



## Consultation on Species Listing Eligibility and Conservation Actions

### *Galaxias gunaikurnai* (Shaw galaxias)

You are invited to provide your views and supporting reasons related to:

- 1) the eligibility of *Galaxias gunaikurnai* (Shaw galaxias) for inclusion on the EPBC Act threatened species list in the Critically Endangered category; and
- 2) the necessary conservation actions for the above species.

The purpose of this consultation document is to elicit additional information to better understand the status of the species and help inform on conservation actions and further planning. As such, the below draft assessment should be considered to be **tentative** as it may change following responses to this consultation process.

Evidence provided by experts, stakeholders and the general public are welcome. Responses can be provided by any interested person.

Anyone may nominate a native species, ecological community or threatening process for listing under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or for a transfer of an item already on the list to a new listing category. The Threatened Species Scientific Committee (the Committee) undertakes the assessment of species to determine eligibility for inclusion in the list of threatened species and provides its recommendation to the Australian Government Minister for the Environment.

Responses are to be provided in writing by email to:  
[species.consultation@environment.gov.au](mailto:species.consultation@environment.gov.au)

Please include species scientific name in Subject field.

or by mail to:

The Director  
Bushfire Affected Species Assessments Section  
Department of Agriculture, Water and the Environment  
John Gorton Building, King Edward Terrace  
GPO Box 858  
Canberra ACT 2601

**Responses are required to be submitted by 04 April 2022.**

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## General background information about listing threatened species

The Australian Government helps protect species at risk of extinction by listing them as threatened under Part 13 of the EPBC Act. Once listed under the EPBC Act, the species becomes a Matter of National Environmental Significance (MNES) and must be protected from significant impacts through the assessment and approval provisions of the EPBC Act. More information about threatened species is available on the department's website at: <https://www.awe.gov.au/environment/biodiversity/threatened>.

Public nominations to list threatened species under the EPBC Act are received annually by the department. In order to determine if a species is eligible for listing as threatened under the EPBC Act, the Threatened Species Scientific Committee (the Committee) undertakes a rigorous scientific assessment of its status to determine if the species is eligible for listing against a set of criteria. These criteria are available on the Department's website at: <http://www.awe.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2021.pdf>.

As part of the assessment process, the Committee consults with the public and stakeholders to obtain specific details about the species, as well as advice on what conservation actions might be appropriate. Information provided through the consultation process is considered by the Committee in its assessment. The Committee provides its advice on the assessment (together with comments received) to the Minister regarding the eligibility of the species for listing under a particular category and what conservation actions might be appropriate. The Minister decides to add, or not to add, the species to the list of threatened species under the EPBC Act. More detailed information about the listing process is at: <https://www.awe.gov.au/environment/biodiversity/threatened/nominations>.

To promote the recovery of listed threatened species and ecological communities, conservation advices and where required, recovery plans are made or adopted in accordance with Part 13 of the EPBC Act. Conservation advices provide guidance at the time of listing on known threats and priority recovery actions that can be undertaken at a local and regional level. Recovery plans describe key threats and identify specific recovery actions that can be undertaken to enable recovery activities to occur within a planned and logical national framework. Information about recovery plans is available on the department's website at: <https://www.awe.gov.au/environment/biodiversity/threatened/recovery-plans>.

## Privacy notice

The Department will collect, use, store and disclose the personal information you provide in a manner consistent with the Department's obligations under the Privacy Act 1988 (Cth) and the Department's Privacy Policy.

Any personal information that you provide within, or in addition to, your comments in the threatened species assessment process may be used by the Department for the purposes of its functions relating to threatened species assessments, including contacting you if we have any questions about your comments in the future.

Further, the Commonwealth, State and Territory governments have agreed to share threatened species assessment documentation (including comments) to ensure that all States and Territories have access to the same documentation when making a decision on the status of a potentially threatened species. This is also known as the '[Common Assessment Method](#)' (CAM). As a result, any personal information that you have provided in connection with your comments may be shared between Commonwealth, State or Territory government entities to assist with their assessment processes.

The Department's Privacy Policy contains details about how respondents may access and make corrections to personal information that the Department holds about the respondent, how respondents may make a complaint about a breach of an Australian Privacy Principle, and how the Department will deal with that complaint. A copy of the Department's Privacy Policy is available at: <https://www.awe.gov.au/about/commitment/privacy> .

### **Information about this consultation process**

Responses to this consultation can be provided electronically or in hard copy to the contact addresses provided on Page 1. All responses received will be provided in full to the Committee and then to the Australian Government Minister for the Environment.

In providing comments, please provide references to published data where possible. Should the Committee use the information you provide in formulating its advice, the information will be attributed to you and referenced as a 'personal communication' unless you provide references or otherwise attribute this information (please specify if your organisation requires that this information is attributed to your organisation instead of yourself). The final advice by the Committee will be published on the department's website following the listing decision by the Minister.

Information provided through consultation may be subject to freedom of information legislation and court processes. It is also important to note that under the EPBC Act, the deliberations and recommendations of the Committee are confidential until the Minister has made a final decision on the nomination, unless otherwise determined by the Minister.

**Consultation questions for Galaxias gunaikurnai (Shaw galaxias)**

**SECTION A - GENERAL**

1. Is the information used to assess the nationally threatened status of the species robust? Have all the underlying assumptions been made explicit? Please provide justification for your response.
2. Can you provide additional data or information relevant to this assessment?
3. Have you been involved in previous state, territory or national assessments of this species? If so, in what capacity?

**PART 1 – INFORMATION TO ASSIST LISTING ASSESSMENT**

**SECTION B DO YOU HAVE ADDITIONAL INFORMATION ON THE ECOLOGY OR BIOLOGY OF THE SPECIES? (If no, skip to section C)**

**Biological information**

4. Can you provide any additional or alternative references, information or estimates on longevity, average life span and generation length?
5. Do you have any additional information on the ecology or biology of the species/subspecies not in the current advice?

**SECTION C ARE YOU AWARE OF THE STATUS OF THE TOTAL NATIONAL POPULATION OF THE SPECIES? (If no, skip to section D)**

**Population size**

6. Has the survey effort for this taxon been adequate to determine its national adult population size? If not, please provide justification for your response.
7. Do you consider the way the population size has been derived to be appropriate? Are there any assumptions and unquantified biases in the estimates? Did the estimates measure relative or absolute abundance? Do you accept the estimate of the total population size of the species? If not, please provide justification for your response.
8. If not, can you provide a further estimate of the current population size of mature adults of the species (national extent)? Please provide supporting justification or other information.

If, because of uncertainty, you are unable to provide a single number, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of possible species numbers, and also choose the level of confidence you have in this estimate:

Number of mature individuals is estimated to be in the range of:

☐ <250 ☐ 250 – 1,000 ☐ 1,000 – 5,000 ☐ 5,000 – 10,000 ☐ >10,000

Level of your confidence in this estimate:

- ☐ 0–30% - low level of certainty/a bit of a guess/not much information to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, information suggests this range
- ☐ 95–100% - high level of certainty, information indicates quantity within this range
- ☐ 99–100% - very high level of certainty, data are accurate within this range

**SECTION D ARE YOU AWARE OF TRENDS IN THE OVERALL POPULATION OF THE SPECIES? (If no, skip to section E)**

9. Does the current and predicted rate of decline used in the assessment seem reasonable? Do you consider that the way this estimate has been derived is appropriate? If not, please provide justification of your response.

**Evidence of total population size change**

10. Are you able to provide an estimate of the total population size during the early 2010s (*at or soon after the start of the most recent three generation*)? Please provide justification for your response.

If, because of uncertainty, you are unable to provide a single number, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of possible species numbers, and also choose the level of confidence you have in this estimate.

Number of mature individuals is estimated to be in the range of:

- ☐ <250 ☐ 250 – 1,000 ☐ 1,000 – 5,000 ☐ 5,000 – 10,000 ☐ >10,000

Level of your confidence in this estimate:

- ☐ 0–30% - low level of certainty/a bit of a guess/not much information to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, information suggests this range
- ☐ 95–100% - high level of certainty, information indicates quantity within this range
- ☐ 99–100% - very high level of certainty, data are accurate within this range

11. Are you able to comment on the extent of decline in the species' total population size over the last approximately 9 to 12 years (i.e. three generations)? Please provide justification for your response.

If, because of uncertainty, you are unable to provide an estimate of decline, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of decline, and also choose the level of confidence you have in this estimated range.

Decline estimated to be in the range of:

☐ 1–30% ☐ 31–50% ☐ 51–80% ☐ 81–100% ☐ 90–100%

Level of your confidence in this estimated decline:

- ☐ 0–30% - low level of certainty/ a bit of a guess/ not much information to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, suggests this range of decline
- ☐ 95–100% - high level of certainty, information indicates a decline within this range
- ☐ 99–100% - very high level of certainty, data are accurate within this range

12. Please provide (if known) any additional evidence which shows the population is stable, increasing or declining.

**SECTION E ARE YOU AWARE OF INFORMATION ON THE TOTAL RANGE OF THE SPECIES? (If no, skip to section F)**

**Current Distribution/range/extent of occurrence, area of occupancy**

13. Does the assessment consider the entire geographic extent and national extent of the species? If not, please provide justification for your response.
14. Has the survey effort for this species been adequate to determine its national distribution? If not, please provide justification for your response.
15. Is the distribution described in the assessment accurate? If not, please provide justification for your response and provide alternate information.
16. Do you agree that the way the current extent of occurrence and/or area of occupancy have been estimated is appropriate? Please provide justification for your response.
17. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the extent of occurrence and/or area of occupancy?

If, because of uncertainty, you are unable to provide an estimate of extent of occurrence, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of extent of occurrence, and also choose the level of confidence you have in this estimated range.

**Current extent of occurrence** is estimated to be in the range of:

☐ <100 km<sup>2</sup> ☐ 100 – 200 km<sup>2</sup> ☐ 200 – 500 km<sup>2</sup> ☐ >500 km<sup>2</sup>

Level of your confidence in this estimated extent of occurrence

- ☐ 0–30% - low level of certainty/ a bit of a guess/ not much data to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, data suggests this range of decline
- ☐ 95–100% - high level of certainty, data indicates a decline within this range
- ☐ 99–100% - very high level of certainty, data is accurate within this range

If, because of uncertainty, you are unable to provide an estimate of area of occupancy, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of area of occupancy, and also choose the level of confidence you have in this estimated range.

**Current area of occupancy** is estimated to be in the range of:

- ☐ <10 km<sup>2</sup> ☐ 10 – 100 km<sup>2</sup> ☐ 100 – 500 km<sup>2</sup> ☐ >500 km<sup>2</sup>

Level of your confidence in this estimated extent of occurrence:

- ☐ 0–30% - low level of certainty/ a bit of a guess/ not much data to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, data suggests this range of decline
- ☐ 95–100% - high level of certainty, data indicates a decline within this range
- ☐ 99–100% - very high level of certainty, data is accurate within this range

**SECTION F ARE YOU AWARE OF TRENDS IN THE TOTAL RANGE OF THE SPECIES? (If no, skip to section G)**

**Past Distribution/range/extent of occurrence, area of occupancy**

18. Do you consider that the way the historic distribution has been estimated is appropriate? Please provide justification for your response.
19. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the former extent of occurrence and/or area of occupancy?

If, because of uncertainty, you are unable to provide an estimate of past extent of occurrence, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of past extent of occurrence, and also choose the level of confidence you have in this estimated range.

**Past extent of occurrence** is estimated to be in the range of:

- ☐ <100 km<sup>2</sup> ☐ 100 – 200 km<sup>2</sup> ☐ 200 – 500 km<sup>2</sup> ☐ >500 km<sup>2</sup>

Level of your confidence in this estimated extent of occurrence

- ☐ 0–30% - low level of certainty/ a bit of a guess/ not much data to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, data suggests this range of decline
- ☐ 95–100% - high level of certainty, data indicates a decline within this range
- ☐ 99–100% - very high level of certainty, data is accurate within this range

If, because of uncertainty, you are unable to provide an estimate of past area of occupancy, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of past area of occupancy, and also choose the level of confidence you have in this estimated range:

**Past area of occupancy** is estimated to be in the range of:

- ☐ <10 km<sup>2</sup> ☐ 10 – 100 km<sup>2</sup> ☐ 100 – 500 km<sup>2</sup> ☐ >500 km<sup>2</sup>

Level of your confidence in this estimated extent of occurrence:

- ☐ 0–30% - low level of certainty/ a bit of a guess/ not much data to go on
- ☐ 31–50% - more than a guess, some level of supporting evidence
- ☐ 51–95% - reasonably certain, data suggests this range of decline
- ☐ 95–100% - high level of certainty, data indicates a decline within this range
- ☐ 99–100% - very high level of certainty, data is accurate within this range

## **PART 2 – INFORMATION FOR CONSERVATION ADVICE ON THREATS AND CONSERVATION ACTIONS**

### **SECTION G DO YOU HAVE INFORMATION ON THREATS TO THE SURVIVAL OF THE SPECIES? (If no, skip to section H)**

20. Do you consider that all major threats have been identified and described adequately?
21. To what degree are the identified threats likely to impact on the species in the future?
22. Are the threats impacting on different populations equally, or do the threats vary across different populations?
23. Can you provide additional or alternative information on past, current or potential threats that may adversely affect the species at any stage of its life cycle?
24. Can you provide supporting data/justification or other information for your responses to these questions about threats?



**SECTION H**    **DO YOU HAVE INFORMATION ON CURRENT OR FUTURE MANAGEMENT FOR THE RECOVERY OF THE SPECIES? (If no, skip to section I)**

25. What planning, management and recovery actions are currently in place supporting protection and recovery of the species? To what extent have they been effective?
26. Can you recommend any additional or alternative specific threat abatement or conservation actions that would aid the protection and recovery of the species?
27. Would you recommend translocation (outside of the species' historic range) as a viable option as a conservation actions for this species?

**SECTION I**    **DO YOU HAVE INFORMATION ON STAKEHOLDERS IN THE RECOVERY OF THE SPECIES?**

28. Are you aware of other knowledge (e.g. traditional ecological knowledge) or individuals/groups with knowledge that may help better understand population trends/fluctuations, or critical areas of habitat?
29. Are you aware of any cultural or social importance or use that the species has?
30. What individuals or organisations are currently, or potentially could be, involved in management and recovery of the species?
31. How aware of this species are land managers where the species is found?
32. What level of awareness is there with individuals or organisations around the issues affecting the species?
  - a. Where there is awareness, what are these interests of these individuals/organisations?
  - b. Are there populations or areas of habitat that are particularly important to the community?

**PART 3 – ANY OTHER INFORMATION**

33. Do you have comments on any other matters relevant to the assessment of this species



## Conservation Advice for *Galaxias gunaikurnai* (Shaw Galaxias)

**This draft document is being released for consultation on the species listing eligibility and conservation actions**

The purpose of this consultation document is to elicit additional information to better understand the status of the species and help inform conservation actions, further planning and a potential recovery plan. The draft assessment below should therefore be considered **tentative** at this stage, as it may change as a result of responses to this consultation process.

Note: Specific consultation questions relating to the below draft assessment and preliminary determination have been included in the consultation cover paper for your consideration.

This document combines the approved conservation advice and listing assessment for the species. It provides a foundation for conservation action and further planning.



*Galaxias gunaikurnai* (Shaw Galaxias) © Copyright, Tarmo. A. Raadik

## Conservation status

*Galaxias gunaikurnai* (Shaw galaxias) is proposed to be listed in the Critically Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999*.

*Galaxias gunaikurnai* was assessed by the Threatened Species Scientific Committee to be eligible for listing under Criteria 1, 2, 3 and 4. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: A2bce+3ce: Critically Endangered
- Criterion 2: B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v): Critically Endangered
- Criterion 3: C2a(i,ii): Critically Endangered
- Criterion 4: D: Critically Endangered
- Criterion 5: Insufficient data

The main factors that make the species proposed for listing in the Critically Endangered category are very severe population reduction, very restricted distribution and locations, very small population size and continuing decline due to multiple threats: introduced species, fire, climate change, and other habitat loss, disturbance and modification impacts.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the [Species Profile and Threat Database](#).

## Species information

### Taxonomy

Conventionally accepted as *Galaxias gunaikurnai* Raadik (2014). *Galaxias gunaikurnai* (Shaw galaxias) was previously known as *Galaxias olidus* Günther (1866) (mountain galaxias), an unresolved species complex (Raadik 2011). In 2014, this complex was revised and subsequently this new taxon, Shaw galaxias, was formally described (Raadik 2014).

### Description

The Shaw galaxias (family Galaxiidae) is a small, native freshwater fish, which has an elongate, tubular and scaleless body with a lateral line. The species commonly grows to 65–70 mm length to caudal fin (LCF) but can reach a maximum of 104 mm LCF and 11 g in weight. The body is predominantly grey-brown to grey-tan on the back and upper sides above lateral line, becoming light tan to creamy brown ventrally, with a cream or white belly; juveniles are similar. The body is overlain by dusky grey shading, with grey-brown to dark grey irregular-shaped blotches and stripes, some extending ventrally across the lateral line. The head and snout are moderately long and rounded, with a large mouth and moderately small, coppery-gold eyes. The fins are soft-rayed, strongly rounded, translucent and slightly pale yellow to dusky. The gill cover is translucent with a small golden patch. This description is drawn from Raadik (2011), Raadik (2014) and Bray (2020).

The species can be distinguished from other species in the mountain galaxias complex by its more elongate body, short but wide/deep head, and mottled blotched pattern on the body and rounded snout (Raadik 2011, 2014; Kuiter 2018).

## Distribution

### Current distribution

The Shaw galaxias is a non-migratory, freshwater resident, which is endemic to Victoria (Vic) (Map 1). It is only known from the headwaters of Shaw Creek (approximately 1470 m above sea level (ASL) in Alpine National Park), which is a tributary of the Caledonia River in the Macalister River catchment in West Gippsland (Thomson River Basin (River Basins of Victoria); Mitchell-Thomson Rivers Region (Australian Hydrological Geospatial Fabric River Regions)) (Map 1) (Raadik 2011, 2014). The Shaw galaxias is the only species in the mountain galaxias complex known from the Caledonia River system (Raadik 2014). *Galaxias lanceolatus* (tapered galaxias) also occurs in the Thomson River Basin, but it is geographically isolated, occurring approximately 70 km to the south-west (Raadik 2014).

The Shaw galaxias is known from a single subpopulation in Shaw Creek and has only been collected from four sites (within a 4 km reach in the upper-most headwaters) (Raadik 2011; 2014; Raadik 2021. pers comm 19 October). The species downstream distribution ends at an artificial instream barrier in 'The Gorge' area (further details below), below which the brown trout (*Salmo trutta*) and the rainbow trout (*Oncorhynchus mykiss*) occur (DEPI 2013; Raadik 2014).

Note: all distances (in km) are river distance.

Predation by introduced salmonids, including the brown trout and the rainbow trout, has been implicated in the decline of *Galaxias* species throughout Australia, including other members of the mountain galaxias complex (Tilzey 1976; Wager & Jackson 1993; Cadwallader 1996; Lintermans 2000; McDowall 2006; Lintermans 2013; Lintermans et al. 2020). Predation on *Galaxias* species by introduced salmonids has been directly documented via gut contents analyses (Vidal et al. 2020) and the distribution of *Galaxias* species and salmonids are usually mutually exclusive (e.g. Tilzey 1976; Lintermans 2000), suggesting that *Galaxias* species have been eliminated by salmonid predation. Indeed, the role of salmonids in the fragmentation of *Galaxias* subpopulations has been well documented in Australia (Lintermans 2000; Raadik & Kuiter 2002; Green 2008b). Accordingly, the Shaw galaxias is likely to be restricted to the headwaters of Shaw Creek (Raadik 2011, 2014).

### **Past distribution and decline**

In the 1960s, the species' distribution extended at least 12 km further downstream of the type locality (and possibly into the mid-reaches of the Caledonia River system) (Raadik 2014). However, by 2002, the Shaw galaxias was absent from a site, approximately 400 m downstream of the type locality (below a small instream barrier), where the predatory brown trout was abundant (Raadik 2011, 2014). Between 2010 and 2011, high flows eroded the instream barrier, allowing brown trout to invade and colonise the headwaters of Shaw Creek, where the Shaw galaxias occurs (Raadik 2014). By May 2012, the abundance of the Shaw galaxias had declined by approximately 98 percent in the headwaters of Shaw Creek (Raadik 2021). Only 150 individuals (mature and juvenile) remained in three small pools in a sphagnum bog in the headwaters of a side tributary (300 m long, 0.3 m wide) and one further single mature individual was found in the headwaters of separate side tributary (Raadik 2014). From 2013–2017, several temporary and permanent artificial, instream barriers were installed, and brown trout were removed from above the barriers via electrofishing (DEPI 2013; Raadik 2014; Raadik 2021. pers comm 19 October). The area upstream of the instream barriers is currently trout-free (Raadik 2021. pers comm 19 October).

Note: all distances (in km) are river distance.

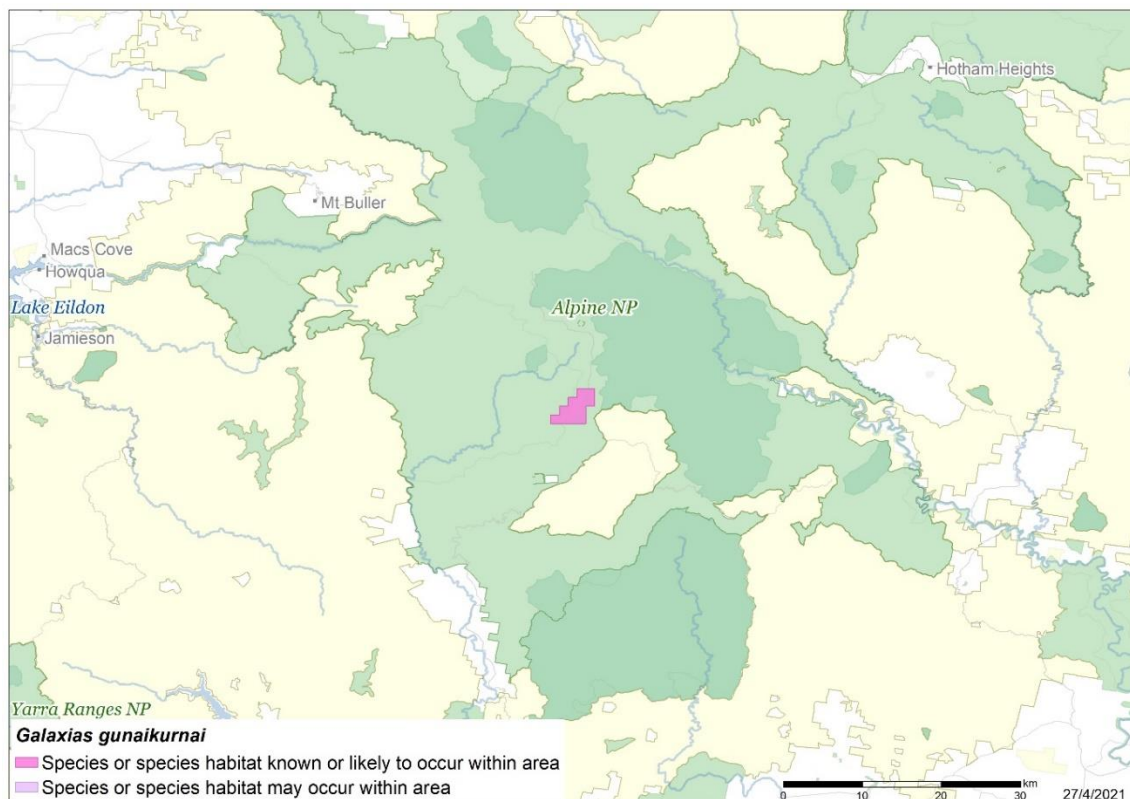
### **Distribution of translocations**

Given the ongoing threat of salmonid reinvasion and predation, which is likely to cause the extinction of the species, translocations are required to ensure species persistence (Threatened Species Recovery Hub 2018). One translocation has been conducted into a stream in an adjacent catchment to Shaw Creek; while it is too early to determine if the subpopulation is self-sustaining or evolutionarily viable (Threatened Species Recovery Hub 2018), the subpopulation has begun to reproduce and increase in abundance (Raadik 2021. pers comm 19 October).

### **Distribution of unconfirmed subpopulations**

An unconfirmed subpopulation of *Galaxias* sp. (purportedly belonging to the mountain galaxias complex, possibly the Shaw galaxias), in the headwaters of Pieman Creek in the Mitchell River system (approximately 14 km north of the Shaw galaxias' type locality), could not be relocated or ascribed to a particular species (Raadik 2011, 2014). Further surveys of the headwater reaches of the Macalister River catchment and the adjacent Wonnangatta River catchment are required to identify if any further remnant subpopulations exist and accurately delineate the small distribution of this species (Raadik 2011, 2014). These surveys have been partly completed and no additional subpopulations have been found (Raadik 2021. pers comm 19 October).

## Map 1 Modelled distribution of the Shaw galaxias



**Source:** Base map Geoscience Australia; species distribution data [Species of National Environmental Significance](#) database.

**Caveat:** The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

**Species distribution mapping:** The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

## Cultural and community significance

### Cultural and community significance to Indigenous Australians

The significance of the ecological community, particular species, spiritual and other cultural values are diverse and varied for the many Indigenous peoples that live in the area and care for Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, all Indigenous people. Such knowledge may be only held by Indigenous groups and individuals who are the custodians of this knowledge.

The specific epithet, *gunaikurnai*, is named after the Gunaikurnai people (Raadik 2011, 2014). The Gunaikurnai people are recognised by the Federal Court and the State of Victoria as the Traditional Owners of a large area of Gippsland spanning from Warragul (west) to the Snowy River (east), and from the Great Divide (north) to the coast (south) (GLaWAC 2021c). The Gunaikurnai people see their land (Wurruk), waters (Yarnda), air (Watpootjan) and every living thing as one (GLaWAC 2021b). All things come from Wurruk, Yarnda and Watpootjan and they are the spiritual life-giving resources, providing the Gunaikurnai people with resources and forming the basis of their cultural practices (GLaWAC 2021b).

The Shaw galaxias and its habitat occur on Country belonging to the Brayakaulung clan (one of the five major clans of the Gunaikurnai people). The cultural significance of the Shaw galaxias to Traditional Owners is unknown. However, given the acknowledged importance to Aboriginal peoples of Connection to Country and the widespread importance of Caring for Country (which includes biodiversity, 'place', custom and totemic elements) it is considered likely that the species has or is associated with some cultural and/or community significance.

Approximately 13 percent of Gunaikurnai Country was burnt during the 2019-20 bushfires (GLaWAC 2021a), however the immediate area and upstream of where the species occurs was not impacted. The Gunaikurnai Bushfire Recovery Crew works across the fire footprint, monitoring the impacts of bushfire and the recovery of species that are significant for their culture and people (GLaWAC 2021a).

### Cultural and community significance to commercial/recreational fishing

The mountain galaxias complex is not a commercial or recreational fishing target (Native Fish Australia 2021).

## Relevant biology and ecology

### Habitat ecology and associated species

The Shaw galaxias has been recorded in the headwaters of Shaw Creek, a small (average width: 0.6–1.4 m; average depth: 0.15–0.20 m), clear, cool alpine creek, flowing through a grassy plain (Raadik 2011, 2014). The creek consists of pools, glides and riffles, with smaller amounts of small cascades, with very little shading except that provided by grasses (Raadik 2011, 2014). The species microhabitat preferences are unknown. However, the substrate at the type locality consists predominantly of bedrock, boulder and cobble, with smaller amounts of pebble, gravel and coarse sand (Raadik 2011, 2014). Instream cover is provided predominantly by rock and overhanging grasses (Raadik 2011, 2014). During winter, the species can survive in very cold water (<5 °C) and the catchment is usually covered by snow for varying periods of time (Raadik 2011, 2014). *Galaxias* species can burrow into substrate to escape declining water level during periods of surface water loss (unpublished data cited in Raadik et al. 2010).



### **Co-occurring species**

The Shaw galaxias is the only native fish species to be recorded within its range (Raadik 2011, 2014). The brown trout and rainbow trout are present downstream of the artificial instream barrier in Shaw Creek (DEPI 2013; Raadik 2014).

### **Diet**

The diet of the Shaw galaxias has not been reported. However, the species is likely to be macroinvertebrate, as observed in other species of the mountain galaxias complex, and consume benthic, drifting and terrestrial invertebrates, such as insects, crustaceans, molluscs, worms and spiders (Cadwallader et al. 1980; Closs 1994; Raadik 2014).

### **Generation length**

The generation length of the Shaw galaxias is unknown. However, it is likely to be similar to other species in the mountain galaxias complex, which is between two and four years (Allen et al. 2002; Raadik 2019a).

### **Reproductive ecology**

The reproductive ecology of the Shaw galaxias is largely unknown. The spawning period is undocumented, but thought to be from winter to early spring (Raadik 2014). Individuals collected in late February (late summer) were at an early stage of gonad development, with most of the body cavity full of fat deposits (Raadik 2011, 2014). Individuals collected in mid-April (mid-Autumn) had gonads filling 50–60 percent of the body cavity (Raadik 2011, 2014). Individuals collected in early May (late Autumn) were at an advanced stage, with males running ripe and female gonads well developed and ripe (Raadik 2011, 2014).

Other members of the mountain galaxias complex have low fecundity (<400 eggs annually) with the sticky eggs generally attached to the underside of rocks in riffles (Cowden 1988; O'Connor & Koehn 1991; Lintermans 2007). Eggs in other members of the mountain galaxias complex are small (approximately 2 mm in diameter), spherical, demersal and adhesive, and hatch after 20–30 days (Cowden 1988; O'Connor & Koehn 1991). Larvae in other members of the mountain galaxias complex are approximately 9 mm long upon hatching (O'Connor & Koehn 1991).

### **Habitat critical to the survival**

The Shaw galaxias is only known from the headwaters of Shaw Creek in West Gippsland, approximately 1470 m ASL (Map 1) (Raadik 2011, 2014). Although the microhabitat preferences of this species are unknown, it has been recorded from a small clear, cool alpine creek, consisting of pools, glides and riffles, with smaller amounts of small cascades, flowing through a grassy plain (Raadik 2011, 2014). Accordingly, such habitat is likely to be necessary for long-term maintenance and evolutionary development of the species.

The habitat critical to the survival of the Shaw galaxias includes the area of occupancy of known subpopulations; areas of similar habitat adjoining known subpopulations (as described above), which provide potential habitat for natural range extension; areas of similar habitat that may contain the species or be suitable for translocations (as described above, in particular, areas where introduced salmonids are absent or have been removed, and barriers exist or can be erected to prevent their return); and the local catchment for the surface and/or groundwater that maintains the habitat of the species.



Actions required to preserve the species' habitat are identified in the Conservation and Recovery Actions.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

### **Important populations**

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

All populations of the Shaw galaxias are important for the long-term recovery and survival of this species.

### **Threats**

The threats impacting the Shaw galaxias are similar to those impacting other *Galaxias* species in south-eastern Australia.

The Shaw galaxias is primarily threatened by predation by introduced salmonids, which has very severely reduced the species' abundance and distribution (Table 1) (Raadik 2014; Threatened Species Recovery Hub 2018; Raadik 2019a; Lintermans et al. 2020). The species' very restricted distribution and very small population size is highly likely to increase its' probability of extinction due to genetic decline (Frankham et al. 2002; IUCN 2012), and render the species more vulnerable to other threats, including further incursion by introduced salmonids, inappropriate fire regimes, the impacts of climate change, other habitat loss, disturbance and modification impacts, and disease (Table 1). Indeed, Lintermans et al. (2020) used expert elicitation to predict that the Shaw Galaxias is the Australian fish at greatest risk of extinction, with >80 percent probability of extinction by 2040 without additional conservation actions. Preliminary results from population genetic analysis indicate that the Shaw galaxias has lost most of its genetic diversity and has a high level of inbreeding (Raadik 2021. pers comm 19 October).

Threats in Table 1 are noted in approximate order of highest to lowest impact, based on available evidence.

**Table 1 Threats impacting the Shaw galaxias**

Threat	Status <sup>a</sup>	Evidence
Introduced species		
Predation by introduced salmonids	<ul style="list-style-type: none"> <li>• Timing: current/future</li> <li>• Confidence: observed</li> <li>• Likelihood: likely</li> <li>• Consequence: catastrophic</li> <li>• Trend: unknown</li> <li>• Extent: across the entire range</li> </ul>	<p>Predation by introduced salmonids, including the brown trout and the rainbow trout, has been implicated in the decline of <i>Galaxias</i> species throughout Australia, including other members of the mountain galaxias complex (Tilzey 1976; Wager &amp; Jackson 1993; Cadwallader 1996; Lintermans 2000; McDowall 2006; Lintermans 2013; Lintermans et al. 2020). Predation on <i>Galaxias</i> species by introduced salmonids has been directly documented via gut contents analyses (Vidal et al. 2020) and the distribution of <i>Galaxias</i> species and salmonids are usually mutually exclusive (e.g. Tilzey 1976; Lintermans 2000), suggesting that <i>Galaxias</i> species have been eliminated by salmonid predation. Indeed, the role of salmonids in the fragmentation of <i>Galaxias</i> subpopulations has been well documented in Australia (Lintermans 2000; Raadik &amp; Kuitert 2002; Green 2008b). <i>Galaxias</i> species do not respond with avoidance behaviour to odour cues from the rainbow trout but do respond with such behaviour to odour cues from the native predator, <i>Anguilla australis</i> (southern shortfin eel) (McLean et al. 2007). This suggests that <i>Galaxias</i> species they may lack an effective anti-predator response to introduced salmonids (McLean et al. 2007).</p> <p>Although this threat was included in the key threatening process 'novel biota and their impact on biodiversity' listed under the EPBC Act (DSEWPaC 2013), salmonid restocking occurs regularly in Vic, including into the Macalister River catchment downstream of Shaw Creek (VFA 2021). Additionally, the brown trout and the rainbow trout now successfully breed in many Victorian waterways and have formed self-sustaining populations in Shaw Creek (Raadik 2011; DSEWPaC 2013; Raadik 2014; VFA 2021).</p> <p>Historically, the Shaw galaxias occurred at least 12 km further downstream of the type locality (and possibly into the mid-reaches of the Caledonia River system) prior to the incursion of salmonids (Raadik 2014). In 2012, following the erosion of the instream barrier and the subsequent incursion of the brown trout, the abundance of the Shaw galaxias declined by 99 percent in the headwaters of Shaw Creek (Raadik 2014; Raadik 2019a; Lintermans et al. 2020).</p> <p>An artificial instream barrier was installed and brown trout were removed from above the barrier in a total of 10 one-week trips between 2013-2017 (DEPI 2013; Raadik 2014; Raadik 2021. pers comm 19 October). However, further rapid and very severe population decline is anticipated following any further incursion or stocking upstream of the instream barrier (Threatened Species Recovery Hub 2018; Lintermans et al. 2020). This could occur through natural drown-out in high flow events or illegal translocation/stocking (either deliberately or accidentally) by anglers (Threatened Species Recovery Hub 2018).</p>

Threat	Status <sup>a</sup>	Evidence
Competition with introduced salmonids	<ul style="list-style-type: none"> <li>• Timing: current/future</li> <li>• Confidence: inferred</li> <li>• Likelihood: likely</li> <li>• Consequence: major</li> <li>• Trend: unknown</li> <li>• Extent: across the entire range</li> </ul>	<p>To a lesser extent than predation, competition with introduced salmonids has also been documented via trophic niche analyses (Vidal et al. 2020) and implicated in the decline of <i>Galaxias</i> species throughout Australia, including other species of the mountain galaxias complex (Glova 1989; Crowl et al. 1992; Cadwallader 1996; McDowall 2006; Raadik et al. 2010). Salmonids (usually juveniles) can compete with <i>Galaxias</i> species (usually adults) for foraging and sheltering resources via interference (aggressive behaviour used to exclude <i>Galaxias</i> species from resources) and exploitation competition (use of similar resources) (Crowl et al. 1992; Cadwallader 1996; Raadik et al. 2010). This can lead to starvation, displacement, reduced reproductive output and mortality of <i>Galaxias</i> individuals (Crowl et al. 1992; Cadwallader 1996; Raadik et al. 2010).</p> <p>Although the impacts of this threat on the Shaw galaxias are undocumented, the species is likely to be affected, given its ecological similarities to other <i>Galaxias</i> species.</p>
Altered hydrology/water quality caused by feral ungulates	<ul style="list-style-type: none"> <li>• Timing: current</li> <li>• Confidence: inferred</li> <li>• Likelihood: likely</li> <li>• Consequence: moderate</li> <li>• Trend: unknown</li> <li>• Extent: across the entire range</li> </ul>	<p>Feral pigs (<i>Sus scrofa</i>), horses (<i>Equus ferus caballus</i>) and deer (multiple species) are found in association with river systems in the Vic Alps (Parks Victoria 2016, 2017). Feral pigs have been listed as a key threatening process under the EPBC Act (DOEE 2017) and feral horses and deer are considered a major emerging pest problem (DSEWPaC 2011; Parks Victoria 2017).</p> <p>By trampling, grazing and wallowing, feral pigs, horses and deer modify stream sides and increase erosion, which alters water quality via eutrophication (enrichment of water with nutrients), and increases sedimentation, siltation and turbidity (Singer et al. 1984; McDowell 2007; Doupe et al. 2010; Davis et al. 2016; DOEE 2017; Parks Victoria 2017; Tolsma &amp; Shannon 2018; Scanes et al. 2021). Additionally, increased sediment load (especially following high rainfall events) can suffocate fish and smother stream substrate, which reduces food availability, refuge and spawning habitat (Raadik &amp; Nicol 2012). Such changes to water quality have been implicated in the decline of <i>Galaxias</i> species, including other members of the mountain galaxias complex (Allan &amp; Lintermans 2018; Driscoll et al. 2019).</p> <p>Although the impacts of this threat on the Shaw galaxias are undocumented, the species is likely to be affected by altered hydrology and water quality if feral ungulates are present. Feral pigs, horses and deer are being actively managed/controlled in the Vic Alps (Parks Victoria 2016, 2017, 2021).</p>

Threat	Status <sup>a</sup>	Evidence
Habitat loss, disturbance or modification		
Inappropriate fire regimes	<ul style="list-style-type: none"> <li>• Timing: current</li> <li>• Confidence: observed</li> <li>• Likelihood: likely</li> <li>• Consequence: major</li> <li>• Trend: increasing</li> <li>• Extent: across the entire range</li> </ul>	<p>Fires have been implicated in the decline of <i>Galaxias</i> species, including other members of the mountain galaxias complex, due to their fragmented distribution and limited recolonisation/dispersal abilities (Stoessel et al. 2012; Raadik &amp; Nicol 2013; Raadik &amp; Nicol 2015; NSW FSC 2016).</p> <p>Fires can degrade stream habitats by increasing water temperature and sediment load, reducing dissolved oxygen levels and altering water chemistry, which can impact aquatic ecosystems up to 80 km downstream of burnt areas (Lyon &amp; O'Connor 2008; Crowther et al. 2015; Harper et al. 2019; Alexandra &amp; Finlayson 2020; Silva et al. 2020). Physiologically, species of the mountain galaxias complex are highly susceptible to such changes in water quality, with an upper thermal tolerance of approximately 33 °C, which declines with reductions in dissolved oxygen and mild exposure to ash and sediment (Mulvey 2021). Additionally, increased sediment load (especially following high rainfall events) can suffocate fish and smother stream substrate, which reduces food availability, refuge and spawning habitat (Lyon &amp; O'Connor 2008; Raadik et al. 2010). As the species is non-migratory, all life history stages (eggs, larvae, juveniles, adults) are susceptible to post-fire impacts.</p> <p>Although salmonids are also susceptible to the impacts of fires (Novak &amp; White 1990; Rinne 1996), they can quickly recolonise streams after fire-related disturbances (Novak &amp; White 1990; Lyon &amp; O'Connor 2008). Accordingly, fires can also increase predation risk for galaxiids, by reducing shading/protective cover from predators, and drowning out instream barriers (via sedimentation) and facilitating salmonid incursion (DSE 2011a; NSW FSC 2016). Salmonids may also be introduced if fire-bombing is undertaken across streams using local water from predator-infested waterways (Raadik 2018).</p> <p>Fires may also create new instream barriers, which can increase fragmentation of the species (DSE 2011a; NSW FSC 2016). Additionally, impacts from toxic fire suppression chemicals, such as foam/fire retardants, can weaken or kill fish if introduced into waterways (Raadik et al. 2010; Raadik 2016, 2018; Raadik 2019a).</p> <p>The Tamboritha-Dingo Hill Track fire in 2018 occurred within 2 km of the Shaw Galaxias subpopulation, however, due to an effective early response from DELWP, Parks Victoria and fire teams with respect to aquatic natural values protection, there was no impact on the species (Raadik 2018).</p>

Threat	Status <sup>a</sup>	Evidence
Altered hydrology/water quality caused by anthropogenic activities	<ul style="list-style-type: none"> <li>• Timing: historical/current</li> <li>• Confidence: inferred</li> <li>• Likelihood: likely</li> <li>• Consequence: minor</li> <li>• Trend: unknown</li> <li>• Extent: across the entire range</li> </ul>	<p>Unsealed roads (including Howitt and Tamboritha Road) and tracks intersect or occur in close proximity to Shaw Creek (Parks Victoria 2016). Recreational activities, such as four-wheel driving, hiking and camping, can cause damage to trails via soil erosion, trail extension and widening, vegetation damage and pollution (Marion et al. 1993; Forman &amp; Alexander 1998). This can mobilise sediment and pollution into streams (Brown 1994; Kidd et al. 2014), which alters water quality and may impact the Shaw galaxias (Raadik 2019a). Further, such tracks provide easy access to Shaw Creek and increase the risk of anthropogenic-assisted salmonid incursion (Threatened Species Recovery Hub 2018).</p> <p>Additionally, weed control activities (e.g., spraying of herbicide) in areas adjacent to the catchment could impact water quality and the Shaw galaxias (Raadik 2021. pers comm 19 October).</p>

Threat	Status <sup>a</sup>	Evidence
Climate change		
Increased temperatures, change to precipitation patterns and more extreme weather events	<ul style="list-style-type: none"> <li>• Timing: current/future</li> <li>• Confidence: observed</li> <li>• Likelihood: almost certain</li> <li>• Consequence: major</li> <li>• Trend: increasing</li> <li>• Extent: across the entire range</li> </ul>	<p>Native freshwater fishes are known to persist in severe droughts, where they have evolved under those conditions (Smith 1982). Indeed, members of the mountain galaxias complex have historically been able to persist through droughts in small pools (Closs &amp; Lake 1996). However, the CSIRO &amp; Bureau of Meteorology (2015) predict eastern Australia will experience decreased average rainfall, and increased frequency of droughts and average temperatures. From 2017–2019, West Gippsland experienced its three driest years on record (Bureau of Meteorology 2020). Additionally, snowfall and snow cover in the Vic Alps has declined and is expected to continue to decline throughout the 21<sup>st</sup> century (Nicholls 2005; Bhend et al. 2012; Fiddes et al. 2015).</p> <p>These changes to rainfall patterns and temperatures are predicted to alter surface run-off and snow melt flow, which will impact the hydrology of small headwater streams (e.g. lower water levels and higher water temperatures) with increasing severity and frequency (DSE 2011b; Berghuijs et al. 2014; CSIRO &amp; Bureau of Meteorology 2015; Bilish et al. 2020; DELWP 2020). Severe and prolonged droughts may also create new instream barriers, which can increase fragmentation and reduce spawning and recruitment (Lennox et al. 2019). Additionally, the frequency and severity of bushfires is increasing due to climate change (CSIRO &amp; Bureau of Meteorology 2015), which is likely to cause long-term changes to water quality and threaten the persistence of native fish (Shu-ren 2003; Whitney et al. 2015). The increased sedimentation/siltation caused by fires (as well as feral ungulates and anthropogenic activities) is likely to smother and infill coarse substrate in the streambed (described above, e.g. Lyon &amp; O'Connor 2008). This prevents <i>Galaxias</i> species from burrowing into substrate to escape declining water level, leaving them susceptible to mortality during periods of surface water loss (unpublished data cited in Raadik et al. 2010). Accordingly, the increased severity and frequency of droughts, compounded by the effects of increasing fires, feral ungulates and anthropogenic activities, is likely to cause decline in the Shaw galaxias (Threatened Species Recovery Hub 2018; Raadik 2019a).</p> <p>Further, the frequency of extreme rainfall events is also increasing with climate change (CSIRO &amp; Bureau of Meteorology 2015; DELWP 2020), which is likely to increase stream bank erosion and sedimentation, alter water quality and drown out instream barriers facilitating salmonid incursion (Magilligan et al. 2015; Threatened Species Recovery Hub 2018; Ross et al. 2019; DELWP 2020; Lintermans et al. 2020).</p>

Threat	Status <sup>a</sup>	Evidence
Disease		
Internal parasites	<ul style="list-style-type: none"> <li>• Timing: current</li> <li>• Confidence: observed</li> <li>• Likelihood: unknown</li> <li>• Consequence: unknown</li> <li>• Trend: unknown</li> <li>• Extent: across the entire range</li> </ul>	<p>Metacercarial cysts, the second life stage of parasitic flatworms (flukes), have been reported in the skin and fins of other species in the mountain galaxias complex (Raadik 2011, 2014).</p> <p>Galaxiids appear to be particularly susceptible to infection with metacercarial cysts, with some fish carrying hundreds of cysts on the body and fins (VFA 2008). Heavily infected galaxiids are weak and slow-moving, making them an easy target for predators (Collyer &amp; Stockwell 2004; VFA 2008). The prevalence of metacercarial cysts in the Shaw galaxias population is unknown and requires further investigation.</p>

Timing—identify the temporal nature of the threat

Confidence—identify the extent to which we have confidence about the impact of the threat on the species

Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species

Consequence—identify the severity of the threat

Trend—identify the extent to which it will continue to operate on the species

Extent—identify its spatial content in terms of the range of the species

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

**Table 2 Shaw galaxias risk matrix**

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Increased temperatures, change to precipitation patterns and more extreme weather events	
Likely		Altered hydrology/water quality caused by anthropogenic activities	Altered hydrology/water quality caused by feral ungulates	Inappropriate fire regimes Competition with introduced salmonoids	Predation by introduced salmonids
Possible					
Unlikely					
Unknown					

**Risk Matrix legend/Risk rating:**

Low Risk	Moderate Risk	High Risk	Very High Risk
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**Categories for likelihood are defined as follows:**

Almost certain – expected to occur every year

Likely – expected to occur at least once every five years

Possible – might occur at some time

Unlikely – such events are known to have occurred on a worldwide bases but only a few times

Unknown – currently unknown how often the incident will occur

**Categories for consequences are defined as follows:**

Not significant – no long-term effect on individuals or populations

Minor – individuals are adversely affected but no effect at population level

Moderate – population recovery stalls or reduces

Major – population decreases

Catastrophic – population extinction/extirpation

**Note:** The threat ‘internal parasites’ has not been included in Table 2 as the consequences are unknown.

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be ‘very high’ (red shading) or ‘high’ (yellow shading). For those threats with an unknown or low risk outcome (green and blue shading) it may be more appropriate to identify further research or maintain a watching brief.



## Conservation and recovery actions

### Primary conservation objective

By 2031-33, at least three geographically separated subpopulations of the Shaw galaxias will be established and will have produced viable offspring. The species' probability of extinction in the wild will have declined, following the removal of introduced salmonid predators and improvement of lost or degraded habitats.

### Conservation and management priorities

#### Introduced species impacts

- Remove and control introduced salmonid predators in the catchment(s) where the Shaw galaxias occurs (Raadik 2017) and catchments where the species does not occur, but translocations could be established. Prevent any further introductions of non-native fish species, including via stocking, into the catchment(s) where the species occurs and catchments where the species does not occur, but translocations could be established.
- Maintain existing instream barriers (natural or artificial) and construct new instream barriers, where appropriate, to prevent incursion of introduced salmonid predators and other non-native fish species (Raadik 2019b). This should include annual inspection and maintenance of barrier integrity to ensure the continued effectiveness.
- Continue to implement strategies to remove and control feral ungulates, including feral pigs, horses and deer, as detailed in the relevant management (Parks Victoria 2016, 2017) or threat abatement plans (DOEE 2017).

#### Fire, climate change and extreme weather impacts

- Provide fire and land managers with maps of known and likely habitat for the species and specific advice to support decision making in fire prevention, preparedness, response and recovery.
- Develop and implement a fire management strategy that optimises the survival of the species during fires.
- Trial temporary, artificial, deep 'refuge' pools (particularly immediately downstream of groundwater inflow areas), following short-term loss of surface water and smothering of substrate with sediment, to provide temporary security from complete population loss and allow for salvage of surviving fish (Raadik et al. 2010). In some areas, artificial spawning structures may also be required to bolster natural spawning following sedimentation events.

### **Habitat, loss disturbance and modifications impacts**

- Maintain vegetated protection zones (no harvesting or soil disturbance) along the entire stream drainage network (wet or dry, stream channel to headwater drainage lines), within catchment(s) where the species occurs.
- Review management of roads and tracks in catchment(s) where the species occurs, including stream crossings (wet/dry, channel or drainage lines), to eliminate sources of direct sediment input into the stream drainage network and prevent illegal translocation of non-native fish species.

### **Ex situ recovery actions**

- To ensure species persistence, establish a captive breeding program, informed by population genetic analysis, to augment extant or extirpated subpopulations and/or establish translocated subpopulations.
- Continue to implement ongoing management activities (e.g., management of threats, monitoring, etc.) to ensure the establishment and persistence of translocated subpopulation.
- Translocations should be conducted according to relevant state legislation, policies, protocols and guidelines, including DPI (2005, 2014), Ayres et al. (2012) and Zukowski et al. (2021), where techniques for other *Galaxias* species are presented and can be applied for the Shaw galaxias. Introduced salmonids/non-native fish species must be absent or excluded from any translocation sites. Translocation sites may include new catchments with potential to be habitat (assisted colonisation), historically occupied catchments where non-native fish species have been removed (reintroduction) or currently occupied catchments (for genetic management/reinforcement).
- For subpopulations with high extirpation risk, prepare salvage/rescue plans to remove a proportion of individuals from the subpopulation and maintain them in captivity until the threat(s) abate (temporary captive maintenance). Implement strict biosecurity, disease prevention and aquarium maintenance procedures to allow the return of fish to the population following abatement of the risk.

## **Stakeholder engagement/community engagement**

- Engage and involve Traditional Owners in conservation actions, including the implementation of Indigenous fire management and other survey, monitoring and management actions.
- Continue to liaise with government agencies, land managers and stakeholder groups in the catchment(s) where the species occurs and does not occur, but translocations could be established. Ensure up-to-date population data and scientific knowledge inform the implementation of conservation actions, particularly regarding the removal and control of introduced salmonid predators..
- Promote community awareness of the Shaw galaxias and identify opportunities for involvement in conservation actions.
- Contribute to impact assessment and planning processes on measures to protect the Shaw galaxias and its habitat, including park management plans and environmental impact assessments.

## **Survey and monitoring priorities**

- Undertake targeted surveys in the species' habitat (including the headwater reaches of the Macalister River catchment and the adjacent Wonnangatta River catchment) to locate any additional subpopulations, accurately delineate the small distribution of this species and identify suitable translocation sites.
- Implement a long-term monitoring program (e.g. abundance, length and weight, or eDNA if robust methods have been developed) to assess population size/trends across the species' range and provide early-predator detection warning (e.g. absence of first four to five age classes indicates one or more predators present) (Raadik et al. 2010).
- Undertake annual monitoring of translocated populations, including genetic analysis, undertake genetic top-ups when required, and evaluate success after three generations.
- Undertake annual monitoring of salmonid predators (e.g. presence and abundance, or eDNA if robust methods have been developed) and monitor and evaluate the efficacy of management interventions.
- Undertake annual monitoring of habitat condition and degradation, including the impacts of herbivores and weed invasion, and monitor and evaluate the efficacy of management interventions.

## Information and research priorities

- Investigate the ecological requirements of the species, including:
  - population genetic structure, levels of genetic diversity and minimum viable population size;
  - life history traits, such as time to maturity, longevity, fecundity, spawning period and number of young;
  - diet and habitat preferences;
  - desiccation, low dissolved oxygen tolerance and water temperature (adults, juveniles, larvae and eggs);
  - climbing ability, movements and dispersal patterns of adults and juveniles; and
  - predator-avoidance behaviour.
- Investigate techniques for captive maintenance, breeding, on-growing and translocation.
- Determine a target density for wild and translocated subpopulations, taking factors such as carrying capacity and the impacts of climate change into consideration.
- Investigate options to enhance the resilience of the species' current habitat to climate change and options for providing new habitat that would be suitable for the species under climate change scenarios.
- Investigate the identity, prevalence and consequences of diseases and parasites on Shaw galaxias.
- Ascertain the cultural significance of the Shaw galaxias to Traditional Owners.

## Links to relevant implementation documents

This Conservation Advice is developed to be able to subsequently inform other planning instruments, such as a Bioregional Plan or a multi-entity Conservation Plan.

[Alpine National Park – Feral horse strategic action plan 2018-2021 \(2017\)](#)

[Guidelines for assessing translocations of live aquatic organisms in Victoria \(2014\)](#)

[Guidelines for the translocation of barred galaxias \(\*Galaxias fuscus\*\) for conservation purposes \(2012\)](#)

[Protocols for the translocation of fish in Victorian inland public waters \(2005\)](#)

[Threat abatement guidelines for the key threatening process 'Novel biota and their impact on biodiversity' \(2013\)](#)

[Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs \(\*Sus scrofa\*\) \(2017\)](#)

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# THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the *Environment Protection and Biodiversity Conservation Act 1999*

The Threatened Species Scientific Committee finalised this assessment on DD Month Year.

## Attachment A: Listing Assessment for *Galaxias gunaikurnai*

### Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC following the imperilled freshwater fish species expert assessment plan.

### Assessment of eligibility for listing

This assessment uses the criteria set out in the [EPBC Regulations](#). The thresholds used correspond with those in the [IUCN Red List criteria](#) except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

### Key assessment parameters

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

**Table 3 Key assessment parameters**

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	<50	30	100	Based on monitoring data (collected annually from 2013-2021), the number of mature individuals is estimated to be approximately 30–100 (midpoint = 65; low confidence) (Raadik 2021).  A precautionary approach has been taken in this assessment (due to likely continuing decline and low confidence of monitoring estimates), so the number of mature individuals is considered to be <50 (i.e., fewer than the midpoint estimated from monitoring data).
Trend	Declined within the last 3 generations; likely to decline following the next threatening event.			The species' density declined by approximately 98 percent between 2008–2013 following salmonid incursion (Raadik 2021), suggesting decline in the number of mature individuals.  The number of mature individuals has been relatively stable since 2013 (Raadik 2021). However, as threats are ongoing, the number of mature individuals is likely to decline following the next threatening event to impact the subpopulation (e.g., salmonid incursion, sedimentation following fire, severe drought, etc.) (See Criterion 1/2).
Generation time (years)	2–4	2	4	The Shaw galaxias is likely to have a generation time of approximately 2–4 years (see Criterion 1).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
<b>Extent of occurrence</b>	4 km <sup>2</sup>	=A00 =4 km <sup>2</sup>	<100 km <sup>2</sup>	<p>E00 is calculated by applying the shortest continuous imaginary boundary which can be drawn to encompass record data from 2002–2021, as outlined in the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN 2019).</p> <p>The minimum plausible E00 value is the A00 estimate, as E00 is smaller than A00 (IUCN 2019). This is the estimate used by IUCN (Raadik 2019a) and Lintermans et al. (2020) rapid assessments. The maximum plausible value is the estimate used in the Threatened Species Recovery Hub (2018) rapid assessment and accounts for the possibility of subpopulations occurring in unsurveyed habitat.</p> <p>The minimum plausible value has been used in this assessment, as it includes all known extant records. All values are within the range of the Critically Endangered category of Criterion 2.</p>
<b>Trend</b>	Contracted historically; stable over the last 3 generations; likely to contract following next threatening event			<p>In the 1960s, the species' distribution extended at least 12 km further downstream than the current distribution (and possibly into the mid-reaches of the Caledonia River system) (Raadik 2014), suggesting range contraction occurred during the late 20th century, following the incursion of introduced salmonids (Raadik 2011, 2014). Accordingly, E00 is considered to have contracted historically.</p> <p>E00 has been stable over the last 3 generations. However, as threats are ongoing, E00 is likely to contract following the next threatening event (e.g., salmonid incursion, sedimentation following fire, severe drought, etc.) (See Criterion 2).</p>
<b>Area of Occupancy</b>	4 km <sup>2</sup>	4 km <sup>2</sup>	<10 km <sup>2</sup>	<p>The minimum plausible value has been calculated using record data from 2002–2021 for the extant subpopulation and applying 2 x 2 km grid cells, as outlined in the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN 2019). This is the estimate used by IUCN (Raadik 2019a) and Lintermans et al. (2020) rapid assessments. The maximum plausible value is the estimate used in the Threatened Species Recovery Hub (2018) rapid assessment and accounts for the possibility of subpopulations occurring in unsurveyed habitat.</p> <p>The minimum plausible value has been used in this assessment, as it includes all known extant records. All values are within the range of the Critically Endangered category of Criterion 2.</p>
<p>A00 is a standardised spatial measure of the risk of extinction, that represents the area of suitable habitat known, inferred or projected to be currently occupied by the taxon. It is estimated using a 2 x 2 km grid to enable comparison with the criteria thresholds. The resolution (grid size) that maximizes the correlation between A00 and extinction risk is determined more by the spatial scale of threats than by the spatial scale at which A00 is estimated or shape of the taxon's distribution. It is not a fine-scale estimate of the actual area occupied. In some cases, A00 is the smallest area essential at any stage to the survival of existing subpopulations of a taxon (e.g., breeding sites for migratory species).</p>				

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
<b>Trend</b>	Contracted historically; stable over the last 3 generations; likely to contract following next threatening event			<p>Using the same reasoning as 'EOO' (above), AOO is considered to have contracted historically, but been stable over the last 3 generations.</p> <p>As threats are ongoing, AOO is likely to contract following the next threatening event (e.g., salmonid incursion, sedimentation following fire, severe drought, etc.) (See Criterion 2).</p>
<b>Number of subpopulations</b>	1	1	>1	<p>There is 1 known wild subpopulation in a single stream with no barriers to connectivity among recorded sites (Raadik 2011; 2014; Raadik 2021. pers comm 19 October).</p> <p>Further surveys of the headwaters reaches of the Macalister River catchment and the adjacent Wonnangatta River catchment are required to identify if any further remnant subpopulations exist and accurately delineate the small distribution of this species (Raadik 2011, 2014). These surveys have been partly completed; no additional subpopulations have been found (Raadik 2021. pers comm 19 October).</p> <p>Given the distribution of <i>Galaxias</i> species and salmonids are usually mutually exclusive (e.g. Tilzey 1976; Lintermans 2000), and salmonids are widely distributed throughout Vic waterways, a precautionary approach (1 subpopulation) has been taken in this assessment.</p> <p>Although 1 translocated subpopulation has begun to reproduce and increase in abundance in an adjacent catchment to Shaw Creek (Raadik 2021. pers comm 19 October); it is too early to determine if it is self-sustaining or evolutionarily viable (Threatened Species Recovery Hub 2018). Accordingly, the translocated subpopulation has not been included in the assessment of the Shaw galaxias against the listing criteria (see Criterion 1).</p>
<b>Trend</b>	Declined historically; stable over the last 3 generations; likely to decline following next threatening event			<p>Using the same reasoning as 'EOO' (above), the number of subpopulations is considered to have declined historically but been stable over the last 3 generations.</p> <p>Incursion of introduced salmonids is a serious risk to the extant wild subpopulation, which could result in extirpation.</p>
<b>Basis of assessment of subpopulation number</b>	See justification for number of subpopulations.			
<b>No. locations</b>	1	1	1	<p>There is a single subpopulation in a single stream with no barriers to connectivity among recorded sites (Raadik 2011; 2014; Raadik 2021. pers comm 19 October). Accordingly, all individuals could be rapidly affected by a single threatening event (e.g., incursion of introduced salmonids).</p> <p>One location has been used in this assessment.</p>

<b>Metric</b>	<b>Estimate used in the assessment</b>	<b>Minimum plausible value</b>	<b>Maximum plausible value</b>	<b>Justification</b>
<b>Trend</b>	Stable			One location has been used in this assessment, so it is not possible for the number of locations to decline any further.
<b>Basis of assessment of location number</b>	See justification for number of locations.			
<b>Fragmentation</b>	Although the species distribution is suspected to have been fragmented by introduced salmonids (see Criterion 1), the species does not meet the requirements to be considered 'severely fragmented'. The species now only occurs within a very restricted distribution in a single stream with no barriers to connectivity among recorded sites (Raadik 2011, 2014; Raadik 2021. pers comm. 19 October).			
<b>Fluctuations</b>	There are no known extreme fluctuations in EOO, AOO, number of subpopulations, locations or number of mature individuals.			



**Criterion 1 Population size reduction**

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	<b>Critically Endangered Very severe reduction</b>	<b>Endangered Severe reduction</b>	<b>Vulnerable Substantial reduction</b>
<b>A1</b>	≥ 90%	≥ 70%	≥ 50%
<b>A2, A3, A4</b>	≥ 80%	≥ 50%	≥ 30%
<p><b>A1</b> 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><b>A2</b> 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><b>A3</b> 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><b>A4</b> 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>Based on any of the following</p> <ul style="list-style-type: none"> <li>(a) direct observation [except A3]</li> <li>(b) an index of abundance appropriate to the taxon</li> <li>(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat</li> <li>(d) actual or potential levels of exploitation</li> <li>(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites</li> </ul>			

**Criterion 1 evidence****Eligible under Criterion 1 A2bce+3ce for listing as Critically Endangered****Generation length**

The generation length of the Shaw galaxias is unknown. However, it is likely to be similar to that of other species in the mountain galaxias complex, which is between two and four years (Allen et al. 2002; Raadik 2019a). This gives an estimated three-generation period of 6–12 years. However, given the minimum timeframe is 10 years, a timeframe of 10–12 years was used for this criterion.

**Exclusion of translocated subpopulation from listing assessment**

The IUCN criteria should be applied to wild subpopulations, as well as self-sustaining translocations, if the latter have produced viable offspring and at least five years have passed since translocation (IUCN 2019).

Although one translocated subpopulation has begun to reproduce and is increasing in abundance in an adjacent catchment to Shaw Creek (Raadik 2021. pers comm 19 October); it is too early to determine if it is self-sustaining or evolutionarily viable (Threatened Species Recovery Hub 2018). The subpopulation has not been established for longer than two generations and other translocated galaxiid subpopulations have disappeared for unknown reasons before reaching three generations (Raadik 2021. pers comm 19 October). Additionally, genetic analysis of the subpopulation's viability has not yet been conducted (Raadik 2021. pers comm 19 October).



Given the very small population size of this species (resulting in a genetically impoverished founder population) and the tendency of galaxiid translocations to fail for unknown reasons, a precautionary approach has been taken in this assessment. Accordingly, the translocated subpopulation has not been included in the assessment of the Shaw galaxias against the listing criteria.

### **Historical population reduction (prior to 2009)**

Predation on *Galaxias* species by introduced salmonids has been implicated in the decline of *Galaxias* species throughout Australia, including other members of the mountain galaxias complex (Tilzey 1976; Wager & Jackson 1993; Cadwallader 1996; Lintermans 2000; McDowall 2006; Lintermans 2013; Lintermans et al. 2020). The distributions of *Galaxias* species and salmonids are usually mutually exclusive (e.g. Tilzey 1976; Lintermans 2000) and the role of salmonids in the fragmentation of *Galaxias* subpopulations has been well documented in Australia (Lintermans 2000; Raadik & Kuitert 2002; Green 2008).

In the 1960s, the species' distribution extended at least 12 km further downstream of the type locality (and possibly into the mid-reaches of the Caledonia River system) (Raadik 2014). However, by 2002, the Shaw galaxias was absent from a site, approximately 400 m downstream of the type locality (below a small instream barrier), where the predatory brown trout was abundant (Raadik 2011, 2014). Additionally, surveys of the headwaters reaches of the Macalister River catchment and the adjacent Wonnangatta River catchment (only partly complete), have not found any additional subpopulations (Raadik 2021. pers comm 19 October). This suggests the species underwent population reduction and range contraction during the late 20<sup>th</sup> century following the incursion of introduced salmonids (Raadik 2011, 2014), but this is outside the timeframe relevant to this criterion.

### **Past population reduction (2009-11 to 2021)**

Following this historical decline, the species is now only known from a single subpopulation in the headwaters of Shaw Creek (Raadik 2011, 2014). Between 2010 and 2011, high flows eroded an instream barrier, allowing the brown trout to invade and colonise the headwaters of Shaw Creek (Raadik 2014). Density of the Shaw galaxias declined by approximately 98 percent between 2008–2013 following salmonid incursion (Raadik 2021). By May 2012, only 150 individuals (mature and juvenile) remained in three small pools in a sphagnum bog in the headwaters of a side tributary (300 m long, 0.3 m wide) and one further single mature individual was found in the headwaters of separate side tributary (Raadik 2014).

From 2013–2017, several temporary and permanent artificial, instream barriers were installed, and brown trout were removed from above the barriers via electrofishing (DEPI 2013; Raadik 2014; Raadik 2021. pers comm 19 October). The area upstream of the instream barriers is currently trout-free (Raadik 2021. pers comm 19 October). Monitoring data (collected annually from 2013–2021) suggests that the density of the Shaw galaxias has fluctuated among years (from 2013–2021) but has remained >80 percent lower than the density estimates prior to salmonid incursion (in 2002 and 2008) (Raadik 2021). This suggests that very severe population reduction has occurred within the last three generations (2009-11 to 2021). As such, the species appears to meet the requirements for listing as Critically Endangered under A2 (past reduction).

### **Future population reduction (2021 to 2031-33)**

The Shaw galaxias was not impacted by the 2019-20 bushfires. However, the species is projected to undergo further very severe decline following future threatening events (particularly incursion of introduced salmonids, sedimentation following fire and severe drought), based on:

- Observed very severe past reduction of the Shaw galaxias following the incursion of introduced salmonids in 2010–2011 (Raadik 2011, 2014);
- Observed/inferred very severe reduction of other *Galaxias* species, including other members of the mountain galaxias complex, following the incursion of introduced salmonids (Tilzey 1976; Wager & Jackson 1993; Cadwallader 1996; Lintermans 2000; McDowall 2006; Lintermans 2013; Lintermans et al. 2020); and
- Observed very severe reduction of other *Galaxias* species in the mountain galaxias complex, due to sedimentation following fires and from poorly constructed tracks at river crossings, and drought stress (Raadik & Nicol 2013; Raadik & Nicol 2015).

A threatening event of this type (i.e., incursion of introduced salmonids, sedimentation following fire or severe drought) is considered likely to occur in the catchment where the Shaw galaxias occurs, within the next three generations. Both the brown trout and the rainbow trout are present in Shaw Creek downstream of an artificial instream barrier, which prevents their incursion into the area occupied by the Shaw galaxias (DEPI 2013; Raadik 2014). Rapid and very severe population decline (with possible extinction) is anticipated following further incursion or stocking beyond the natural barrier (Threatened Species Recovery Hub 2018; Lintermans et al. 2020). This could occur through natural drown-out in high flow events or illegal translocation/stocking (either deliberately or accidentally) by anglers (Threatened Species Recovery Hub 2018).

Additionally, increased temperatures, change to precipitation patterns and more extreme weather events (driven by climate change) are likely to cause decline in the species. Changes to rainfall patterns and temperatures are predicted to cause decreased surface run-off, which will impact the hydrology of small headwater streams (e.g., lower water levels and higher water temperatures) with increasing severity and frequency (Döll & Zhang 2010; DSE 2011b; Arnell & Gosling 2013; CSIRO & Bureau of Meteorology 2015; DELWP 2020). The increased frequency and severity of bushfires is likely to cause long-term changes to water quality and threaten the persistence of native fish (Shu-ren 2003; Whitney et al. 2015), e.g. via increased sedimentation, which can smother and infill coarse substrate in the streambed (described above, e.g. Lyon & O'Connor 2008). Further, the increasing frequency of extreme rainfall events is likely to increase stream bank erosion and sedimentation, alter water quality and potentially drown out instream barriers facilitating salmonid incursion (Magilligan et al. 2015; Threatened Species Recovery Hub 2018; Ross et al. 2019; DELWP 2020; Lintermans et al. 2020). Further information about these threats is available in Table 1.

One or more of these events is projected to occur within the next three generations and is projected to result in very severe population reduction (>80 percent) of the Shaw galaxias. This is supported by the expert elicitation conducted by Lintermans et al. (2020), which predicted that the Shaw galaxias is the Australian fish at greatest risk of extinction, with >80 percent probability of extinction by 2040 without additional conservation actions.

As such, the species appears to meet the requirements for listing as Critically Endangered under A3 (future reduction).

### **Conclusion**

The species is estimated to have undergone very severe population reduction (>80 percent) within the last three generations and is projected to undergo further very severe population reduction (>80 percent) within the next three generations. The cause has not ceased. The data presented above appear to demonstrate that the species is eligible for listing as **Critically Endangered** under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

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**Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy**

	Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
<b>B1.</b> Extent of occurrence (EOO)	< 100 km <sup>2</sup>	< 5,000 km <sup>2</sup>	< 20,000 km <sup>2</sup>
<b>B2.</b> Area of occupancy (AOO)	< 10 km <sup>2</sup>	< 500 km <sup>2</sup>	< 2,000 km <sup>2</sup>
<b>AND at least 2 of the following 3 conditions:</b>			
(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			

**Criterion 2 evidence**

**Eligible under Criterion 2 B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v) for listing as Critically Endangered**

**Exclusion of translocated subpopulation from listing assessment**

As indicated under Criterion 1, the translocated subpopulation has not been included in the assessment of the Shaw galaxias against the listing criteria.

**Extent of occurrence (EOO) and area of occupancy (AOO)**

The EOO and AOO are estimated at 4 km<sup>2</sup>. These figures are based on the mapping of point records from 1998–2014, obtained from state governments, museums and CSIRO. The AOO was calculated using a 2 x 2 km grid cell method (IUCN 2019). As EOO was smaller than AOO, the AOO estimate was also used as the EOO estimate in this assessment (see Table 3) (IUCN 2019).

The species' EOO and AOO appear to meet the requirements for listing as Critically Endangered under B1 (<100 km<sup>2</sup>) and under B2 (<10 km<sup>2</sup>).

### Number of locations

There is a single subpopulation in a single stream with no barriers to connectivity among recorded sites (Raadik 2011; 2014; Raadik 2021. pers comm 19 October). Accordingly, all individuals could be rapidly affected by a single threatening event (e.g., incursion of introduced salmonids) (Threatened Species Recovery Hub 2018; Lintermans et al. 2020). This could occur through natural drown-out in high flow events or illegal translocation/stocking (either deliberately or accidentally) by anglers (Threatened Species Recovery Hub 2018). The number of locations used in this assessment is one. The species' number of locations appears to meet the requirement for listing as Critically Endangered under this criterion.

### Continuing decline

As described in Criterion 1, the Shaw galaxias' distribution extended at least 12 km further downstream of the type locality (and possibly into the mid-reaches of the Caledonia River system), prior to the inferred range contraction during the late 20<sup>th</sup> century (following the incursion of introduced salmonids) (Raadik 2011, 2014). Accordingly, the EOO, AOO, area, extent and/or quality of habitat, and number of subpopulations and mature individuals are likely to have declined over this time period.

Additionally, the Shaw galaxias population underwent very severe reduction between 2008–2013 following salmonid incursion (Raadik 2021), suggesting decline in area, extent and/or quality of habitat, and number of mature individuals over this time period. As there was only a single subpopulation which was not extirpated, EOO, AOO and number of subpopulations did not decline.

Although EOO, AOO, area, extent and/or quality of habitat, and number of subpopulations and mature individuals appear to be relatively stable currently (see Criterion 1), the species is projected to undergo further very severe decline should similar threatening events occur in the very restricted distribution of the single remaining subpopulation (particularly incursion of introduced salmonids, sedimentation following fire and severe drought), based on:

- Observed very severe past reduction of the Shaw galaxias following the incursion of introduced salmonids in 2010–2011 (Raadik 2011, 2014);
- Observed/inferred very severe reduction of other *Galaxias* species, including other members of the mountain galaxias complex, following the incursion of introduced salmonids (Tilzey 1976; Wager & Jackson 1993; Cadwallader 1996; Lintermans 2000; McDowall 2006; Lintermans 2013; Lintermans et al. 2020); and
- Observed very severe reduction of other *Galaxias* species in the mountain galaxias complex, due to sedimentation following fires and from poorly constructed tracks at river crossings, and drought stress (Raadik & Nicol 2013; Raadik & Nicol 2015).

A threatening event of this type (i.e., incursion of introduced salmonids, sedimentation following fire or severe drought) is considered likely to occur in the catchment where the Shaw galaxias occurs, within the next three generations (see Criterion 1 – future population reduction). In particular, rapid and very severe population decline (with possible extinction) is anticipated following further incursion or stocking of introduced salmonids beyond the natural barrier (Threatened Species Recovery Hub 2018; Lintermans et al. 2020). This would result in likely extinction of the species, and therefore would constitute continuing decline in EOO, AOO, area, extent and/or quality of habitat, and number of subpopulations and mature individuals.

Additionally, the species' very restricted distribution and very small population size (impacting inbreeding, genetic drift, etc.) render it more vulnerable to reduced genetic diversity and genetic decline (Frankham et al. 2002; IUCN 2012). Genetic diversity is an important factor influencing a population's persistence (Frankham 2005; Bouzat 2010) and populations lacking genetic diversity often have higher rates of extinction (Markert et al. 2010). Lintermans et al. (2020) used expert elicitation to predict that the Shaw Galaxias is the Australian fish at greatest risk of extinction, with >80 percent probability of extinction by 2040 without additional conservation actions. Additionally, preliminary results from population genetic analysis indicate that the Shaw galaxias has lost most of its genetic diversity and has a high level of inbreeding, which restricts its' evolutionary potential (Raadik 2021. pers comm 19 October). This is another factor that could cause continuing decline in EOO, AOO, and number of subpopulations and mature individuals.

The species appears to be undergoing continuing decline in EOO, AOO, area, extent and/or quality of habitat, and number of subpopulations and mature individuals. Accordingly, the species appears to meet the continuing decline requirement for listing under this criterion.

### **Severe fragmentation**

Although the species distribution is suspected to have been fragmented by introduced salmonids (see Criterion 1), the species does not meet the requirements to be considered 'severely fragmented'. The species now only occurs within a very restricted distribution in a single stream with no barriers to connectivity among recorded sites (Raadik 2011, 2014; Raadik 2021. pers comm. 19 October). The species does not appear to meet the severe fragmentation requirement for listing under this criterion.

### **Extreme fluctuations**

The density of the Shaw galaxias has fluctuated among years (Raadik 2021); however, these fluctuations do not meet the requirements to be considered 'extreme fluctuations' (IUCN 2019). There are no known extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals. The species does not appear to meet the extreme fluctuations requirement for listing under this criterion.

## Conclusion

The species' EOO, AOO and number of locations appear to be very restricted; and EOO, AOO, area, extent and/or quality of habitat, number of subpopulations and mature individuals appear to be undergoing continuing decline. The data presented above appear to demonstrate that the species is eligible for listing as **Critically Endangered** under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

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**Criterion 3 Population size and decline**

	<b>Critically Endangered Very low</b>	<b>Endangered Low</b>	<b>Vulnerable Limited</b>
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
<b>C1.</b> An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	<b>Very high rate 25% in 3 years or 1 generation (whichever is longer)</b>	<b>High rate 20% in 5 years or 2 generation (whichever is longer)</b>	<b>Substantial rate 10% in 10 years or 3 generations (whichever is longer)</b>
<b>C2.</b> An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) (ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

**Criterion 3 evidence****Eligible under Criterion 3 C2a(i,ii) for listing as Critically Endangered****Exclusion of translocated subpopulation from listing assessment**

As indicated under Criterion 1, the translocated subpopulation has not been included in the assessment of the Shaw galaxias against the listing criteria.

**Number of mature individuals**

Based on monitoring data from 2013–2021, the number of mature individuals is estimated to be approximately 30–100 (midpoint = 65) (Raadik 2021). This estimate is low confidence, as it has been derived from density estimates for the total population (i.e., including juveniles) from 2013–2021. Density estimates fluctuate among years; these fluctuations are likely to be an artefact of sampling and not likely to represent actual change in the population size. However, this variability introduces some error into the mature individuals estimate (above). Additionally, it is difficult to determine maturity in the field, as juveniles and adults appear superficially similar and length at maturity can vary among individuals. This introduces further error into the mature individuals estimate (above).



Given that continuing decline is likely to be occurring and the monitoring estimates are low confidence, a precautionary approach has been taken in this assessment and the number of mature individuals is considered to be <50 (i.e., fewer than the midpoint estimated from monitoring data). The number of mature individuals appears to meet the requirements for listing as Critically Endangered (<250).

### **Continuing decline**

As discussed in Criterion 2 (see above), the species appears to be undergoing continuing decline in the number of mature individuals. The species appears to meet the C2 continuing decline requirement for listing under this criterion.

### **Number/proportion of mature individuals**

The Shaw galaxias is known from a single subpopulation in the headwaters of Shaw Creek (Raadik 2011, 2014). Accordingly, 100 percent of individuals occur in one subpopulation. Additionally, given that continuing decline is likely to be occurring and the monitoring estimates are low confidence, a precautionary approach has been taken in this assessment and the number of mature individuals in the subpopulation is considered to be <50 (i.e., fewer than the midpoint estimated from monitoring data). The species appears to meet these requirements for listing under this criterion.

### **Extreme fluctuations**

There are no known extreme fluctuations in the number of mature individuals (see Criterion 2). The species does not appear to meet the extreme fluctuations requirement for listing under this criterion.

### **Conclusion**

The number of mature individuals is <50 (with 100 percent of individuals in a single subpopulation) with continuing decline. The data presented above appear to demonstrate that the species is eligible for listing as **Critically Endangered** under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

**Criterion 4 Number of mature individuals**

	<b>Critically Endangered Extremely low</b>	<b>Endangered Very Low</b>	<b>Vulnerable Low</b>
<b>D. Number of mature individuals</b>	< 50	< 250	< 1,000
<b>D2.<sup>1</sup> Only applies to the Vulnerable category</b> 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: area of occupancy < 20 km <sup>2</sup> or number of locations ≤ 5

<sup>1</sup> The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the [common assessment method](#).

**Criterion 4 evidence****Eligible under Criterion 4 D for listing as Critically Endangered****Exclusion of translocated subpopulation from listing assessment**

As indicated under Criterion 1, the translocated subpopulation has not been included in the assessment of the Shaw galaxias against the listing criteria.

**Number of mature individuals**

As explained under Criterion 3, a precautionary approach has been taken in this assessment and the number of mature individuals is considered to be <50. The species appears to meet the requirements for listing under this criterion.

Species cannot be listed under Criterion D2 under the EPBC Act (see <sup>1</sup>).

**Conclusion**

The number of mature individuals is likely to be fewer than 50. The data presented above appear to demonstrate that the species is eligible for listing as **Critically Endangered** under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

## Criterion 5 Quantitative analysis

	<b>Critically Endangered Immediate future</b>	<b>Endangered Near future</b>	<b>Vulnerable Medium-term future</b>
<b>Indicating the probability of extinction in the wild to be:</b>	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

## Criterion 5 evidence

### Insufficient data to determine eligibility

#### Exclusion of translocated subpopulation from listing assessment

As indicated under Criterion 1, the translocated subpopulation has not been included in the assessment of the Shaw galaxias against the listing criteria.

#### Population viability analysis

Population viability analysis has not been undertaken for the Shaw galaxias.

#### Conclusion

There are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

### Adequacy of survey

The survey effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

## Listing and Recovery Plan Recommendations

A decision about whether there should be a Recovery Plan for this species has not yet been made. The purpose of this consultation document is to elicit additional information to help inform the decision.

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### Cataloguing data

This publication (and any material sourced from it) should be attributed as: Department of Agriculture, Water and the Environment 2022, *Conservation advice for Galaxias gunaikurnai (Shaw galaxias)*, Canberra.



This publication is available at the [SPRAT profile for Galaxias gunaikurnai \(Shaw galaxias\)](#)

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### Acknowledgements

The Department would like to acknowledge Dr. Tarmo A. Raadik (DELWP) for their information and advice to support the assessment.

### Version history table

Document type	Title	Date [dd mm yyyy]
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-	-	-