

Threatened Species Assessment

Maccullochella macquariensis Trout Cod

Taxonomy

Maccullochella macquariensis (Cuvier, 1829)

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 1991).

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

Proposed conservation status

Endangered in Victoria

Criterion B2ab(i,ii,iii,iv,v)

Species Information

Description and Life History

The Trout Cod is an elongate, streamlined, moderately large percoid fish with a typically blue-grey colouration on the back and sides, becoming paler, almost white, on the ventral surface of the abdomen. This colouration is overlain by darker spots, blotches and irregular lines on the back and sides, but which are largely absent on the forehead and snout. Fins are blue-grey, with the tail, soft dorsal, anal and pelvic fins frequently with white margins. In profile, the head is straight, the top jaw overhangs the lower jaw, and a dark eye stripe extends from the snout horizontally through the eye to the operculum. Trout Cod grow to a maximum of about 700 mm in length and 16 kg in weight (Lake 1971), but are usually smaller (910 mm and 5 kg; Lintermans 2007),

Douglas et. al. (1994) considered that Trout Cod, like captive Murray Cod, formed pairs and spawned annually, usually in spring (September to November) and probably in response to increasing day-length and water temperature. Trout Cod breeding appears to be stimulated by a rise in water temperature to between 15 degrees C and 20 degrees C in October-November (G. Gooley in Koehn and O'Connor 1990; Koehn and Harrington 2006). The fertilised eggs of Trout Cod are adhesive, demersal, opaque and 2.5-3.6 mm in diameter (Ingram and Rimmer 1992). The adhesive properties of the eggs suggest that a hard substrate might be preferred as an egg-laying site and it is speculated that typical egg-laying sites would include on or in logs, amongst rocks, or on hard clay surfaces (Cadwallader 1979; Koehn and O'Connor 1990). The fecundity of Trout Cod ranged from 2,027 to 14,000 in the wild (Lyon et al. 2012). This is higher than the 1,200-11,300 eggs stripped from individual hatchery broodfish (Ingram and Rimmer 1992). Hatching commences 5-10 days after fertilisation at 20 degrees C and is mostly completed 2-3 days later, though may occur for up to 10 days (Ingram and Rimmer 1992). Newly hatched larvae are 6.0-8.8 mm in length and begin feeding about 10 days after hatching. Larvae occur in the drift after hatching, with peak numbers in November

Trout Cod reach sexual maturity at 3-5 years, between 0.75 and 1.5 kg in weight, and at lengths as small as 35 cm for males and 43 cm for females (G. Gooley, in Koehn and O'Connor 1990), although fish as small as 25.4 cm have been reported in spawning condition (J.O. Langtry, in Cadwallader 1977). The smallest confirmed spawning female in the wild is 283 mm, 299 g and 5 years old (Lyon et al. 2012). Generally male Trout Cod mature younger and

smaller than females, although there would be some variation depending on environmental conditions and growth rate.

The Trout Cod is a carnivorous, top-order predator, and its diet includes freshwater crustaceans such as crayfish, yabbies and shrimps, as well as fish and aquatic insects (Cadwallader 1979). Trout Cod fry reared in fertilised earthen ponds feed on a wide range of zooplankton, particularly cladocerans and copepods, and aquatic insects.

Movements are limited, especially by adults, with high levels of site fidelity and most recolonization occurring through either juvenile movements or larval drift (Koehn and Harrington 2006; Koehn et al. 2008; Koehn and Nicol 2016).

Generation Length

The generation length of the Trout Cod is estimated to be 5 to 10 years. This is based on Seven Creeks adult population data, which showed a limited number of adults, with a high recapture rate of adults within the population. A coarse estimate of generation time is to take age at maturity away from maximum age and halve it, so if the maximum age is about 23.5 (from Todd et al 2004 paper which estimated max age at 20-25) and age at sexual maturity is 5.5 years, then $23.5 - 5.5 = 18$, and halved is 9.

Distribution

The Trout Cod is endemic to the Murray-Darling River system in south-eastern Australia, with records from the Murray River (SA and NSW), Murrumbidgee River (NSW and ACT), Macquarie River (NSW) and the Goulburn, Broken, Campaspe, Ovens, King, Buffalo and Mitta Mitta Rivers (Vic)

At present only two potentially sustainable, breeding populations of Trout Cod are known from only one naturally occurring, sustainable breeding population in the Murray River (NSW) downstream of the Yarrawonga Weir between Yarrawonga and Barmah (Cadwallader and Gooley 1984; Ingram et al. 1990; Douglas et al. 1994). A second sustainable, breeding occurs from population into translocated Seven Creeks below Polly McQuinns Weir (Vic) in the early 1900s, and these have now been supplemented by breeding from stocked populations established from early 2000s in the Ovens river, lower Goulburn River, Murrumbidgee rivers (NSW) (Lyon et al. 20102; Koehn et al. 2013). A number of other stocking locations have failed to establish long-term self-breeding populations (Koehn et al. 2013).

Habitat

The Trout Cod is a riverine species, inhabiting a variety of flowing waters in the mid to upper reaches of rivers and streams with cover in the form of woody debris or boulders. The Murray River downstream from Yarrawonga Weir is a large (60-100 m wide), flowing and deep (>3 m) river with a sand, silt and clay substrate, and contains abundant woody debris. Trout Cod have been detected from within, under or adjacent to snags (logs), branch piles and steep clay banks, usually in areas of relatively fast flowing current. Seven Creeks is a relatively narrow stream (5-7 m wide) having a rock, gravel and sand substrate, and pools (generally <2 m deep) interspersed by rapids and cascades up to about 4 m in height. Larger Trout Cod are often found in the deeper pools but smaller fish have also been taken amongst boulders, under logs and other cover in shallower waters. Habitats have been well documented in the Murray river habitats and consist of high levels of woody habitat, further from the bank and in faster water than the other large bodied fish species (Koehn and Nicol 2016).

Threats

Threats cited in the National Recovery Plan include removal of snags, woody debris and rocks from potential habitat (especially mid-stream woody habitats); reduction in/alteration of flows (such as abstraction of water); barriers to migration/movement (such as dams, weirs, causeways and levees); removal of riparian vegetation/habitat; increased siltation or sedimentation, including from fires (Lyon and O'Connor 2008); blackwater fish kills (King et al. 2012); loss of larvae into irrigation channels and pumps and damage passing over weirs (Baumgartner 2006, 2009; King and O'Connor 2007); potential predators/competitors (especially redfin and trout), and recreational fishing (e.g. incidental capture and release) mortality.

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% |
| <p>A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.</p> <p>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.</p> <p>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]</p> <p>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.</p> <p style="text-align: center;"><i>based on any of the following:</i></p> <ul style="list-style-type: none"> (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:

Ineligible under Criterion A

The past population reduction does not meet the threshold for eligibility under criterion A2, and the future population reduction does not meet the threshold for eligibility under criterion A3.

Maccullochella macquariensis

Trout Cod

| 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 km ² | < 5,000 km ² | < 20,000 km ² |
| B2. Area of occupancy (AOO) | < 10 km ² | < 500 km ² | < 2,000 km ² |
| 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 B2 as Endangered

The Area of Occupancy (AoO) across the taxon's range is estimated to be 332 km², based on 2 x 2 km grids derived from accepted, post-1970 records in the Victorian Biodiversity Atlas, and on anecdotal expert data.

It is estimated to have four locations. A catastrophic event such as fire is unlikely to affect all populations. Low flows may occur, but over a relatively long time scale. The Broken River population is under different threats from the Goulburn River.

It has a continuing decline in (i), (ii), (iii), (iv) and (v) above. The largest population (Overs River) is subject to climate change with low flows impacting the taxon during the Millennium Drought. As the Owens is largely unregulated, there is limited chance of putting environmental flows to increase survivorship. It may also affect the Sevens Creek population.

| 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 | | | |

Maccullochella macquariensis

Trout Cod

Evidence:

Eligible under Criterion C as Vulnerable

It is estimated that there are 1,500 to 7,000 mature individuals. Ovens River population stocking has been successful, with the adult population increasing over time. Sevens Creek and Goulburn River populations appear to be small but static. All other populations have decreased and are considered non-existent in terms of breeding populations.

There is estimated to be a continuing decline of 1 to 25% (midpoint 15%) over the next three generations.

Hughes Creek, Koetong Creek and Cudgewa Creek populations were lost in the last 25 to 40 years. The Goulburn River is currently stable, but in low abundances. Changes to flow regimes may cause a shift in this balance. The Ovens River population declined during the Millennium Drought. With climate change, it is feasible that this may occur again.

| 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 km ² or number of locations ≤ 5 [Ⓜ] |

Evidence:

Ineligible under Criterion D

It is estimated that there are 1,500 to 7,000 mature individuals.

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

References

- Baumgartner, L. J., Reynoldson, N., and Gilligan, D. M. (2006). Mortality of larval Murray cod (*Maccullochella peelii peelii*) and golden perch (*Macquaria ambigua*) associated with passage through two types of low-head weirs. *Marine and Freshwater Research* 57, 187-191.
- Baumgartner, L. J., Reynoldson, N. K., Cameron, L., and Stanger, J. (2009). Effects of irrigation pumps on riverine fish. *Fisheries Management and Ecology* 16, 429-437.
- Cadwallader, P. L. (1977). J.O. Langtry's 1949-50 Murray River investigations. *Fisheries and Wildlife Paper, Victoria* No. 13.
- Cadwallader, P. L. (1979). Distribution of native and introduced fish in the Seven Creeks river system, Victoria. *Australian Journal of Ecology* 4, 361-385.
- Cadwallader, P. L., and Gooley G. J. (1984). Past and present distributions and translocations of Murray cod *Maccullochella peelii* and trout cod *M. macquariensis* (Pisces: Percichthyidae) in Victoria. *Proceedings of the Royal Society of Victoria* 96, 33-43.
- DSE (2013). *Advisory List of Threatened Vertebrate Fauna in Victoria 2013*. Department of Sustainability and Environment, Melbourne. Retrieved from https://www.environment.vic.gov.au/__data/assets/pdf_file/0014/50450/Advisory-List-of-Threatened-Vertebrate-Fauna_FINAL-2013.pdf

Maccullochella macquariensis

Trout Cod

- Douglas, J. W, Gooley G. J., and Ingram B. A. (1994). *Trout cod, Maccullochella macquariensis (Cuvier) (Pisces: Percichthyidae), Recovery Handbook and Recovery Plan*. Victorian Fisheries Research Institute, Department of Conservation and Natural Resources: Victoria.
- Ingram, B. A. and Rimmer, M. A. (1992). Induced breeding and larval rearing of the endangered Australian freshwater fish trout cod, *Maccullochella macquariensis* (Cuvier) (Percichthyidae). *Aquaculture and Fisheries Management* 24, 7-17.
- Ingram, B. A., Barlow, C. G., Burchmore, J. J., Gooley, G. J., Rowland, S. J., and Sanger, A. C. (1990). Threatened native freshwater fishes in Australia - some case histories. *Journal of Fish Biology* 37 (Suppl. A), 175-82.
- King, A. J., and O'Connor, J. P. (2007). Native fish entrapment in irrigation systems: a step towards understanding the significance of the problem. *Ecological Management and Restoration* 8, 32-38.
- King, A. J., Tonkin, Z., and Lieschke, J. (2012). Short-term effects of a prolonged blackwater event on aquatic fauna in the Murray River, Australia: considerations for future events. *Marine and Freshwater Research* 63, 576-586.
- Koehn J.D. and Harrington D.J. (2006). Conditions and timing of the spawning of Murray cod (*Maccullochella peelii peellii*) and the endangered trout cod (*M. macquariensis*) in regulated and unregulated rivers. *Rivers Research and Applications* 22:327-343
- Koehn JD. Nicol S.J., McKenzie, J. A., Leischke JA., Lyon J.P., and Pomorin K. (2008). Spatial ecology of an endangered native Australian Percichthyid fish, the trout cod *Maccullochella macquariensis*. *Endangered Species Research* 4: 219-225.
- Koehn J.D. and Nicol S.J. (2014). Comparative habitat use by large riverine fishes. *Marine and Freshwater Research* 65(2), 164-174 <http://dx.doi.org/10.1071/MF13011>
- Koehn J.D. and Nicol, S.J. (2016) Comparative reach-scale movements of four large fish species in a lowland river. *Journal of Fish Biology* 88(4): 1350-1368
- Koehn, J. D. and O'Connor, W. G. (1990). *Biological Information for Management of Native Freshwater Fish in Victoria*. Government Printer: Melbourne) 65 pp.
- Koehn, J. D., Lintermans, M., Lyon, J. P., Ingram, B.A., Gilligan, D. M., Todd, C. R. and Douglas, J. W. (2013) Recovery of the endangered trout cod *Maccullochella macquariensis*: What have we achieved in over 25 years? *Marine and Freshwater Research* 64(9), 822-837.
- Lake, J. S. (1971). *Freshwater Fishes and Rivers of Australia*. Nelson: Melbourne.
- Lintermans, M. (2007). *Fishes of the Murray-Darling Basin: An Introductory Guide*. Murray-Darling Basin Commission: Canberra.
- Lyon, J. P., and O'Connor, J. P. (2008). Smoke on the water: Can riverine fish populations recover following a catastrophic fire-related sediment slug? *Austral Ecology* 33, 794-806
- Lyon, J. P., Todd, C., Nicol, S. J., MacDonald, A., Stoessel, D. A., Ingram, B. A., et al. (2012). Reintroduction success of threatened Australian trout cod (*Maccullochella macquariensis*) based on growth and reproduction. *Marine and Freshwater Research* 63, 598-605.
- SAC (1991). Flora and Fauna Guarantee Scientific Advisory Committee: Final Recommendation on a Nomination for Listing. Nomination No. 4 *Maccullochella macquariensis*
- Trout Cod Recovery Team (2008). *National Recovery Plan for the Trout Cod Maccullochella macquariensis*. Department of Sustainability and Environment, Melbourne.