

Big trouble for little fish: Identifying Australian freshwater fishes at imminent risk of extinction

In brief

In Australia, many freshwater fish species have declined sharply since the 1950s. Preventing extinctions will require identifying the species most at risk.

We used structured expert elicitation and other available published and unpublished data to identify the freshwater fishes at greatest risk of extinction, and to estimate the likelihood of extinction within ~20 years if there is no change to current management.

We identified 22 species at high risk of extinction (from ~315 species known to occur in Australia), 20 of which had at least a 50% probability of becoming extinct within ~20 years under current management. Twelve of the species identified have only been formally

described in the past decade, and seven are awaiting description.

Twenty-one of the species identified are small-bodied, with the majority occurring in southern Australia, a region where introduced predatory trout species have taken a heavy toll, especially on native galaxiids.

Although the majority of these species were once far more widespread, all 22 fishes now have small distributions with areas of occupancy ranging between 4 – 44 km²; this greatly increases the risk that single catastrophic events, such as a large bushfire, could cause species extinctions. Climate change is another threat to all of the identified species.

Only three of the species identified are currently listed nationally as threatened under Australian legislation

(*The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)). Listing of the other 19 species would provide essential protection and recognition for the remaining individuals of these species and their critical habitat.

The fate of all 22 species will depend upon individual targeted action, investment and collaboration among governments and non-government organisations to mitigate threats and support recovery.

The assessments were undertaken prior to the 2019–20 Black Summer bushfires, which impacted many of the species that were identified as highly imperilled in our assessment. Some species may now be on the brink of imminent extinction.



The main threat to the Daintree rainbowfish is loss of stream flow due to drought, climate change and water extraction. Image: M. Hammer, MAGNT

The stocky galaxias is one of 14 species of galaxias identified as at high risk of extinction. Predation by introduced trout is a major threat to these small-bodied native species.
Image: Tarmo Raadik



Background

The Australian Government has committed to averting extinctions, and this first requires identification of the species at most immediate risk. This can forewarn governments, conservation managers and the community so that they can implement emergency care and recovery actions to prevent extinctions before it is too late.

Freshwater fishes (and their habitats) are declining at alarming rates in many parts of the world, including in Australia, where the populations of many species have fallen sharply since the 1950s. The declines have been attributed to habitat loss, introduced species, alteration to natural flow regimes, habitat fragmentation, water pollution and overexploitation.

Despite evidence of catastrophic declines, freshwater fishes have typically been neglected in conservation planning. Compared to other vertebrate groups, there are currently few species listed under national environmental legislation (EPBC Act). Application of IUCN criteria by the Australian Society for Fish Biology (ASFB) indicates that many more freshwater fish species qualify for statutory listing. Without listing, at-risk species are not afforded basic protection.

Further, recent taxonomic work has shown that there are many undescribed species that are likely to meet criteria for listing as threatened, and in many cases in higher categories, e.g., Critically Endangered. Only one fish species, the Pedder galaxias, is officially recorded as extinct in the wild in Australia (with another now considered extinct before it was described), although we have almost certainly lost other species before we even knew about their existence.

Research aims

For Australian freshwater fishes we aimed to:

1. Identify the species at most immediate risk of extinction;
2. Estimate the probability of extinction (in the wild) in the next ~20 years for each of the species identified;
3. Identify key threats to these species and our progress towards lessening their impacts; and

4. Identify what policy, resourcing, management and prioritisation are required to prevent extinctions.

The findings of this research will be of greatest importance to policy-makers in state and federal government agencies and funding bodies, as well as conservation land managers and researchers looking to prioritise and apply research and management actions for threatened freshwater fishes.

What we did

Our assessment of extinction risk of Australian freshwater fishes used available published and unpublished evidence, and was undertaken using a structured expert elicitation approach.

An initial list of 90 freshwater fishes at high risk of extinction within ~20 years was produced by the ASFB Threatened Fishes Committee based on expert review by committee members and external experts. Further assessment reduced this to a shortlist of 37 species. Included in this assessment were: 1) species that were assessed by the ASFB as meeting IUCN criteria for listing in a threatened category (Critically Endangered, Endangered or Vulnerable); and 2) additional species that have only recently been recognised and currently undescribed, but likely to meet threatened criteria. A final list of 22 species were considered to be at risk of extinction within ~20 years. For each of these species, the ASFB identified the major threats; historical, recent and predicted population trajectories; initial estimates of extinction risk; biology; habitat requirements; population parameters; and geographic range.

Our research team included 15 researchers and freshwater fish biologists from 10 Australian universities, state-based research institutions (such as the Arthur Rylah Institute), and Bush Heritage Australia. Each of these experts participated in

a workshop in early 2018, where we used structured expert elicitation to estimate the extinction probabilities for the final list of 22 species considered to be at high risk of extinction. We performed statistical modelling of the expert estimates to predict the probability of extinction for each species, finding that there was a high level of agreement among the experts in their assessments of extinction risk for most species. We also assessed the timing (continuing, near future, distant future), extent (proportion of the range likely to be impacted) and severity (the proportion of the population likely to be impacted) of threats, assessed the level of current understanding on how to manage each threat, and the effectiveness of current management actions.

This waterfall in New South Wales is all that protects the upstream population of stocky galaxias from the invasive trout below.
Image: Mark Lintermans



The little pygmy perch in the far south-west corner of Western Australia is one of only three of the imperilled species that is formally protected under the EPBC Act. Image: Stephen Beatty, Harry Butler Institute, Murdoch University



Table 1. The 22 Australian freshwater fish species at greatest risk of extinction; their likelihood of extinction within ~20 years; if they have been formally described; and their conservation listings under the EPBC Act (as at August 2019) and the Australian Society for Fish Biology (as assessed using IUCN criteria).

Species	Region	Area of occupation (km ²)	Likelihood of extinction (%)	Year described	EPBC Status	ASFB Status
Shaw galaxias <i>Galaxias gunaikurnai</i>	Vic	4	≥70	2014	Not Listed	Critically Endangered
West Gippsland galaxias <i>Galaxias longifundus</i>	Vic	12–16	≥70	2014	Not Listed	Critically Endangered
Tapered galaxias <i>Galaxias lanceolatus</i>	Vic	16	≥70	2014	Not Listed	Critically Endangered
Dargo galaxias <i>Galaxias mungadhan</i>	Vic	16	≥70	2016	Not Listed	Critically Endangered
Morwell galaxias <i>Galaxias sp.</i>	Vic	20	≥70	Undescribed	Not Listed	Not Assessed
McDowall's galaxias <i>Galaxias mcdowalli</i>	Vic	8–28	≥70	2014	Not Listed	Critically Endangered
Malanda rainbowfish <i>Melanotaenia sp.</i>	Qld	28	≥70	Undescribed	Not Listed	Critically Endangered
Stocky galaxias <i>Galaxias tantangara</i>	NSW	4	50–69	2014	Not Listed	Critically Endangered
Red-fin blue-eye <i>Scaturiginichthys vermeilipinnis</i>	Qld	4	50–69	1991	Endangered	Critically Endangered
Kosciuszko galaxias <i>Galaxias supremus</i>	NSW	8	50–69	2014	Not Listed	Critically Endangered
Yalmy galaxias <i>Galaxias sp.</i>	Vic	36	50–69	Undescribed	Not Listed	Not Assessed
East Gippsland galaxias <i>Galaxias aequipinnis</i>	Vic	12	50–69	2014	Not Listed	Critically Endangered
Hunter galaxias <i>Galaxias sp.</i>	NSW	44	50–69	Undescribed	Not Listed	Not Assessed
Moroka galaxias <i>Galaxias sp.</i>	Vic	4	50–69	Undescribed	Not Listed	Not Assessed
Barrow cave gudgeon <i>Milyeringa justitia</i>	WA	8	50–69	2013	Not Listed	Not Assessed
Swan galaxias <i>Galaxias fontanus</i>	Tas	15	50–69	1978	Endangered	Critically Endangered
Short-tail galaxias <i>Galaxias brevissimus</i>	NSW	16	50–69	2014	Not Listed	Critically Endangered
Running River rainbowfish <i>Melanotaenia sp.</i>	Qld	16	50–69	Undescribed	Not Listed	Critically Endangered
SW Victoria river blackfish <i>Gadopsis sp.</i>	Vic	28	50–69	Undescribed	Not Listed	Not Assessed
Daintree rainbowfish <i>Cairnsichthys bitaeniatus</i>	Qld	12	50–69	2018	Not Listed	Not Assessed
Little pygmy perch <i>Nannoperca pygmaea</i>	WA	40	40–49	2013	Endangered	Critically Endangered
Bloomfield River cod <i>Guyu wujalwujalensis</i>	Qld	12	40–49	2001	Not Listed	Vulnerable

Key findings

The research identified 20 Australian freshwater fishes that have at least a 50% probability of becoming extinct within the next ~20 years if there is no change in current management (see Table 1). A further two species had a 40–49% likelihood. The Shaw galaxias (*Galaxias gunaikurnai*) and the West Gippsland galaxias (*G. longifundus*), both from Victoria, had the highest estimated extinction risks, each with a likelihood greater than 70%.

The results suggest that the total number of future extinctions may be significantly higher than historic extinction rates of Australian freshwater fishes.

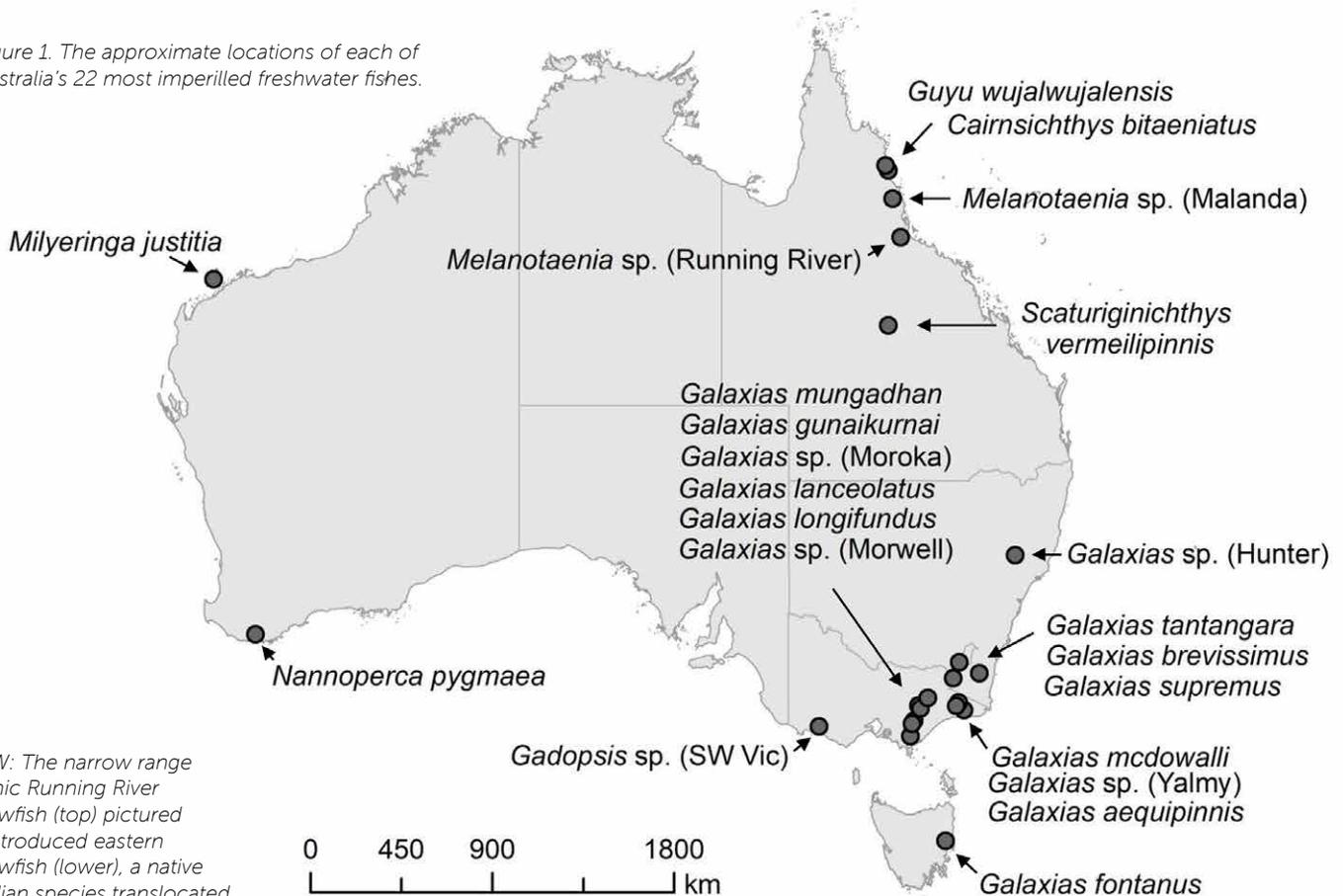
The 22 species are widely scattered across Australia, although the majority are located in southern Australia (see Figure 1).

Nineteen of the 22 species we considered are not listed as threatened under national legislation, so legislative

drivers for protection and recovery actions are largely absent. Seven are not yet formally described.

Fourteen of the fish are galaxiids (Galaxiidae), three are rainbowfishes (Melanotaeniidae), and three are temperate basses (Percichthidae). All but one, (the southwest Victoria river blackfish, body length of approximately 150–240mm) are small-bodied, with an adult total length of less than approximately 150mm.

Figure 1. The approximate locations of each of Australia's 22 most imperilled freshwater fishes.



BELOW: The narrow range endemic Running River rainbowfish (top) pictured with introduced eastern rainbowfish (lower), a native Australian species translocated outside its natural range. Image: M. Hammer, MAGNT



The SW Victoria River blackfish is a recently identified, undescribed new species. It persists as three very small, isolated populations. The main threat to this species is recreational angling. Image: Tarmo Raadik



The Malanda rainbowfish is at risk from hybridisation with the larger and more common eastern rainbowfish.
Image: Michael Hammer, MAGNT



The threats facing the most imperilled freshwater fishes are presented in Table 2.

More than half of the species on the list are galaxiids. Galaxiids have been severely impacted by trout, predatory species which were introduced for recreational fishing (which continue to be stocked). Many galaxiids do not thrive or readily breed in captivity, so their persistence relies on the availability of perennial trout-free streams.

There has been some progress towards managing the threat of trout, but our assessment indicates that the status quo management of trout will result in extinctions of native galaxiids. Installing trout barriers where possible, and performing

carefully considered translocations of galaxiids to establish new populations are key to ensuring their long-term survival. However, urgent sustained effort is needed to improve trout management, including collaborations with recreational anglers, increased awareness, and changing values among government and key sectors of society. Other threats to galaxiids include inappropriate fire regimes and other climate-related threats.

Each of the fishes identified are extremely range-restricted, occupying areas ranging between 4 and 44km² each. With the exception of the Barrow cave gudgeon, Running River rainbowfish and Bloomfield River cod (which appear naturally range restricted), these small distributions

are the result of severe range contractions due to threats such as introduced species (including native species moved outside of their natural range).

While other threats have pushed these species to their currently perilous states, the biggest factor that is now contributing to their likelihood of extinction is having small geographically isolated populations, which makes remaining populations highly vulnerable to further threats. For example, ash flows following a large fire, trout reaching a section of stream during high flows, or headwater streams drying out during a drought could result in the total extinction of a species.

Table 2. The threats facing the most imperilled Australian freshwater fishes, the number of species affected by each threat, and the threat impact score (a measure of the overall impact (considering timing, extent and severity) of a threat across all species relative to other threats).

Rank	Threat	No. of species affected	Threat impact score
1	Small, single or few isolated populations (increased vulnerability to other threats)	21	100
2	Increase in drought frequency, intensity (reduced water quality and availability of suitable habitat)	19	79
3	Increase in storm, flooding frequency, intensity (erosion impacts)	18	81
4	Increase in fire frequency, intensity (post-fire debris flow/toxic retardants)	17	76
5	Trout predation	15	71
6	Soil erosion, sedimentation (habitat and water quality deterioration)	12	58
7	Feral pig (habitat degradation)	3	3
8	Eastern gambusia (competition/predation)	3	14
9	Tilapia (competition/predation)	3	13
10	Native eastern rainbowfish (displacement/hybridisation)	2	10
11	Translocated native sooty grunter (competition/predation)	2	9
12	Temperature extremes	2	7
13	Secondary salinisation (water quality)	1	4
14	Deliberate disposal of industrial effluents (water quality)	1	1

These predictions for extinction risk were generally higher than those for Australian birds and mammals using the same methods. Most of the fishes we considered have far smaller distributions, and have received far less management investment and conservation effort than the birds and mammals assessed to be at high risk of imminent extinction.

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Shaw galaxias

The Shaw galaxias (*Galaxias gunaikurnai*) is the Australian fish at greatest risk of extinction, with a greater than 70% likelihood of extinction within ~20 years without additional conservation action.

Surveys have estimated that there are only 80 mature individuals remaining in an area of only 4km². The species has been lost from most of its former range due to predation by introduced trout species; it currently persists as a single population upstream of a waterfall with trout below. Artificial barriers restrict movement of trout into the stream, but the risk of reinvasion is high – mechanisms for potential invasion include illegal transportation by anglers and drown-out of trout barriers during high flows. Other threats include drought (leading to loss of water in majority of the catchment, reducing habitat and water quality), floods (mobilising large quantities of in-channel sediment) and fire (post-fire debris flow during high intensity rainfall) and fire suppression impacts (toxic retardants).

Victoria's Shaw galaxias is one of 14 species of galaxias identified as at high risk of extinction. Predation by introduced trout is a major threat to these small-bodied native species. Photo: Tarmo Raadik



Implications and recommendations

Our assessments of extinction probability preceded the 2019–20 wildfires, which are likely to have severely worsened the conservation outlook for many of the species considered in our study, but also many others that were not included. In the case of one of the species we considered, the undescribed "Yalmy" galaxias, an extensive post-fire assessment has confirmed one male and one female to be alive in separate locations. While there is an intention to reunite them as soon as possible, the species is now on the brink of extinction.

We predict that most of the Australian freshwater fishes considered have a high probability (50% or greater) of becoming extinct in the next two decades. Only immediate, individual targeted action, investment and collaboration to mitigate threats and to support recovery of each of these species will prevent this from happening.

Specific recommendations include:

1. Threat mitigation and recovery actions for many species should commence before they are

formally listed as threatened under the EPBC Act, and even before they are formally described.

2. The highly imperilled but currently unlisted taxa should be formally listed as threatened under relevant state and federal legislation in order to afford protection to remaining individuals and their critical habitat.
3. There is an urgent need to develop a national freshwater fish action plan to coordinate recovery efforts. Further, any update to the Threatened Species Strategy should include freshwater fishes. If the strategy is not updated, the need for an action plan becomes even more important.
4. Completion of the national Freshwater Pest Fish Strategy and adoption as a Threat Abatement Plan will be a crucial and effective step in managing this major threat to Australian freshwater fishes.
5. Climate change was another major threat affecting all 22 species. A national framework and funding to address climate-related threats is also urgently required.

More information

Lintermans, M., Geyle, H.M., Beatty, S., Brown, C., Ebner, B., Freeman, R., Hammer, M.P., Humphreys, W.F., Kennard, M.J., Kern, P., Martin, K., Morgan, D., Raadik, T.A., Unmack, P.J., Wager, R., Woinarski, J.C.Z., and Garnett, S.T. (2020). Big trouble for little fish: Identifying Australian freshwater fishes in imminent risk of extinction. *Pacific Conservation Biology*. <https://doi.org/10.1071/PC19053>

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