Threatened Species Assessment

Craterocephalus fluviatilis
Murray Hardyhead

Taxonomy

Craterocephalus fluviatilis McCulloch, 1912

The Murray Hardyhead is a member of the family Atherinidae (Silversides), which consists of approximately 170 species worldwide, 26 of which are found in Australia (Ivantsoff et al. 1987). The taxon was first described by McCulloch (1913) and has historically been confused with morphologically similar conspecifics including the Lake Eyre Hardyhead *Craterocephalus eyresii,* Darling River Hardyhead *C. amniculus* and Unspecked Hardyhead *C. stercusmuscarum fulvus* (Crowley and Ivantsoff 1990; Ebner et al. 2003).

Current conservation status

Listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

Listed as threatened under the *Flora and Fauna Guarantee Act 1988* (SAC 1994).

Categorised as Critically endangered in the 2013 Advisory list of threatened vertebrate fauna in Victoria (DSE 2013).

Proposed conservation status

Critically Endangered in Victoria

Criteria A3ce+4ace; B1ab(i,ii,iii,iv,v)c(iv)+2ab(i,ii,iii,iv,v)c(iv)

Species Information

Description and Life History

Murray Hardyhead is an endemic, small gold to silver-green fish (<85 mm total length). Two dorsal fins are present, the first of which has 4–7 spines, the second, one spine and 5–8 rays. The anal fin is opposite the second dorsal fin, is small, and has one spine and 6–9 rays. The pectoral fins are located high on the sides close to the top of the operculum opening and consist of one spine and 11–13 rays. The pelvic fins are small, abdominal and consist of one spine and 5–6 rays.

Murray Hardyhead have a prolonged spawning season from September to March (spring and summer), with peak larval abundance occurring in late October to early November (Ellis 2005). Spawning is triggered by temperature and increasing day length (Ivantsoff and Crowley 1996, Ellis 2005, Stoessel et al. 2018). The taxon is a batch spawner, females depositing clutches of up to 80 adhesive eggs on submerged vegetation (Ellis 2005). Following spawning, reproductively spent adults suffer high mortality rates, with few surviving more than 12 months of age (Bice and Ye 2006, Ellis 2006). Eggs hatch on average 11 days after fertilisation at temperatures of 25°C (Stoessel et al. 2018). Length at maturity is around 25 to 30 mm standard length (Ellis 2005), fish in captivity attaining this length within as little as three months (Stoessel et al. 2018). The presence of three size classes in Round Lake in April 2008, somewhat backs claims that under ideal conditions, maturation may occur in the wild in less than three months (Stoessel pers. obs.). Individuals spawned early in a season likely reach maturity in the same season, and thus, under ideal conditions, there may be multiple spawning's in a season (Ellis and Kavanagh 2014, Stoessel et al. 2018).

Juvenile and adult Murray Hardyhead feed predominantly on micro-crustaceans, although larger fish tend to have a more diverse diet, consuming larger prey items such as dipteran pupae (Ellis 2006). In captivity, larvae readily feed

on rotifers and zooplankton, while adults will accept a range of food types including tubifex worms, artemia nauplii, processed flakes and pelletised food (Ellis 2010, Stoessel et al. 2018). In populations in wetlands in the wild, flooding during the spawning period (spring to summer) enhances zooplankton abundance (mostly rotifers and their eggs) which likely benefits recruitment success of the taxon (Wedderburn et al. 2010).

Generation Length

The generation length of Murray Hardyhead is estimated to be 6 to 12 months. From monitoring and age data from surveys, there can be several cohorts in a good year. At the end of winter, generally all adults are seen, and in spring, mostly young and no adults. The maximum lifespan is 18 months (Bice and Ye 2006, Ellis 2006).

Distribution

The Murray Hardyhead is endemic to the mid and lower Murray-Darling River system in south-eastern Australia. In Victoria, it is considered extinct at 9 out of 13 historically known sites. Three of these are near Mildura in the State's north-west (Cardross Lakes Basin 2 and 3 and Lake Hawthorn); with the three remainder near Kerang in north-central Victoria (Golf Course Lake, Tutchewop Lake, Cullens Lake, Long Lake, Lake Wandella, Lake Yando.. At most, eight populations remain within Victoria, two of which are historic (Round Lake and Cardross Basin 1), two potentially re-established via translocation (Lake Elizabeth, Woorinen North Lake), two new (non-historical) sites confirmed as established by translocation (Lake Koorlong and Brickworks Billabong), and one discovered following floods in Victoria in 2011 (Lake Kelly; Stoessel 2012). The capture of a single specimen in surveys of Reedy Lake in 2013, suggests the species may also persist at the site in low abundance. The status and extent of the population in Reedy Lake is, however, yet to be determined (DELWP 2018).

Habitat

Very little is known of the habitat used by the now extinct riverine populations in the Murray, lower Darling, and the Murrumbidgee River systems (Stoessel 2010). Virtually all knowledge regarding habitat use of the taxon is based on observations of a small number of remnant isolated populations in wetlands in Victoria and South Australia (Stoessel 2010). Importantly, current occupied habitats may not be representative of preferred habitat, but of marginal refuge habitat (Stoessel 2010). Remnant populations of Murray Hardyhead occupy still and slow-flowing waters including billabongs, lakes and margins and backwaters of lowland rivers (Lloyd and Walker 1986, Crowley and Ivantsoff 1990, Ivantsoff and Crowley 1996). Individuals are frequently observed schooling in open-water and amongst aquatic vegetation such as fringing emergent rushes *(Cumbungi* and *Juncus* spp.), and submerged macrophytes including *Ruppia* and *Myriophyllum* spp. (Ivantsoff and Crowley 1996, Raadik and Fairbrother 1999, Ebner et al. 2003, Hammer and Wedderburn 2008). Remnant populations of Murray Hardyhead are generally located in saline habitats, however, the taxon has been recorded in wetlands with salinities as low as 0.4 ppk in Riverglades Wetland in South Australia, to as high as 58.9 ppk in Lake Kelly (Wedderburn et al. 2007, Wedderburn et al. 2008, Stoessel 2012). Although salinity is implied as a key factor influencing distribution and abundance of remnant populations (Wedderburn et al. 2007), the taxon's predominant habitation of saline sites may be a consequence of reduced competition from alien fishes that such sites afford (particularly from Eastern Gambusia *Gambusia holbrooki* and Common Carp *Cyprinus carpio;* Wedderburn et al. 2010, Stoessel 2012), rather than a species-specific preference for such sites (Stoessel 2010).

Threats

Murray Hardyhead is an annual taxon, with populations dominated by 0+ individuals (Ellis 2005). Any perturbations which disrupt spawning and recruitment may therefore result in the rapid local extinction of populations (Stoessel 2010).

The rapid ongoing decline in the range and abundance of Murray Hardyhead is a response to numerous compounding factors. Fragmentation, deterioration and loss of habitat, flow alteration, river regulation, drought, changes to irrigation practices and alien fishes have all undoubtedly contributed to the taxon's decline. Threats are rarely mutually exclusive, with most sites impacted by more than a single threat. The following describes threats at individual sites and is taken from DELWP (2018).

Modernisation of irrigation has resulted in a significant reduction in runoff and increased salinisation at several sites (Cardross Lakes, Woorinen North Lake, Round Lake, Disher Creek Evaporation Basin and Berri Evaporation Basin). Environmental watering priorities are determined annually with no long-term guarantee of water supply. With decreasing water levels (both long and short term), salts become concentrated which results in potentially

lethal salinity levels; water quality monitoring at sites is therefore a vital component of management. On the other hand, freshwater inflows combined with groundwater outflows result in declining salinity levels in the long term; eventual invasion by less tolerant competitors and predator fish species is inevitable without exclusion screens. Declining salinity affects all off-channel sites. Climate change predictions suggest declines in rainfall and increases in temperature are likely in much of southern Australia.

As a result of river regulation and barriers to migration or movement, few opportunities now exist for dispersal and recolonisation. Dispersal during flooding was likely pivotal for recolonisation of sites and genetic exchange. Isolated wild, and captive populations may be at risk of genetic drift due to the often-small number of individuals at sites and the increased likelihood of inbreeding and domestication.

Eastern Gambusia is suggested as the likely cause of the extinction of at least one population; predation by Redfin (*Perca fluviatilis*) is likely to be underestimated in the Lower Lakes. The introduction of Carp has likely played a direct role in the decline of Murray Hardyhead, due to Carp feeding behaviour which increases turbidity and disturbs and uproots aquatic macrophytes.

The loss of macrophytes in many river systems which are suggested as a critical habitat of Murray Hardyhead for spawning and shelter, has likely contributed considerably to the decline of the species.

The impact of parasitic infections is unknown, as is the cause of the deformities; consequences of infection and deformities at sites may be intensified in stressed environments; it has been implied that a nematode infection may have been the cause of high mortalities in captive fish. Parasites affect fish at Round Lake, Woorinen North Lake, Cardross Lakes, Disher Creek Evaporation Basin; deformities affect fish at Cardross Lakes, Lake Hawthorn and Round Lake.

IUCN Criteria

Criterion A. Population size reduction.
Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Evidence:

Eligible under Criterion A2 as Endangered

The population reduction over the last 10 years is estimated to be 40 to 60 %, based on (a), (c) and (e) above.

In the past ten years, a total of 20 sites were known to have had Murray Hardyhead present. The species is now confirmed as extinct at eight of these sites (Lake Hawthorn, Cardross Lake (Basin 1), Brickworks Billabong, Angus River, Marne River, Scotts Creek Wetland, Lake Albert and Turvey's Drain), and is likely to be extinct at a further four (Lake Kelly, Round Lake, Woorinen North Lake, and Gurra Gurra Wetland). This represents a decline in the number of known populations of 60% (i.e. over the past 10 years). Although many of these wetlands are small when compared with the largest site known to contain a population (i.e. Lake Alexandrina in South Australia), the percentage change as a whole is still likely to be considerable. It is therefore estimated that the loss of the 12 populations has likely resulted in a decline of at least 40% of the overall population size (i.e. a decline of 40% in the number of individuals present 10 years ago)

Eligible under Criterion A3 as Critically Endangered

The population reduction over the next 10 years is projected to be 80 to 100%, based on (c) and (e) above.

Based on current trends where a subpopulation has been lost every 1 to 2 years (over the entire range of the species) for the past 40 years, the loss of the two remaining subpopulations in Victoria in the next 10 years is extremely likely without further intervention.

Eligible under Criterion A4 as Critically Endangered

The population reduction over any 10 year period, including both past and future, is estimated to be 80 to 100 %, based on (a), (c) and (e) above. The causes of reduction may not have ceased, be understood or be reversible.

The past decline is based on known extinctions from surveys and monitoring. Based on current trends where a subpopulation has been lost every 1 to 2 years (over the entire range of the species) for the past 40 years, the loss of the two remaining subpopulations in Victoria in the next 10 years is extremely likely without further intervention.

Criterion B. Geographic range in the form of either B1 (extent of occurrence) and/or B2 (area of occupancy			
	Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Evidence:

Eligible under Criterion B1 as Critically Endangered

The Extent of Occurrence (EoO) across the taxon's range is estimated to be 88 km², based on accepted, post-1970 records from the Victorian Biodiversity Atlas (VBA).

Considering the dispersal ability of the taxon, the barriers or lack of habitat separating them, the individuals can be considered to be severely fragmented and if a subpopulation was lost, there would be little or no possibility of natural recolonisation.

It is estimated to have one location, as all threats identified are generic and apply consistently across the ecological and geographic range of the taxon.

It has a continuing decline in (i), (ii), (iii), (iv) and (v) above. It is estimated to have extreme fluctuations in (iv) above. Based on monitoring data and surveys of fluctuating populations at similar sites year to year, the species has a boom-bust lifestyle. It is possible to observe > 1000 in six nets and then another year get more or less none.

Eligible under Criterion B2 as Critically Endangered

The Area of Occupancy (AoO) across the taxon's range is estimated to be 8 km², based on 2 x 2 km grids derived from accepted, post-1970 records in the VBA. However, as many as three of the possible five populations may be extinct. As above it is severely fragmented, has one 1 location, has a continuing decline in (i), (ii), (iii), (iv) and (v) and extreme fluctuations in (iv) above.

Criterion C. Small Population size and decline				
		Critically Endangered	Endangered	Vulnerable
Number of mature individuals		< 250	< 2,500	< 10,000
AND at least one of C1 or C2				
C1	An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2	An observed, estimated, projected or inferred continuing decline AND least 1 of the following 3 conditions:			
(a)	(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
	(ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals				

Evidence:

Ineligible under Criterion C

It is estimated that there are 12,000 to 600,000 mature individuals, which exceeds the thresholds for criterion C.

Criterion D. Very small or restricted population			
	Critically Endangered	Endangered	Vulnerable
Number of mature individuals (observed or estimated)	<·50	<·250	<·1,000
D2 Only applies to the VU category Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time.	-	-	D2. Typically: AoO <·20 km2 or number of locations ≤·5

Evidence:

Eligible under criterion D as Vulnerable

The taxon is estimated to be very restricted.

Criterion E (Quantitative Analysis) was not addressed as the taxon does not have a detailed Population Viability Analysis.

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