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Two new species of fish, previously confused with the Macquarie Perch *Macquaria australasica* Cuvier 1830 (Actinopterygii: Perciformes: Percichthyidae) from east coast drainages in Australia.

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ABSTRACT

The iconic Macquarie Perch *Macquaria australasica* Cuvier, 1830 as currently recognized is a moderate-sized fish growing to 46 cm in length and 3.5 kg, with an elongate-oval body which is laterally compressed. It is regularly taken by recreational fishing enthusiasts wherever it is found. While some populations have arisen in some rivers and reservoirs from specimens translocated by humans (e.g. the Yarra River in Melbourne, Victoria), it is known to naturally occur in the drainages of the Murray Darling Basin (flowing west) and also the Shoalhaven and Hawkesbury/Nepean River systems in coastal New South Wales (flowing east).

Dufty (1986) found that three genetic stocks exist worthy of species-level recognition.

These were those populations naturally occurring west of the Great Dividing Range, the Hawkesbury River specimens and the naturally occurring specimens in the lower Shoalhaven River system.

As the two eastern forms are unnamed, the purpose of this paper is to formally name those species.

Keywords: Fish; taxonomy; nomenclature; Macquarie Perch; *Macquaria*; *australasica*; Murray River; Darling River; Yarra River; Shoalhaven River; Hawkesbury River; Nepean River; Kangaroo River; New South Wales; Australia; new species; *hoserae*; *honlami*.

INTRODUCTION

The iconic Macquarie Perch *Macquaria australasica* Cuvier 1830 as currently recognized is a moderate-sized fish growing to 46 cm in length and 3.5 kg in weight, with an elongate-oval body which is laterally compressed. It is regularly taken by recreational fishing enthusiasts wherever it is found. While some populations have arisen in some rivers and reservoirs from specimens translocated by humans (e.g. the Yarra River in Melbourne, Victoria), it is known to naturally occur in the drainages of the Murray Darling Basin (flowing west) and also the Shoalhaven and Hawkesbury/Nepean River systems in coastal New South Wales (flowing east).

Dufty (1986) found that three genetic stocks exist worthy of species-level recognition.

These were those populations naturally occurring west of the Great Dividing Range, the Hawkesbury River specimens and the naturally occurring specimens in the lower Shoalhaven River system, including specimens taken from the tributary Kangaroo River.

In line with the Australian Federal Government's "Big Australia" policy, that being to increase the human population of 25 million (2020), from 13 million in around 1970, to over 100 million within 100 years "so that we can tell China what to do", as stated by the former Prime Minister, Kevin Rudd in 2019 (Zaczek 2019), the human pressure on the relevant ecosystems has increased in line with the human populations nearby and will clearly continue to do so.

Numbers of fish have declined sharply in many parts of the range of putative *Macquaria australasica*, in particular that population from the Shoalhaven River system.

Local environmentalists, including an organisation called "OzFish Unlimited" in 2019 sought to conserve the sharply declining and potentially extinct Shoalhaven River population, by searching for remaining specimens (Copeland, 2019).

They found difficulties getting public support for their actions as the local population was being treated by government as merely one of many populations of putative *Macquaria australasica.* The Shoalhaven River population had not been formally recognized by science as taxonomically distinct and was therefore being treated as non-existent by the State Wildlife Department.

It was therefore not eligible to be funded by government for any conservation program.

I was approached by a number of people to formally name the Shoalhaven River population as a separate species to enable conservation programs to be enacted to save the species, assuming it was not already too late.

MATERIALS, METHODS AND RESULTS

Before formally naming the Shoalhaven River population of putative *Macquaria australasica* I had to verify and confirm claims that the said fish was in fact sufficiently different from the type form of *M. australasica* with a type locality of the Murray/Darling River system to warrant taxonomic recognition.

To do this, specimens were examined from the Shoalhaven River system and all other parts of the known range of *M. australasica*, to A/ Confirm if any forms warranted taxonomic recognition beyond the single species currently recognized and B/ If so, if there were any available names for those taxa.

Obviously a thorough review of the relevant literature was undertaken to assist in the relevant tasks.

It emerged that genetic work had already been undertaken to confirm that populations in the Shoalhaven River system and the Hawkesbury/Nepean River system were genetically distinct from the main (western) populations from the Murray/Darling River system (Dufty 1986).

It also came as a surprise to find that while there were numerous available names (synonyms) for populations of *M. australasica*, all in fact applied to western populations and none could be applied to either the Shoalhaven River system and the Hawkesbury/Nepean River system populations.

The fish from the Shoalhaven River system and the Hawkesbury/Nepean River system also were significantly different morphologically from the Murray/Darling *M. australasica* and so the fact that until now they had not been taxonomically recognized came as an even greater surprise.

I also note that Anonymous (2018) wrote:

> "Because of morphological and genetic differences between Murray-Darling Basin and eastern Macquarie perch (Hawkesbury-Nepean and Shoalhaven) there were calls for revising the taxonomic status to recognise the Shoalhaven, Hawkesbury-Nepean and Murray-Darling Basin as separate species (Dufty 1986; Faulks *et al*,. 2010; Faulks *et al*,. 2011; Pavlova *et al*,. 2017a; 2017b)."

Anonymous (2018) also noted:

> "The Murray-Darling Basin and Hawkesbury-Nepean lineages diverged approximately 385 000 to 119 000 years ago (Pavlova *et al*,. 2017b). There additionally appears to be divergence within the Hawkesbury-Nepean system, with the southern Hawkesbury-Nepean diverging from the northern Hawkesbury-Nepean approximately 191 000 to 58 000 years ago (Pavlova *et al*,. 2017b).
>
> An individual collected from the Kangaroo River (Shoalhaven system), prior to the presumed extinction of the Shoalhaven River lineage was found to be highly differentiated from both the Hawkesbury-Nepean and Murray-Darling Basin lineages (Pavlova *et al*,. 2017b), supporting a long term evolutionary trajectory of the Shoalhaven lineage. Analysis of mitochondrial lineage divergence showed that the Shoalhaven Basin diverged from the common ancestor of the Murray-Darling Basin and Hawkesbury-Nepean around 1 332 000 to 419 000 years ago (Pavlova *et al*,. 2017b)."

With the clear result being two unnamed forms, sufficiently divergent to be named at the species level (see preceding), the purpose of this paper is to formally name those species in accordance with the rules of the *International Code of Zoological Nomenclature* (Ride *et al.* 1999).

Of relevance also is that species-level recognition of the coastal forms is in fact parallel to a position already taken with the two still (known to be) living east coast species related to *Maccullochella peelii* (Mitchell, 1838), which according to the evidence of Pavlova *et al.* (2017b) diverged as a result of the same geological event and at the very same time (citing Nock *et al.* 2010).

Literature relevant to the investigation, taxonomic, nomenclatural and wildlife conservation conclusions herein include Anonymous (2018), Allen (1989), Appleford *et al.* (1998), Arthington (1991), Arthington and McKenzie (1997), Arthur Rylah Institute (2017), Australian Capital Territory Government (1999), Battaglene (1998), Broadhurst *et al.* (2012, 2013), Brown and Morgan (2015), Bruce *et al.* (2007), Cadwallader (1978. 1979, 1981, 1984), Cadwallader and Backhouse (1983), Cadwallader and Douglas (1986), Cadwallader and Eden (1979), Cadwallader and Rogan (1977), Copeland (2019), Crowl *et al.* (1992), Cuvier (1830), Dufty (1986), Ebner *et al.* (2007), Ebner and Lintermans (2007), Erskine (2016), Faragher and Harris (1994), Farrington *et al.* (2014), Faulks *et al.* (2010, 2011), Gehrke *et al.* (1999), Gilligan (2005), Gray *et al.* (2000), Günther (1859), Hall *et al.* (2009a, 2009b), Harris and Rowland (1996), Ho and Ingram (2012), Ingram and De Silva (2007), Ingram *et al.* (1994, 2000), Jackson (1981), Knight and Bruce (2010), Koehn and O'Connor (1990), Koster *et al.* (2014), Lake (1959, 1971, 1978), Lintermans (1991a, 1991b, 2002, 2005, 2006a, 2006b, 2007, 2008, 2012, 2013a, 2013b), Lintermans and Ebner (2010), Lintermans *et al.* (2014), Lugg and Copeland (2014), MacDonald *et al.* (2014), McKeown (1934), Nock *et al.* (2010), Pavlova (2017a, 2017b), Pearce *et al.* (2017), Ride *et al.* (1999), Starrs *et al.* (2011), Stead (1913), Todd and Lintermans (2015), Tonkin *et al.* (2006, 2010, 2016, 2017), Trueman (2007), Wharton (1968, 1973) and sources cited therein.

Rather than run the risk of species or subspecies becoming threatened or extinct due to non-recognition of them as has occurred before as shown in Hoser (2019a, 2019b), I have opted to publish this paper in its current form.

Naming of taxa is perhaps the most important step in their ultimate preservation and it is with this motivation in mind (protection of biodiversity) that I have chosen to publish this paper.

INFORMATION RELEVANT TO THE FORMAL DESCRIPTIONS THAT FOLLOW

There is no conflict of interest in terms of this paper or the conclusions arrived at herein.

Several people including anonymous peer reviewers who revised the manuscript prior to publication are also thanked as a relevant staff at museums who made specimens and records available in line with international obligations.

In terms of the following formal descriptions, spellings should not be altered in any way for any purpose unless expressly and exclusively called for by the rules governing Zoological Nomenclature as administered by the International Commission of Zoological Nomenclature.

In the unlikely event two newly named taxa are deemed conspecific by a first reviser, then the name to be used and retained is that which first appears in this paper by way of page priority and as listed in the abstract keywords.

Some material in descriptions for taxa may be repeated for other taxa in this paper and this is necessary to ensure each fully complies with the provisions of the *International Code of Zoological Nomenclature* (Fourth edition) (Ride *et al.* 1999) as amended online since.

Material downloaded from the internet and cited anywhere in this paper was downloaded and checked most recently as of 2 January 2020, unless otherwise stated and were accurate in terms of the context cited herein as of that date.

Unless otherwise stated explicitly, colour and other descriptions apply to living adult specimens of generally good health and not under any form of stress by means such as excessive cool, heat, dehydration or abnormal skin reaction to chemical, abnormal water conditions or other input.

While numerous texts and references were consulted prior to publication of this paper, the criteria used to separate the relevant species or subspecies has already been spelt out and/ or is done so within each formal description and does not rely on material within publications not explicitly cited herein.

MACQUARIA HOSERAE SP. NOV.

LSID urn:lsid:zoobank.org:act:53AC5FDF-308B-4074-9607-4F3748C39C93

Holotype: A preserved specimen at the Australian Museum in Sydney, New South Wales, Australia, Ichthyology Collection, Specimen number IB.7906, collected from the Grose River, immediately below and north of Blackheath, in the Blue Mountains of New South Wales, Australia, Latitude -33.63 S., Longitude 150.28 E. This facility allows access to its holdings.

Paratypes: 1/ A preserved specimen at the National Museum of Victoria, Melbourne, Victoria, Australia, Ichthyology collection, specimen number A31793-2, collected from Bowens Creek, upstream of Mount Irvine/Bilpin Road, Blue Mountains, New South Wales, Australia, Latitude -33.50 S., Longitude 150.47 E.

2/ A preserved specimen at the National Museum of Victoria, Melbourne, Victoria, Australia, Ichthyology collection, specimen number A21325 (Alt field no. PU99 71), collected from the pool just below the Jack Evans walking track crossing at Erskine Creek, approx. 4 km north-west of Warragamba, New South Wales, Australia, Latitude -33.84 S., Longitude 150.58 E.

Diagnosis: The three species *Macquaria australasica* Cuvier 1830, *M. hoserae sp. nov*. and *M. honlami sp. nov.* have until now been treated as one and the same species. They are all separated from all other species within the Percichthyidae by the following suite of characters: Form of the body is more-or-less oblong, vertically compressed; eye moderate; cleft of the mouth nearly horizontal, with the jaws equal. One dorsal, with eleven spines, anal fin with three; all the spines strong. No teeth in the jaws or on the palate. Branchiostegals five. Both limbs of the praeoperculum serrated; operculum with two points. Scales moderate, ctenoid. Air-bladder simple; pyloric appendages in moderate number. Snout scaleless and elongate. The fourth and fifth dorsal spines longest; the second of the anal fin much longer and stronger than the third. D. 11/11, A 3/8, L. LAT. 65-66, Caec. pylor. 3.

Colouration is more-or-less uniform almost black or dark silvery grey to bluish grey or grey-green above (*M. australasica*) or alternatively blotched with grey-brown, buff and dark-greyish over the head and body and otherwise a greyish-silver or brown colour (*M. hoserae sp. nov*. and *M. honlami sp. nov.*).

Nominate *M. australasica* from the Murray Darling Basin, grow to 46 cm long and weigh up to 3.5 kg. Their colouration varies from almost black or dark silvery grey to bluish grey or green-grey above, paler to off-white below, often with a yellowish tinge.

Both *M. hoserae sp. nov*. and *M. honlami sp. nov.* are readily separated from *M. australasica* as described above by having a distinctively smaller size at maturity where they grow to less than 25 cm in length and weigh no more than 1.5 kg. Both species are different to *M. australasica* in that they are blotched with grey-brown, buff and dark-greyish over the head and body and can otherwise be silvery-grey (*M. honlami sp. nov.*) or brownish (*M. hoserae sp. nov.*) in colour on the upper surfaces and upper flanks.

Both *M. hoserae sp. nov*. and *M. honlami sp. nov.* have one less vertebrae than *M. australasica.*

M. hoserae sp. nov. is readily separated from both *M. australasica* and *M. honlami* by being a generally brownish as opposed to greyish or silvery in colour. Blotches on the lower rear flanks are large and well defined, versus ill-defined in *M. australasica* and broken in *M. honlami sp. nov.*.
In side by side comparison, both *M. hoserae sp. nov*. and *M. honlami sp. nov.* have more skin between the upper dorsal spines, making them less prominent than is the case in *M. australasica.* Also see the comparative photos between *M. hoserae sp. nov*. (bottom) and *M. australasica* (top) on page 13 of Anonymous (2018) and *M. honlami sp. nov.* in Copeland (2019).

The three species *M. australasica*, *M. hoserae sp. nov*. and *M. honlami sp. nov.* can also be readily distinguished and separated from one another by the colour of the iris, being silvery white in *M. australasica*, silvery-grey in *M. honlami sp. nov.* and brown in *M. hoserae sp. nov.*.

The dark mid-lateral line is prominent in *M. australasica* and indistinct in both *M. hoserae sp. nov*. and *M. honlami sp. nov.*.
Conservation: Anonymous (2018) gives a detailed account of the conservation history of the three species *M. australasica*, *M. hoserae sp. nov*. and *M. honlami sp. nov.* and ongoing threats they are aware of.

According to Huntsdale (2019) no *M. honlami sp. nov.* had been seen in the wild for 20 years and the taxon may already be extinct.

However the root cause of these problems, the human overpopulation of Australia (see for example Zaczek 2019) is not addressed.
The relevant comments in Hoser (1991) therefore apply.
Pavolva *et al.* (2017) argue for the mixing specimens of populations of putative *M. australasica* including potentially the three species identified herein, which would otherwise be reproductively isolated. The basis of the recommendation is to aid genetic diversity and long-term survival of populations.
This contention is rejected here as no amount of genetic diversity has protected any populations of these fish against the onslaught of human activity since European settlement of Australia and destruction of three unique genetic and biological entities for uncertain short term potential gain in the face of a far greater threat that is not being mediated is simply a waste of time and effort.
Preservation of unique species in the wild state should be a goal of wildlife conservation, as opposed to creating a planet full of mutant mutts still under threat and decline from unabated human population growth!
Distribution: *M. hoserae sp. nov*. is restricted to the Hawkesbury Nepean River system of the central coast of New South Wales, Australia, in particular the upper reaches that flows through the Blue Mountains region of New South Wales as well as southern tributaries of the Nepean River.

Specimens from the Georges River in western Sydney are also tentatively assigned to this species.

Etymology: Named in honour of my mother, Katrina Hoser, of Lane Cove (Sydney), New South Wales in recognition of contributions to wildlife conservation over a period of more than 50 years.

MACQUARIA HONLAMI SP. NOV.

LSID urn:lsid:zoobank.org:act:C437A0BD-31C4-4ACA-833F-2BC3C9620FCC

Holotype: A preserved specimen at the Australian Museum in Sydney, New South Wales, Australia, Ichthyology Collection, Specimen number I.16625-001, collected from the Kangaroo River, New South Wales, Australia, Latitude -34.72 S., Longitude 150.50 E. This facility allows access to its holdings.

Diagnosis: The three species *Macquaria australasica* Cuvier 1830, *M. hoserae sp. nov*. and *M. honlami sp. nov.* have until now been treated as one and the same species. They are all separated from all other species within the Percichthyidae by the following suite of characters: Form of the body is more-or-less oblong, vertically compressed; eye moderate; cleft of the mouth nearly horizontal, with the jaws equal. One dorsal, with eleven spines, anal fin with three; all the spines strong. No teeth in the jaws or on the palate. Branchiostegals five. Both limbs of the praeoperculum serrated; operculum with two points. Scales moderate, ctenoid. Air-bladder simple; pyloric appendages in moderate number. Snout scaleless and elongate. The fourth and fifth dorsal spines longest; the second of the anal fin much longer and stronger than the third. D. 11/11, A 3/8, L. LAT. 65-66, Caec. pylor. 3.

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In side by side comparison, both *M. hoserae sp. nov.* and *M. honlami sp. nov.* have more skin between the upper dorsal spines, making them less prominent than is the case in *M. australasica. Also* see the comparative photos between *M. hoserae sp. nov.* (bottom) and *M. australasica* (top) on page 13 of Anonymous (2018) and *M. honlami sp. nov.* in Copeland (2019).

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The dark mid-lateral line is prominent in *M. australasica* and indistinct in both *M. hoserae sp. nov.* and *M. honlami sp. nov..*

Conservation: Anonymous (2018) gives a detailed account of the conservation history of the three species *M. australasica*, *M. hoserae sp. nov.* and *M. honlami sp. nov.* and ongoing threats.

According to Huntsdale (2019) no *M. honlami sp. nov.* had been seen in the wild for 20 years and may already be extinct.

However the root cause of these problems, the human overpopulation of Australia (see for example Zaczek 2019) is not addressed.

The relevant comments in Hoser (1991) therefore apply.

Pavolva *et al.* (2017) argue for the mixing of specimens of populations of putative *M. australasica* including potentially the three species identified herein, which would otherwise be reproductively isolated. The basis of the recommendation is to aid genetic diversity and long-term survival of populations.

This contention is rejected here as no amount of genetic diversity has protected any populations of these fish against the onslaught of human activity since European settlement of Australia and destruction of three unique genetic and biological entities for short term potential gain in the face of a far greater threat that is not being mediated is simply a waste of time and effort.

Preservation of unique species in the wild state should be a goal of wildlife conservation, as opposed to creating a planet full of mutant mutts still under threat and decline from unabated human population growth!

Distribution: *M. honlami sp. nov.* is restricted to the Shoalhaven River system on the south coast of New South Wales, Australia, where it is best known from the Kangaroo River system, which is a part of the greater Shoalhaven River system. However none have been seen in the wild for about 20 years (Huntsdale, 2019), since about 1998 (Pavolva *et al.* 2017a) and the species may therefore already be extinct.

Etymology: Named in honour of Hon Lam, originally from China, but more recently of north Ringwood, Victoria, Australia, owner of the Fish Café, Park Orchards, in recognition of his logistical services in feeding the team at Snakebusters: Australia's best reptiles at short notice on countless occasions after the dedicated crew had spent many hours educating others about wildlife and conservation in Australia's best reptiles shows, being the only ones in Australia that are hands-on and let people hold the animals.

REFERENCES CITED

Allen, G. R. 1989. *Freshwater Fishes of Australia*. T.F.H. Publications, Brookvale, NSW, Australia.

Anonymous, 2018. National Recovery Plan for the Macquarie Perch (*Macquaria australasica*). Australian Government, Department of Environment and Energy and New South Wales Government, Department of Primary Industries:85 pp. Online at: https://www.environment.gov.au/system/files/resources/bdee49ef-45da-4eb7-b548-bcfce460a21b/files/recovery-plan-macquarie-perch-2018.pdf

Appleford, P., Anderson, T. A. and Gooley, G. J. 1998. Reproductive cycle and gonadal development of Macquarie perch, *Macquaria australasica* Cuvier (Percichthyidae), in Lake Dartmouth and tributaries of the Murray-Darling Basin, Victoria, Australia. *Marine and Freshwater Research* 49:163-169.

Arthington, A. H. 1991. Ecological and genetic impacts of introduced and translocated freshwater fishes in Australia. pp. 33-43. in: Billington, N. and Herbert, P. D. N. (eds.) (1991). *International Symposium on the Ecological and Genetic Implications of Fish Introductions FIN* 8.

Arthington, A. and McKenzie, F. 1997. *Review of impacts of displaced/introduced fauna associated with inland waters, Australia*. State of the Environment Technical Paper Series (Inland Waters), Department of Environment, Canberra, Australia.

Arthur Rylah Institute (ARI) 2007. *An Assessment of the Status of Macquarie Perch,* Macquaria

australasica*, in Hughes Creek, Victoria 2006/2007*. Fish survey report prepared for the Goulburn Broken Catchment Management Authority. Arthur Rylah Institute for Environmental Research, Victorian Department of Sustainability and Environment, Heidelberg. Victoria, Australia.

Australian Capital Territory Government (ACT Gov) 1999. Macquarie Perch (*Macquaria australasica*): An endangered species, Action Plan No. 13. Environment ACT, Canberra, Australia.

Battaglene, S. 1988. *Macquarie Perch*. Agfact F3.2.5, New South Wales Agriculture and Fisheries.

Broadhurst, B. T., Ebner, B. C. and Clear, R. C. 2012. A rock-ramp fishway expands nursery grounds of the endangered Macquarie Perch (*Macquaria australasica*). *Australian Journal of Zoology* 60, 91-100.

Broadhurst, B. T., Ebner, B. C., Lintermans, M., Thiem, J. D. and Clear, R. C. 2013. Jailbreak: a fishway releases the endangered Macquarie perch from confinement below an anthropogenic barrier. *Marine and Freshwater Research* 64:900-908.

Brown, C. and Morgan, J. 2015. Predator recognition and responses in the endangered Macquarie perch (*Macquaria australasica*). *Marine and Freshwater Research* 66:127-134.

Bruce, A., Knight, J. and Creese, B. 2007. *Survey of aquatic threatened species Macquarie perch* (Macquaria australasica) *and Adam's emerald dragonfly* (Archaeophya adamsi) *within the Hawkesbury-Nepean catchment.* Interim report to the Hawkesbury-Nepean Catchment Management Authority by the NSW Department of Primary Industries, Port Stephens Fisheries Centre, NSW, Australia.

Cadwallader, P. L. 1978. Some causes of decline in range and abundance of native fishes in the Murray-Darling River system. *The Proceedings of the Royal Society of Victoria* 90:211-224.

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. 1981. Past and present distributions and translocations of Macquarie Perch *Macquaria australasica*, with particular reference to Victoria. *The Proceedings of the Royal Society of Victoria* 93:23-30.

Cadwallader, P. L. 1984. Use of scales and otoliths to age Macquarie perch, *Macquaria australasica* (Pisces: Percichthyidae). *Technical Report Series* No. 12, Snobs Creek Freshwater Fisheries Research Station and Hatchery, Arthur Rylah Institute for Environmental Research.

Cadwallader, P. L. and Backhouse, G. N. 1983. *A Guide to the Freshwater Fish of Victoria.* Victorian Government Printing Office, Melbourne.

Cadwallader, P. L. and Douglas, J. 1986. Changing food habits of Macquarie perch, *Macquaria australasica* Cuvier (Pisces: Percichthyidae), during the initial filling phase of Lake Dartmouth, Victoria. *Marine and Freshwater Research* 37(5):647-657.

Cadwallader, P. L. and Eden, A. K. 1979. Observations on the food of Macquarie Perch, *Macquaria australasica* (Pisces: Percichthyidae) in Victoria. *Australian Journal of Marine and Freshwater Research* 30:401-409.

Cadwallader, P. L. and Rogan, P. L. 1977. The Macquarie perch, *Macquaria australasica* (Pisces: Percichthyidae), of Lake Eildon, Victoria. *Australian Journal of Ecology* 2:409-418.

Copeland, C. 2019. Search For The Kangaroo River Perch, (2 December), online at:

https://ozfish.org.au/2019/12/search-for-the-kangaroo-river-perch/

Crowl, T. A., Townsend, C. R. and McIntosh, A. R. 1992. The impact of introduced brown and rainbow trout on native fish: the case of Australasia. *Reviews in Fish Biology and Fisheries* 2:217-241.

Cuvier, G. 1830. Des Maquaries, et de la Maquarie de la Nouvelle-Hollande. In: Cuvier, G. and Valenciennes, A. 1830. *Histoire naturelle des poissons*. Tome cinquième. Livre cinquième. Des Sciénoïdes:377-381.

Dufty, S. 1986. Genetic and morphological divergence between populations of Macquarie perch (*Macquaria australasica*) east and west of the Great Dividing Range. Honours Thesis, University of New South Wales.

Ebner, B., Broadhurst, B., Lintermans, M. and Jekabsons, M. 2007. A possible false negative: lack of evidence for trout predation on a remnant population of the endangered Macquarie perch, *Macquaria australasica*, in Cotter Reservoir, Australia. *New Zealand Journal of Marine and Freshwater Research* 41:231-237.

Ebner, B. and Lintermans, M. (eds.) 2007. *Fish passage, movement requirements and habitat use for Macquarie perch*. Final Report to the Department of Agriculture, Fisheries and Forestry Australia. Parks, Conservation and Lands, Canberra:139 pp.

Erskine, W. D. 2016. *River reaches, historical channel changes and recommended methods to improve Macquarie perch habitat on Hughes Creek, Victoria, May 2016*. Supervising Scientist Report 208, Supervising Scientist, Darwin, Northern Territory.

Faragher, R. A. and Harris, J. H. 1994. The historical and current status of freshwater fish in New South Wales. *Australian Zoologist* 29(3):166-176.

Farrington, L. W., Lintermans, M. and Ebner, B. C. 2014. Characterising genetic diversity and effective population size in one reservoir and two riverine populations of the threatened Macquarie perch. *Conservation Genetics* 15(3):707-716.

Faulks, L. K., Gilligan, D. M. and Beheregaray, L. B. 2010. Evolution and maintenance of divergent lineages in an endangered freshwater fish, *Macquaria australasica*. *Conservation Genetics* 11(3):921-934.

Faulks, L. K., Gilligan, D. M. and Beheregaray, L. B. 2011. The role of anthropogenic vs. natural instream structures in determining connectivity and genetic diversity in an endangered freshwater fish, Macquarie perch (*Macquaria australasica*). *Evolutionary Applications* 4:589-601.

Gehrke, P. C., Astles, K. L. and Harris, J. H. 1999. Within-catchment effects of flow alteration on fish assemblages in the Hawkesbury-Nepean River system, Australia. *Regulated Rivers: Research and Management* 15:181-198.

Gilligan, D. M. 2005. Fish Communities of the Murrumbidgee catchment: Status and trends. *Fisheries Final Report Series* 75. New South Wales Department of Primary Industries.

Gray, S. C., De Silva, S. S., Ingram, B. A. and Gooley, G. J. 2000. Effects of river impoundment on body condition and reproductive performance of the Australian native fish, Macquarie perch (*Macquaria australasica*). *Lakes and Reservoirs: Research and Management* 5:281-291.

Günther, A. 1859. *Catalogue of fishes in the British Museum. Volume First.* British Museum, London, 576 pp.

Hall, K. C., Broadhurst, M. K., Butcher, P. A. and Rowland, S. J. 2009a. Effects of angling on post-release mortality, gonadal development and somatic condition of Australian bass *Macquaria novemaculeata*. *Journal of Fish Biology* 75(10):2737-2755.

Hall, K. C., Butcher, P. A. and Broadhurst, M. K. 2009b. Short term mortality of Australian bass, *Macquaria novemaculeata*, after catch-and-release angling. *Fisheries Management and Ecology* 16(3):235-247.

Harris, J. H. and Rowland, S. J. 1996. Australian freshwater cods and basses. pp. 150-163 in: McDowall, R. (ed.) (1996). *Freshwater fishes of South-Eastern Australia*. Reed Books, Chatswood, NSW, Australia.

Ho, H. K. and Ingram, B. A. 2012. *Genetic risk assessment for stocking Macquarie perch into Victorian waterways 2011.* Fisheries Victoria Internal Report Series no.45, August 2012, Victorian Department of Primary Industries, Alexandra, Victoria.

Hoser, R. T. 1991. *Endangered Animals of Australia*. Pierson Publishing, Mosman, NSW, Australia:240 pp.

Hoser, R. T. 2019a. 11 new species, 4 new subspecies and a subgenus of Australian Dragon Lizard in the genus *Tympanocryptis* Peters, 1863, with a warning on the conservation status and long-term survival prospects of some newly named taxa. *Australasian J. of Herpetology* 39:23-52.

Hoser, R. T. 2019b. Richard Shine *et al.* (1987), Hinrich Kaiser *et al.* (2013), Jane Melville *et al.* (2018 and 2019): Australian Agamids and how rule breakers, liars, thieves, taxonomic vandals and law breaking copyright infringers are causing reptile species to become extinct. *Australasian J. of Herp.* 39:53-63.

Hunt, T. L., Douglas, J. W., Allen, M. S., Gwinn, D. C., Tonkin, Z., Lyon, J. and Pickworth, A. 2011. Evaluation of population decline and fishing sustainability of the endangered Australian freshwater fish *Macquaria australasica*. *Fisheries Management and Ecology* 18(6):513-520.

Huntsdale, J. 2019. Murky hunt for what could be Australia's first extinct native freshwater fish. ABC Illawarra, 7 December. Online at:

https://www.abc.net.au/news/2019-12-07/search-for-potentially-extinct-kangaroo-river-perch/11769692

Ingram, B. A. and De Silva, S. S. 2007. Diet composition and preference of juvenile Murray cod, trout cod and Macquarie perch (Percichthyidae) reared in fertilised earthen ponds. *Aquaculture* 271:260-270.

Ingram, B. A., Rimmer, M. A. and Rowland, S. J. 1994. Induced spawning trials with captive Macquarie perch, *Macquaria australasica* (Percichthyidae). *Proceedings of the Linnaean Society of New South Wales* 114:109-116.

Ingram, B. A., Douglas, J. W. and Lintermans, M. 2000. Threatened fishes of the world: *Macquaria australasica* Cuvier, 1830 (Percichthyidae). *Environmental Biology of Fishes* 59:68.

Jackson, P. D. 1981. Trout introduced into south-eastern Australia: their interaction with native fishes. *Vic. Nat.* 98:18-24.

Knight, J. and Bruce, A. 2010. Threatened Fish Profile: 'Eastern' Macquarie perch *Macquaria australasica* Cuvier, 1830. *Australian Society for Fish Biology Newsletter* 40(2):73-76.

Koehn, J. D. and O'Connor, W. G. 1990. Threats to Victorian native freshwater fish. *Victorian Naturalist* 107:5-12.

Koster, W. M., Dawson, D. R., Morrongiello, J. R. and Crook, D. A. 2014. Spawning season movements of Macquarie perch (*Macquaria australasica*) in the Yarra River, Victoria. *Australian Journal of Zoology* 61(5):386-394.

Lake, J. S. 1959. *The freshwater fishes of New South Wales*. New South Wales State Fisheries Bulletin No. 5.

Lake, J. S. 1971. *Freshwater fishes and rivers of Australia.* Thomas Nelson, Sydney, Australia:61 pp.

Lake, J. S. 1978. *Australian Freshwater Fishes: An illustrated field guide.* Thomas Nelson Australia Pty Ltd, West Melbourne, Australia.

Lintermans, M. 1991a. The decline of native fish in the Canberra region: the effects of habitat modification. *Bogong* 12(3):4-7.

Lintermans, M. 1991b. The decline of native fish in the Canberra region: the impacts of introduced species. *Bogong* 12(4):18-22.

Lintermans, M. 2002. *Fish in the Upper Murrumbidgee Catchment: A Review of Current Knowledge*. Environment ACT, Canberra, Australia:92 pp.

Lintermans, M. 2005. *Environmental Flows in the Cotter River, ACT, and the response of the threatened fish species* Macquaria australasica *and* Gadopsis bispinosus *in 2003 and 2004.* Consultancy report to ACTEW Corporation and ACTEWAGL. Environment ACT, Canberra, Australia:33 pp.

Lintermans, M. 2006a. Threatened fish in mountain streams: out of sight, out of mind. pp. 41-54. in *Proceedings of the May 2006 National Parks Association: Caring for Namadgi – Science and People*. National Parks Association of the ACT, Canberra, Australia.

Lintermans, M. 2006b. *The re-establishment of the endangered Macquarie perch* Macquaria australasica *in the Queanbeyan River, New South Wales, with an examination of dietary overlap with alien trout.* Technical report, CRC for Freshwater Ecology, Canberra, Australia:34pp.

Lintermans, M. 2007. *Fishes of the Murray-Darling Basin: An introductory guide*. Murray-Darling Basin Commission Publication No. 10/07.

Lintermans, M. 2008. *The Status of Macquarie Perch* Macquaria australasica *in the Mongarlowe River in 2007 and 2008.* Consultants report to the Friends of the Mongarlowe River Inc.:30 pp.

Lintermans, M. 2012. Managing potential impacts of reservoir enlargement on threatened *Macquaria australasica* and *Gadopsis bispinosus* in southeastern Australia. *Endangered Species Research* 16:1-16.

Lintermans, M. 2013a. The rise and fall of a translocated population of the endangered Macquarie perch, *Macquaria australasica*, in south-eastern Australia. *Marine and Freshwater Research* 64:838-850.

Lintermans, M. (ed.) 2013b. *Using translocation to establish new populations of Macquarie perch, trout cod and two-spined blackfish in the Canberra region*. Final report to ACTEW Water. Institute for Applied Ecology, University of Canberra, Canberra.

Lintermans, M. and Ebner, B. 2010. Threatened Fish Profile: 'Western' Macquarie perch *Macquaria australasica* Cuvier 1830. *Australian Society for Fish Biology Newsletter* 40(2):76-78.

Lintermans, M., Lyon, J. P., Hames, F., Hammer, M. P., Kearns, J., Raadik, T. A. and Hall, A. 2014. Managing fish species under threat: case studies from the Native Fish Strategy for the Murray-Darling Basin, Australia. *Ecological Management and Restoration* 15:57-61.

Lugg, A. and Copeland, C. 2014. Review of cold water pollution in the Murray Darling Basin and impacts upon fish communities. *Ecological Management and Restoration* 15:71-79.

MacDonald, A. J., Young, M. J., Lintermans, M. and Sarre, S. D. 2014. Primers for detection of Macquarie perch from environmental and trace DNA samples. *Conservation Genetics Resources* 6:551-553.

McKeown, K. C. 1934. Notes on the food of trout and Macquarie perch in Australia. *Rec. of the Aust. Museum* 19(2):141-152.

Nock, C. J., Elphinstone, M. S., Rowland, S. J. and Baverstock, P. R. 2010. Phylogenetics and revised taxonomy of the Australian freshwater cod genus, *Maccullochella* (Percichthyidae). *Marine and Freshwater Research*. 61:980-991.

Pavlova, A., Beheregaray, L. B., Coleman, R., Gilligan, D., Harrisson, K. A., Ingram, B. A., Kearns, J., Lamb, A. M., Lintermans, M., Lyon, J., Nguyen, T. T. T., Sasaki, M., Tonkin, Z., Yen, J. D. L. and Sunnucks, P. 2017a. Severe consequences of habitat fragmentation on genetic diversity of an endangered Australian freshwater fish: a call for assisted gene flow. *Evolutionary Applications* 10: 531-550.

Pavlova, A., Gan, H. M., Lee, Y. P., Austin, C. M., Gilligan, D. M., Lintermans, M. and Sunnucks, P. 2017b. Purifying selection and genetic drift shaped Pleistocene evolution of the mitochondrial genome in an endangered Australian freshwater fish. *Heredity* 118:466 -476.

Pearce, L., Gilligan, D., McLellan, M., Asmus, M. and Daly, T. 2017. A retreat for Maccas: Recreational angler-driven Macquarie perch recovery. *Proceedings of the Murray-Darling Basin Native Fish Forum* 2017:39-42.

Ride, W. D. L. (*ed.*) *et al.* (on behalf of the International Commission on Zoological Nomenclature) 1999. *International code of Zoological Nomenclature*. The Natural History Museum - Cromwell Road, London SW7 5BD, UK.

Starrs, D., Ebner, B. C., Lintermans, M. and Fulton, C. J. 2011. Using sprint swimming performance to predict upstream passage of the endangered Macquarie perch in a highly regulated river. *Fisheries and Management Ecology* 18:360-374.

Stead, D. G. 1913. An account of some experiments on the acclimatisation of two species of Australian freshwater perch. *Report of the Australasian Association for the Advancement of Science* 14:279-288.

Todd, C. R. and Lintermans, M. 2015. Who do you move: a stochastic population model to guide translocation strategies for an endangered freshwater fish in southeastern Australia. *Ecological Modelling* 311:63-72.

Tonkin, Z. D., Humphries, P. and Pridmore, P. A. 2006. Ontogeny of feeding in two native and one alien fish species from the Murray-Darling Basin, Australia. *Environmental Biology of Fishes* 76:303-315.

Tonkin, Z., Lyon, J. and Pickworth, A. 2010. Spawning behaviour of the endangered Macquarie perch *Macquaria australasica* in an upland Australian river. Ecological Management and Restoration 11(3):223-226.

Tonkin, Z., Kearns, J., O'Mahony, J. and Mahoney, J. 2016. Spatio-temporal spawning patterns of two riverine populations of the threatened Macquarie perch (*Macquaria australasica*). *Marine and Freshwater Research* 67:1762-1770.

Tonkin, Z., Kearns, J., Lyon, J., Balcombe, S. R., King, A. J. and Bond, N. R. 2017. Regional scale extremes in river discharge and localised spawning stock abundance influence recruitment dynamics of a threatened freshwater fish. *Ecohydrology* 2017, e1842.

Trueman, W. T. 2007. *A review of attempts at the artificial propagation of the Macquarie perch*

Macquaria australasica *with recommendations for future action.* Native Fish Australia Technical Report 2. Native Fish Australia (Victoria), Doncaster, Victoria, Australia.

Wharton, J. C. F. 1968. Spawning areas of Macquarie perch *Macquaria australasica* above the Eildon Lake (Victoria). *Australian Society for Limnology Newsletter* 6(1):11-13.

Wharton, J. C. F. 1973. Spawning, induction, artificial fertilization and pond culture of the Macquarie perch (*Macquaria australasica* [Cuvier, 1830]). *Australian Society of Limnology Bulletin* 5:43-65.

Zaczek, Z. 2019. Former PM Kevin Rudd says Australia should drastically increase its population to 50 MILLION to make sure nation can defend itself in the face of threats from China. *Daily Mail* (Australia) (27 November), published online at: https://www.dailymail.co.uk/news/article-7729689/Kevin-Rudd-says-Australia-increase-population-50-MILLION-defend-China.html