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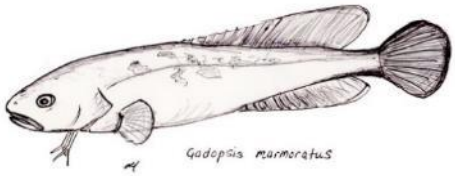

Ecology, Monitoring, Conservation

Monitoring of Murray hardyhead sub-populations to inform wetland management in the Victorian Mallee region, Autumn 2019

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A report to the Mallee Catchment Management Authority

mallee catchment management authority

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Background

The Murray hardyhead is a small-bodied (<90 mm) species that is endemic to the lowland floodplains of the Murray and Murrumbidgee rivers where it was historically common (Ellis *et al.* 2013; Lintermans 2007). The species has experienced rapid and ongoing decline, attributed to multiple, compounding threats (DELWP 2017; Ellis et al. 2013; Hammer et al. 2013). Many of these threats relate to 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 (referred to as electrical conductivity, EC in μScm^{-1}, in the present report) as well as the impact of alien species. Additionally, the species was further impacted during the Millennium Drought (Ellis et al. 2013; Hammer et al. 2013). During this period, sub-populations at many sites became extinct, while others experienced dramatic declines in abundance (DELWP 2017). Since the drought, some sub-populations have improved but many remain absent. Emergency rescue and the establishment of captive maintenance and breeding facilities as well as surrogate refuges during the drought has been important to conserve the species (Ellis et al. 2013; Hammer et al. 2013). These backup populations have also be utilised for reintroductions aimed at reestablishing sub-populations of the species (Bice *et al.* 2014; Whiterod 2019).

The species is listed as endangered globally (under the *International Union for the Conservation of Nature* (IUCN) Red List of Threatened Species) and nationally (under the *Environment Protection and Biodiversity Conservation* Act 1999, EPBC Act) and threatened under the Victorian *Flora and Fauna Guarantee* Act 1988 (FFG Act). Presently, it persists as a limited number of partially isolated sub-populations across two meta-populations (Lower Murray and mid-Murray: Adams et al. 2011; Thiele 2018). The mid-Murray meta-population includes known and recently rediscovered South Australian sub-populations (Whiterod 2019; Whiterod and Gannon 2019), a recently reintroduced sub-population in NSW (Ellis *et al.* 2018) and is known from several locations in Victoria (DELWP 2017). In the Victorian Mallee, the

species has been recently known from three wetlands (Lake Hawthorn, Koorlong Lake and Brickworks Billabong), all of which have resulted from reintroduction (Ellis *et al.* 2013).

This study provided an update on the status of these three known sub-populations of Murray hardyhead in the Victorian Mallee.

Koorlong Lake

Koorlong Lake is located 12km south of Mildura and was historically filled though irrigation and stormwater runoff. The lake was first identified as a potential Murray hardyhead translocation site during 2009, with ~300 fish being released in November of the same year. During autumn 2013, an additional 90 captively-bred fish were released into the wetland (Ellis *et al.* 2013). These fish went on to successfully breed and as such, Murray hardyhead have been sampled from this location every year between 2009 and 2016 (although not during every survey each year) (Ellis and Wood 2015; Huntley 2016; Wood 2017). The last survey undertaken at this lake, during autumn 2016, did not detect any Murray hardyhead in Koorlong Lake (Wood 2017).

Lake Hawthorn

Lake Hawthorn is located on the west fringe of the township of Mildura. It is a large, shallow basin which receives water primarily from stormwater and irrigation runoff. During periods of high flow in the nearby Murray River it will become connected. Previously, the wetland supported a wild population of Murray hardyhead, however during the Millennium Drought, the lake dried (Ellis *et al.* 2013). Lake Hawthorn remained unsuitable for Murray hardyhead for a number of years following the Millennium drought until October 2018. At this time the lake was again deemed suitable for Murray hardyhead and ~600 captive bred fish were released (Arthur Rylah Institute, unpublished data). Due to the relatively high EC at the time (~68 000 EC) the fish were released in a location where a small flow of fresh water was entering the lake with the hope that this would allow the fish to adapt to the high EC more readily. Since release of Murray Hardyhead, 1,111 ML of environmental water (by 26 April 2019) was been delivered to the lake in the attempt to provide the fish with suitable environmental conditions for survival and breeding. The wetland has not been surveyed since the reintroduction of Murray hardyhead.

Brickworks Billabong

Brickworks Billabong is a shallow, saline waterbody located adjacent to the Murray River 5km north-west of the township of Merbein. The Murray River is the local source of water for this billabong and it enters during times of elevated flow though the adjacent Cowanna Billabong, or over the floodplain during periods of very high flow. Brickworks Billabong was identified as a potential Murray hardyhead translocation site during 2013. Careful management resulted in it being deemed ready for translocation of Murray hardyhead which first occurred during January 2014 with the release of 70 fish sourced from the nearby Koorlong Lake. A further release of fish (~2500), sourced from the Riverland, were released into the lake during March 2015 (Ellis and Wood 2015).

With the strategic addition of environmental water in order to maintain habitat and promote productivity booms, Murray hardyhead were caught in varying abundance up to and including during widescale flooding in 2016. Flooding resulted in connectivity across the floodplain and with the Murray River which likely resulted in the dispersal of fish, however post flooding, Murray hardyhead were recorded in the highest abundance ever recorded at the wetland. Yet, the last survey of this wetland, during Autumn 2017, did not detect Murray hardyhead (Wood 2017).

Project objective

The present study involved the field survey of Koorlong Lake, Brickworks Billabong and Lake Hawthorn to:

- Determine the status of species in each wetland;
- Provide assessment of the habitat suitability in each wetland; and
- Provide recommendation on the management and delivery of environmental water.

The outcomes of the study are important for the effective management on these individual wetlands but also the regional conservation of the species.

Survey methods

The field survey was conducted in a manner that was consistent with previous surveys to allow for temporal comparison. Specifically, three previously established sites were sampled across each of the three wetlands (Figure 1 and 2; Table 1 and Appendix 1). Each site was sampled using three single-winged fyke nets (3-m wing and 4-mm stretched mesh size) and a

single large mesh fyke net (single 8-m wing and 28-mm stretched mesh size). All nets were deployed in the evening and retrieved the following morning.

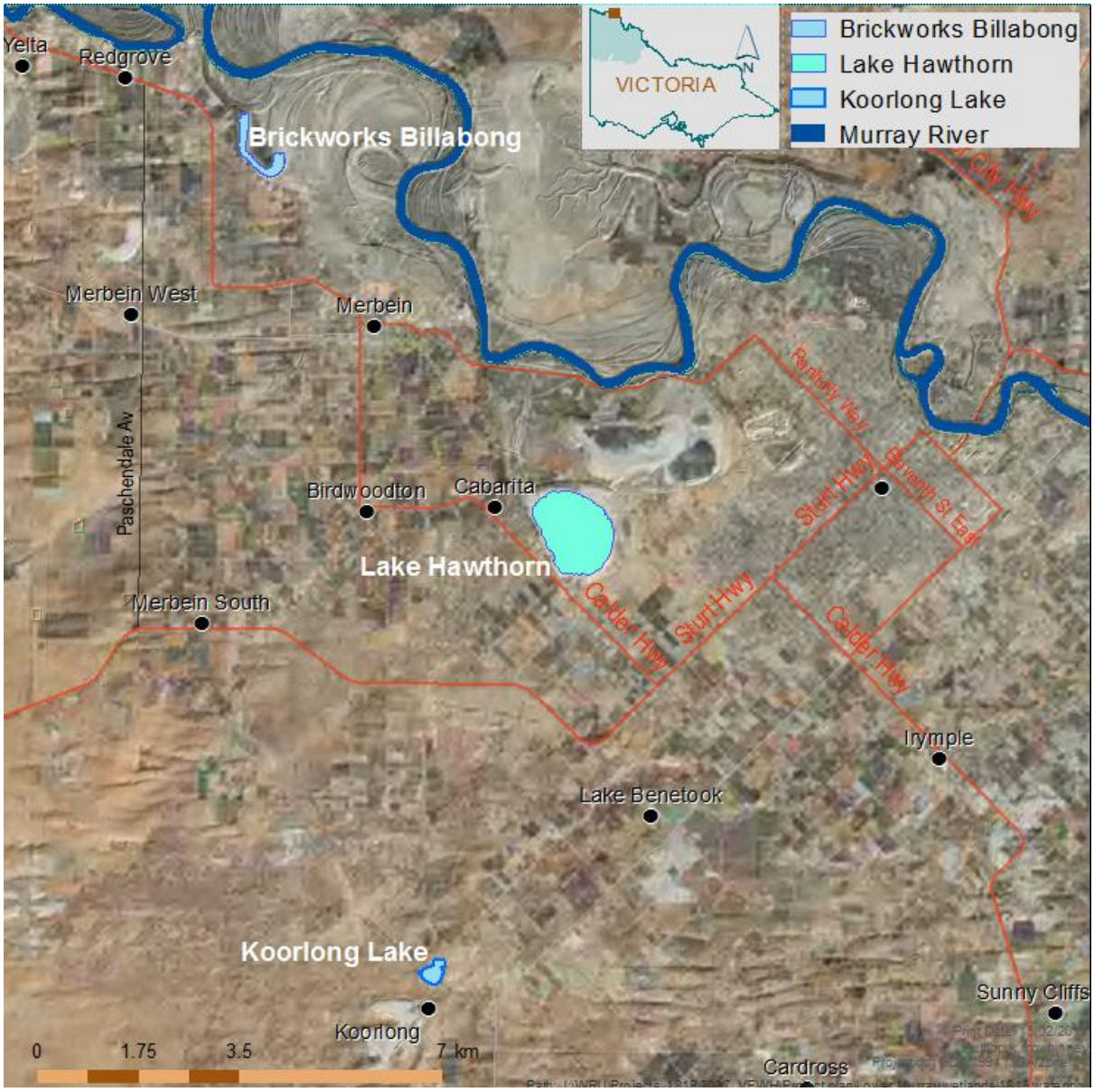


Figure 1. Location of sites sampled for Murray hardyhead across the Victorian Mallee.

All sampled fish were identified to species (Lintermans 2007), counted and observed to obtain general biological information (reproductive condition and external disease or parasites). For Murray hardyhead, total length (TL, mm) was recorded for the first 50 individuals to allow assessment of length structure. Records of other fauna opportunistically sampled were also noted.

Table 1. Summary of sites sampled across the three wetlands in the Mallee region in 2019

No	Site code	Waterway	Location	Easting	Northing	Date sampled
1	MD19-29	Lake Hawthorn	Site 1	601799	6214958	25-Mar-19
2	MD19-30	Lake Hawthorn	Site 2	601150	6214522	25-Mar-19
3	MD19-31	Lake Hawthorn	Site 3	600524	6215495	25-Mar-19
4	MD19-32	Koorlong Lake	Site 1	598842	6207563	25-Mar-19
5	MD19-33	Koorlong Lake	Site 2	598720	6207295	25-Mar-19
6	MD19-34	Koorlong Lake	Site 3	598879	6207299	25-Mar-19
7	MD19-35	Brickworks Billabong	Site 1	595501	6222090	26-Mar-19
8	MD19-36	Brickworks Billabong	Site 2	595528	6221653	26-Mar-19
9	MD19-37	Brickworks Billabong	Site 3	596115	6221448	26-Mar-19

Figure 2. The three wetlands sampled across the Victorian Mallee: (top left) Lake Hawthorn; (top right) Brickworks Billabong; and (bottom left and right) Koorlong Lake.

Environmental descriptors, such as extent of habitat cover (submerged physical structure and submerged and emergent vegetation), flow and pool condition as well as water quality parameters (electrical conductivity, dissolved oxygen concentration, pH and water

temperature) were also recorded to aid the interpretation of results and assist with broader condition assessment.

Results

Catch summary

In total, some 13,914 fish across four species (two natives, two aliens) were recorded during the present survey (Table 2 and Figure 3). The majority of fish were sampled from Koorlong Lake (11,256 fish), with considerably fewer recorded from Brickworks Billabong (2658 fish) and no fish recorded at Lake Hawthorn. Murray hardyhead were only detected at each of the three sites at Koorlong Lake (1853 fish) being absent from the other two wetlands. The alien Eastern Gambusia (45.4% of total catch) and native Carp Gudgeon (37.7%) dominated the catch with only two Gold fish sampled from Koorlong Lake. Opportunistically, Common Yabby and Eastern Long-necked Turtle were observed.

Table 2. Summary of the fish and opportunistic catch recorded across the three wetlands in the Victorian Mallee.

Site code	Waterway	Location	Murray hardyhead	Carp Gudgeon	Eastern Gambusia	Goldfish	Common Yabby	Esatern long-necked Turtle
MD19-29	Lake Hawthorn	Site 1						
MD19-30	Lake Hawthorn	Site 2						
MD19-31	Lake Hawthorn	Site 3						
MD19-32	Koorlong Lake	Site 1	302	990	1800	2		17
MD19-33	Koorlong Lake	Site 2	103	2415	66			7
MD19-34	Koorlong Lake	Site 3	1448	855	3275			15
MD19-35	Brickworks Billabong	Site 1		734	960		2	
MD19-36	Brickworks Billabong	Site 2		162	575		1	
MD19-37	Brickworks Billabong	Site 3		33	194			
			1853	**5189**	**6870**	**2**	**3**	**39**

Figure 3. Mix of Eastern Gambusia and Carp Gudgeon (left) and the two Goldfish (right) sampled from Koorlong Lake during autumn 2019.

Environmental and habitat descriptors

At the time of sampling, Koorlong Lake maintained a high water level. The wetland was surrounded by fringing vegetation (*Cumbungi sp*. and *Juncus sp*.) and submerged *Ruppia sp*. was present. The wetland was relative fresh (4933–5050 EC), slightly alkaline (pH 7.20–7.88) and moderately warm (18.5–21.79°C) with dissolved oxygen low (1.99–3.08 mgL^{-1}).

Brickworks Billabong, at the time of sampling, was shallow (< 0.3 m) and devoid of aquatic habitat with the exception of a few individual strands of *Ruppia sp.* identified in the eastern end of the billabong. Due to the low nature of the water, a band of drying clay ringed the waterbody and was also devoid of vegetation. The wetland was relatively saline (19,570–19,900 EC), slightly alkaline (pH 7.87–8.11) and cool (13.5–14.04°C) with low dissolved oxygen (2.23–5.29 mgL^{-1}).

At the time of sampling, Lake Hawthorn was drying, thus was relatively shallow (>0.7 m). Fringing and emergent vegetation was non-existent, however, patches of *Ruppia sp*. were present, particularly toward the middle of the lake where water depth was greater. Due to the environmental watering that had occurred over summer, EC (70,230–75,920 EC) was higher than that experienced during early summer 2018 (when fish were released). Although pH (7.35–7.38) and water temperature were suitable (13.49–15.21°C), dissolved oxygen concentrations were low (1.81–2.19 mgL^{-1}).

Murray hardyhead

Murray hardyhead were only sampled from Koorlong Lake (Figure 4 and 5 and Table 1). The species has sampled in relatively high abundance with a broad length structure (22–82 mm), indicating a self-sustaining population with recent recruitment. The majority of fish would have resulted from spawning during the previous spring, however some of the smaller fish (<35 mm) would have resulted from a second spawning event during summer (involving year old and rapidly maturing fish from the spring spawning). There are also some fish present that have survived beyond a year (>65 mm).

Figure 4. Murray hardyhead sampled from Koorlong Lake during autumn 2019.

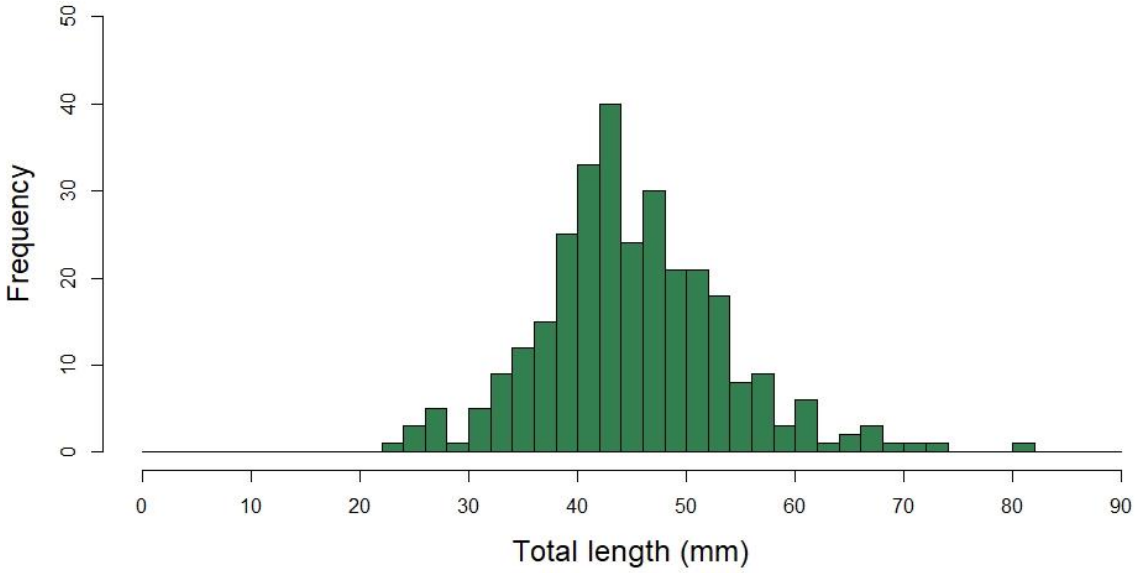


Figure 5. Length structure of Murray hardyhead sampled in Koorlong Lake, autumn 2019.

Discussion and Recommendations

The present study provided an updated assessment on the status of three known sub-populations of Murray hardyhead across the Victorian Mallee. The species was only detected in Koorlong Lake with it not observed in Brickworks Billabong during the present study and reintroduction failure evident at Lake Hawthorn. This mixed outcome (i.e. detection of one out of three) highlights the challenges that must be overcome to successfully maintain sub-populations of this threatened species. Equally, the need for further active management (i.e. environmental watering and reintroductions) and monitoring is emphasised. Specifically, discussion and management recommendations are provided for each of the three wetlands below.

Koorlong Lake

Koorlong Lake supported a robust and self-sustaining sub-population of Murray hardyhead. The relatively high abundance during the present survey indicates a currently thriving population. This sub-population is, and remains, a relatively safe refuge for Murray hardyhead in the Victorian Mallee. This outcome is an excellent illustration of the benefits of successful reintroduction and management of small-bodied freshwater fishes. This is interesting as the wetland also supports high abundance of other small bodied freshwater fish (e.g. Eastern Gambusia and Carp Gudgeon) that would be considered to be in direct competition with Murray hardyhead.

The ongoing success of Murray hardyhead at Koorlong Lake indicates that the environmental watering regime has proved sufficient to their needs and does not require modification. Other parameters, such as water quality also appear to be fine, perhaps except for dissolved oxygen which was relatively low during sampling. A possible explanation of this could be that with the lake at maximum inundation, a large proportion of vegetation was recently inundated and is proceeding to decompose. This results in reduced dissolved oxygen in the water column as the microbes breaking down this vegetation consume it. The main effects of this would be concentrated around the fringe of the lake (where this process is occurring) and also consequently where water quality samples were taken. The mobility of Murray hardyhead would ensure that it can avoid areas of hypoxia water in the wetland. The wetland supports

a healthy range of submerged and emergent aquatic vegetation to act as refuge from predators as well as substrate on which to deposit eggs.

While it appears that Murray hardyhead do not have a competitive advantage over other species within this lake, it seems that the competition is not overtly detrimental. If the hydrology of lake was to be manipulated to give Murray hardyhead a competitive advantage over other species, drying to increase EC would be the recommended process. However, we are unsure if, during drying, the EC of the lake would be sufficiently raised to be detrimental to other fish species. Also, the time required to undertake this task may impact breeding and growth of Murray hardyhead as majority of drying would occur during summer. In the scheme of things, it would be recommended to continue to manage the hydrological regime of this lake as per the current model that benefits Murray hardyhead (opposed to negatively impacting other species).

Lake Hawthorn

Murray hardyhead were not detected in Lake Hawthorn during the present survey suggesting that the reintroduction that took place in October 2018 was unsuccessful. This is perhaps unsurprising given the low number of fish released and the prevailing EC. Whilst the EC (68,000 EC) at the time of fish release would not result in juvenile or adult mortality it is anticipated that egg hatching and recruitment would not be possible (i.e. no egg hatching at >~60,000 EC) (Stoessel *et al.* in review; Wedderburn *et al.* 2008). Furthermore, despite environmental watering the EC has increased to ~75,000 EC at the time of the present survey.

It is timely for renewed consideration of the suitability of the Lake Hawthorn for Murray hardyhead. The wetland historically supported a sustainable population of Murray hardyhead before complete drying of the wetland (Ellis *et al.* 2013). The EC regime of the wetland was managed lower when the species was previously present. Yet, Lake Hawthorn remained unsuitable of Murray hardyhead for a number of years following the drought. Whilst the suitability of the wetland has improved, it continues to maintain elevated EC, which limits the ability of Murray hardyhead to establish self-sustaining populations. If re-establishing a population of Murray hardyhead at this location is regarded as a high priority, a concerted effort is required. This includes active management to ensure a more appropriate EC regime and reintroductions of a greater scope. Environmental watering in late winter and early spring to ensure ~20,000–30,000 EC during the spring breeding period before allowing EC to

increase to at ~50,000–60,000 EC over summer to provide Murray hardyhead a competitive advantage. In terms of reintroductions, the release of more fish over multiple years is recommended to increase the chance of re-establishment (Whiterod 2019). As with the other wetlands, more comprehensive sampling will be needed to support a reintroduction effort at Lake Hawthorn.

Brickworks Billabong

The current status of Murray hardyhead at Brickworks Billabong is unknown. It was not observed during the present survey, but additionally opportunistic sampling detected two individuals (Arthur Rylah Institute, unpublished data). Confirmation of the persistence of the species is encouraging as it was repeatedly recorded following its reintroduction (Ellis and Wood 2015; Huntley 2016). Despite 2016–17 flooding creating an opportunity for the species to disperse out of the wetland, for instance, it was observed in high abundance following disconnection of the wetland (Wood 2017). Furthermore, although not detected in Autumn 2017, conditions of the wetland have remained suitable for the species over recent years.

The current environmental conditions in Brickworks Billabong are suitable to support Murray hardyhead. Water quality parameters are all within acceptable ranges for Murray hardyhead survival and successful recruitment. The lack of aquatic structure (e.g. *Ruppia* sp.) may limit the population of the species; however, this wetland has never supported large amounts submerged vegetation and Murray hardyhead have thrived here previously. The presence of some *Ruppia sp*. suggests that viable seed is present in the billabong and it may still flourish in the future.

The currently low water level of the lake needs to be monitored, and the recent environmental watering should be sufficient to maintain sufficient water though winter. With close observation of EC as the wetland dries further, the EC may increase sufficiently, resulting in the death of other fish species, giving Murray hardyhead a competitive advantage. In this instance, however, maintaining sufficient depth may be more important that attempting to remove other fish species by this method. More generally, the present environmental watering regime appears broadly appropriate (Wood 2017). This being that during early spring, the wetland is filled to capacity to reduce EC (to allow spawning and recruitment), promote a productivity boom (i.e. more food) and facilitate the growth of submerged aquatic vegetation – all of which will enhance the suitability for Murray hardyhead. A subsequent top-

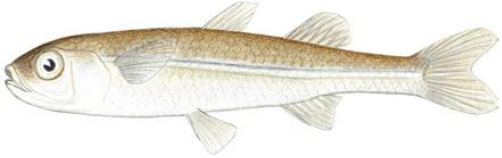
up may be required over late summer or early winter, if the water level drops and EC increases significantly and this would hopefully result in sufficient water to last until the following spring.

Monitoring of wetlands over time

The monitoring of the present study provided a necessary snapshot of the status of Murray hardyhead across the three wetlands. Regular monitoring is critical to provide timely information on population status (abundance, length structure, evidence of recruitment) as well as the prevailing fish community. In the future, it is recommended that a robust repeat sampling methodology, which utilises both multiple fyke and seine netting events during each monitoring period, is employed (Whiterod 2019; Whiterod and Gannon 2019). The repeat sampling is important as it accounts for variable detection probability and abundance, which is a feature of Murray hardyhead (e.g. Gwinn *et al.* 2015; Wedderburn *et al.* 2019; Wedderburn 2018). The monitoring scope should be annual (i.e. late summer/early autumn) or bi-annual (i.e. spring and late summer/early autumn) sampling of the existing sites in each wetland. Critically, the outcomes of this monitoring need to be linked to real-time triggers for management to ensure persistence of self-sustaining sub-populations.

Conclusion

The present study provides information on three important sub-populations of Murray hardyhead. The species was detected at only one wetland suggesting that reintroductions at the other two wetlands were unsuccessful. Management of this threatened species in the Victorian Mallee should be a high priority, with ongoing efforts to support current sub-populations and establish new sub-populations. This should be done by working together with scientists and water managers across locations which also support Murray hardyhead populations. A combined effort will be the only way to ensure the ongoing survival of this species and should be viewed as critically important for the regional recovery of the species



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Appendix 1

Lake Hawthorn sites

Koorlong Lake sites

Brickworks Billabong sites