent record of SPP within this system
Normans Lagoon	2010	Environmental watering	-	Project with OEH in response to hypoxic black water event and fish kill
Blakney Creek	2006	Redfin perch incursion rescue	50	Stocked into surrogate refuge (earthen pond) at NFC
	2007	Redfin perch incursion rescue	50	Stocked into surrogate refuge (earthen pond) at NFC
	2009	Redfin perch incursion rescue	63	Stocked into an experimental breeding facility at Tumut
Pudman Creek	2007	Fish release	379	Project with Lachlan CMA and Greening Australia
	2008	Fish release	6	
	2009	Fish release	37	
	2010	Fish release	106	
Thegoa Lagoon	2011	Fish release	4500	
Washpen Creek	2011	Fish release	4500	
David Mitchell Wetlands Charles Sturt University	2011	Fish release	2500	Attempts to establish a surrogate refuge
Deniliquin wetlands	2012	Fish release	200	Murray Local Land Services and Deniliquin Shire Council

2.4.5 Genetics conservation units

Although once considered to historically form one contiguous meta-population across the southern MDB (particularly Murray River Catchment), the species has now contracted to 14 genetically distinct subpopulations (Cole *et al.* 2016; Hammer 2008b). These being (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) Campapse River; (9) Upper Murray (Norman Lagoon); (10) Coppabella Creek; (11) Kiewa River; (12) Ovens River; (13) Mitta Mitta River; and (14) Lachlan River. This genetic distinction is used to define conservation units, which inform management of the species.

2.4.6 Known threats and identified knowledge gaps

River regulation, cold water pollution and associated habitat deterioration including loss of aquatic vegetation, floodplain alienation and flow changes as well as predation and competition with introduced species including Redfin perch, Trout, and possibly Eastern gambusia and competition and habitat alteration by Common Carp have contributed to population declines in Southern Pygmy Perch. Knowledge gaps exist on the biology, ecology and movement patterns for this species (Lintermans 2007). Table 5 provides a summary of knowledge status of this species in the southern MDB.

Table 5.Status of knowledge of the biology and ecology for life stages of Southern Pygmy Perch (low (1–3); moderate (4–7), and high (7–10) knowledge: adapted from Koehn et al. (2017)).

Spawning	Eggs	Larvae	Juveniles	Adults
Moderate	Moderate	Low	Low	Moderate

2.4.7 Overall summary

Although occurring broadly and despite some post-drought recovery, the species continues to decline across the southern MDB. Equally, backup populations are limited, with previous efforts hampered by numerous conservation units (requiring separate consideration) identified for the species.

2.5 Yarra Pygmy Perch (*Nannoperca obscura*)

2.5.1 Conservation status

International (IUCN)	National (EPBC)	VIC (FFG Act)	SA (2009 Action Plan)	NSW
Vulnerable	Vulnerable	Threatened	Critically Endangered	Endangered

2.5.2 Identification guide

Yarra Pygmy Perch is small (~75mm), has a pointed head, small mouth (not reaching below the eye), slightly rounded tail and single deeply notched dorsal fin (Lintermans 2007). The body colour is gold to dusky brown with a pale belly and dark spots in a row along the midline. These features, along with an irregular shaped (imperfect circle) black pupil, distinguish the species from the Southern Pygmy Perch, which it is often confused with. Additionally, the fins of breeding males are black whereas male Southern Pygmy Perch develop bright red fins during spawning.

2.5.3 Background

Yarra Pygmy Perch is known from coastal areas from Western Victoria through to South Eastern SA to lower reaches of the southern MDB, where the only MDB population is found. Throughout its range, the species occurs in patchily and fragmented lower flow habitats within drainage channels and wetlands, preferably with an abundance of submerged aquatic vegetation. In the southern MDB – where it was only formally recognised within the MDB in 2001 (Brauer *et al.* 2013; Hammer *et al.* 2010) – it is restricted to fringing habitats of Lake Alexandrina, the lower reaches of the Mount Lofty Ranges tributary streams and waterways of Hindmarsh Island (Hammer 2004; Hammer *et al.* 2002; Wedderburn and Hammer 2003). During the Millennium Drought, there were dramatic declines in the availability and condition of these habitats and the species experienced

declines in range and abundance (Hammer 2007a; Hammer 2008c; Wedderburn *et al.* 2012). The species was last detected in February 2008 (Holmes Creek at Estick Creek mouth: Hammer 2008c), after which time it is considered to have become regionally extinct. At this stage, a total of 200 wild Yarra Pygmy Perch were rescued from drying habitats at three sites for temporary captive maintenance and breeding, which has enabled the establishment of several backup populations in captive and surrogate settings (Hammer *et al.* 2013; Whiterod 2019).

2.5.4 Post-drought status

Over 2010–2011, the return of post-drought flows to the lower reaches of the southern MDB prompted reintroductions in an attempt to re-establish wild populations. This relied on backup populations, which have achieve varying levels of productivity (Bice *et al.* 2014; Whiterod 2019). Importantly, self-sustaining populations in high abundance were maintained in the Flinders University captive maintenance and breeding facility and the Crouch Dam surrogate refuge , both of which were utilised as the source of reintroductions with 5850 fish reintroduced at five former sites over 2011–2014 (Bice *et al.* 2014). Short-term survival (i.e. recapture) and wild recruitment was observed over 2013 to 2014 (Bice *et al.* 2014). Yet, in autumn 2014, only one individual was detected across the region (during targeted monitoring of the reintroduction sites) despite broader monitoring across its former range (Bice *et al.* 2014; Wedderburn 2014; Wedderburn and Barnes 2014). At this time, the main surrogate refuge (Crouch Dam) collapsed and this backup population was lost. During spring 2015, 900 Yarra Pygmy Perch were reintroduced into three sites on Hindmarsh Island with survival observed for up to one month (Wedderburn *et al.* 2016), these were the last wild records of the species in the southern MDB despite regular monitoring across the region. Most recently, an occupancy study across the lower Murray conducted in November to December 2018 failed to detect the species (Wedderburn *et al.* 2019). The study involved triplicate surveys, to increase probability of detection, at 32 sites where Yarra Pygmy Perch has been recorded historically (Bice *et al.* 2008; Higham *et al.* 2005; Wedderburn and Hammer 2003), at sites where the species was reintroduced (Bice *et al.* 2014; Wedderburn *et al.* 2016) and several other sites in the region that have suitable habitat. As such, the species now only persists as five backup populations, all of which maintain low abundances and have concern over their viability. The genetic status of backup populations is currently being assessed. Of some

encouragement, a new surrogate refuge (Price Dam) created in September 2018, has shown signs of recruitment and appears to be establishing.

2.5.5 Genetic conservation units

The MDB population of Yarra Pygmy Perch represents a single genetic conservation unit as it is a distinct genetic lineage (i.e. evolutionary significant units, ESU) from other populations across the range of the species (Brauer *et al.* 2013; Hammer *et al.* 2010). Previously when present, there was some gene flow amongst locations in the southern MDB but genetic diversity is extremely low implying limited fitness (Brauer *et al.* 2013). In addition to assessing the genetic status of backup populations a genetic rescue is currently being trialed.

2.5.6 Known threats and identified knowledge gaps

Threats are heightened by the extreme localisation of this species in the southern MDB. These threats relate to river regulation (and water level stability), habitat alteration, including the loss of aquatic vegetation, predation and competition with introduced species namely Redfin Perch and Eastern Gambusia. Limited knowledge exists on the ecology of the species (Table 6).

Table 6. Status of knowledge of the biology and ecology for life stages of Yarra Pygmy Perch (low (1–3); moderate (4–7), and high (7–10) knowledge: adapted from Koehn et al. (2017)).

Spawning	Eggs	Larvae	Juveniles	Adults
Low	Moderate	Low	Low	Moderate

2.5.7 Overall summary

As of 2019, Yarra Pygmy Perch are suspected to now be extinct from the MDB (Wedderburn *et al.* 2019). The backup populations appear to also be in peril with potentially <1000 individuals in total remaining across four captive facilities and surrogate refuges, although the early signs of a new surrogate refuge afford some hope. Critical actions and hard decisions (i.e. exploring genetic rescue) are required to increase production of the species to allow for the capacity to undertake translocations back into the MDB in the future. Without this response the first freshwater fish extinction from the MDB will be confirmed (Wedderburn *et al.* 2019).

Section 3 GENERAL SUMMARY

The target threatened small-bodied freshwater fishes – Murray Hardyhead, Southern Pygmy Perch, Southern Purple-spotted Gudgeon, Yarra Pygmy Perch, Olive Perchlet and Flathead Galaxias – face an uncertain future in the SA MDB region. Each of the target species, except for Yarra Pygmy Perch, historically occurred more broadly across the southern MDB. Having experienced historical declines, these species were profoundly impacted by the Millennium Drought, which led to declines in known range and abundance, and threatened regional persistence. Each species is now only known from a limited number of wild and backup populations (Table 7).

Table 7. Summary of the known wild and backup populations for each threatened small-bodied freshwater fish species.

Species	Conservation unit	Known populations		
		Wild	Backup	
			Captive facility	Surrogate refuge
Flathead Galaxias	MDB	Few	0	0
Murray Hardyhead	Lower Murray	Numerous	0	2
	Mid-Murray	5	0	0
	Kerang Lakes (Round and Lake Kelly)	1	0	0
	Woorinen North Lake	0	0	0
	Lake Elizabeth	1	0	0
Olive Perchlet	MDB	1	0	0
Southern Purple-spotted Gudgeon	MDB	1	3	1
Southern Pygmy Perch	Angas River	Numerous	0	0
	Finniss River	Numerous		0
	Lake Alexandrina & surrounds	Numerous		1
	Tookayerta	Numerous		0
	Avoca River	1	0	1
	Goulburn and Broken rivers	Unknown	0	0
	upper Broken River	Unknown	0	0
	Campapse River	3	0	2
	Upper Murray (Albury)	0	0	0
	Coppabella Creek	Few	0	1
	Kiewa River	Unknown	0	0
	Ovens River	Few	0	0
	Mitta Mitta River	Unknown	0	0
	Lachlan River	Few	0	2
Yarra Pygmy Perch	MDB	0	2	4

Thus, a critical moment in time has been reached where concerted actions and a multi-jurisdiction strategy are required to prevent species loss. The present report provides background information for six small-bodied freshwater species to assist with managing the long-term survival of each target species in the Southern MDB. In summary, the present report highlights the intensity of the situation at hand. Without appreciation of this risk, and a long-term commitment by a range of stakeholders, the loss of species will be inevitable.

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