DEPARTMENT OF PRIMARY INDUSTRIES AND WATER

Threatened Tasmanian Galaxiidae

Recovery Plan 2006 - 2010

Australian Government

Tasmania

Disclaimer

This recovery plan has been prepared under the provisions of both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Tasmanian *Threatened Species Protection Act 1995* (TSP Act). There are 11 Galaxiidae species covered in this plan, of which 7 are listed as threatened under both State and Commonwealth legislation and four are listed under the TSP Act only. All but one species covered by this plan are endemic to Tasmania. For *Galaxiella pusilla*, which also occurs in Victoria and South Australia, this plan addresses the Tasmanian populations only. Adoption as a national recovery plan under the EPBC Act only refers to species listed under the EPBC Act.

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The listing status of all threatened species referred to in this recovery plan were correct at the time of publication.

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Contents

Summary

This recovery plan includes all 11 threatened species of Galaxiidae (freshwater fish) in Tasmania, almost half of the 25 Tasmanian native freshwater fish species. It describes the species' biology, distribution, conservation status, threats and the recovery objectives and actions to achieve them over the next five years. The plan replaces the 1997 plan for five species (Crook and Sanger 1997) which has been implemented from 1998 - 2002. This plan will remain operative until superseded by a revised plan.

The only Tasmanian threatened freshwater fish not covered by this plan is the Australian grayling *Prototroctes maraena.*

Abbreviations

DPIW	Department of Primary Industries and Water (Tasmania)
DPIWE	Department of Primary Industries, Water and Environment (Tasmania)
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
IFS	Inland Fisheries Service Tasmania
PWS	Parks and Wildlife Service
TSP Act	Tasmanian *Threatened Species Protection Act 1995*
WHA	Tasmanian Wilderness World Heritage Area

Species and Status

Species	**Status (EPBC Act 1999)**	**Status (TSP Act 1995)**	**Distribution**
Pedder galaxias (*Galaxias pedderensis*)	Extinct in the wild	endangered	Tasmania
Swan galaxias (*Galaxias fontanus*)	Endangered	endangered	Tasmania
Clarence galaxias (*Galaxias johnstoni*)	Endangered	endangered	Tasmania
Swamp galaxias (*Galaxias parvus*)		rare	Tasmania
Saddled galaxias (*Galaxias tanycephalus*)	Vulnerable	endangered	Tasmania
Golden galaxias (*Galaxias auratus*)	Endangered	rare	Tasmania
Arthurs paragalaxias (*Paragalaxias mesotes*)	Endangered	endangered	Tasmania
Shannon paragalaxias (*Paragalaxias dissimilis*)		vulnerable	Tasmania
Great Lake paragalaxias (*Paragalaxias eleotroides*)		vulnerable	Tasmania
Western paragalaxias (*Paragalaxias julianus*)		rare	Tasmania
Dwarf galaxias (*Galaxiella pusilla*)	Vulnerable	rare	Tasmania, Victoria, South Australia

Habitat Requirements and Threats

All 11 species are non-diadromous i.e. they complete their life cycle in freshwater. They have naturally very limited distributions and have declined and/or are at risk of future decline due to introduced species and/or loss or degradation of habitat. These threats apply in different ways for the different species.

Objectives, Performance Criteria and Actions

The overall objective of recovery actions for all species in this plan is to ensure the long-term survival of the species in the wild (or in *ex-situ* sites for Pedder galaxias), by minimising the effects of threatening processes. Conservation status will be improved by ensuring no further decline in the extent of occurrence, area of occupancy, number and connectivity of populations, and number of mature individuals, and by increasing these criteria where feasible. Improvement to the extent of downlisting is not achievable for those species of naturally very restricted distribution with threats that cannot be completely controlled (e.g. illegal introductions of introduced fish which are likely to cause catastrophic decline). Due to category definitions, they will continue to meet the criteria for listing with at least the present status. This applies to all the species in this plan, including dwarf galaxias if only the Tasmanian distribution is considered.

Recovery Plan Objectives	Performance Criteria	Actions
1. To protect existing populations.	No decline in area of occupancy, extent of occurrence, number or connectivity of populations or number of mature individuals.	• Coordinate implementation of recovery program. • Monitor populations for health and security from threats. • Research to determine habitat requirements. • Manage habitat to minimise threats. • Manage recreational and commercial fisheries and pest fish to minimise threats.
2. To increase public awareness and involvement in the recovery process.	The local community is aware of and involved in the recovery process.	• Develop and implement a communications strategy. • Maintain the recovery team links with the community.
3. To maximise area of occupancy (as appropriate within environmental and practical constraints).	Area of occupancy (number and/ or size of populations) has increased.	• Survey for new populations and/or suitable translocation sites. • Undertake habitat rehabilitation (e.g. removal and exclusion of introduced species). • Reintroduce/allow expansion into rehabilitated sites. • Prepare translocation proposals and implement if required.
4. Maintain genetic structure and diversity.	Intraspecific genetic structure and diversity has been determined and used to inform conservation management.	• Research species genetics. • Consider genetic implications in management decisions.

Estimated Cost of Recovery

2006 prices in $ 000s

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Coordination; Information	62	56	56	56	56	286
Pedder galaxias	36	31	22	22	27	138
Swan galaxias	24	29	12	10	10	85
Clarence galaxias	35	35	11	11	11	103
Swamp galaxias	20	26	10	10	10	76
Saddled galaxias	43	38	22	21	21	145
Golden galaxias	38	43	34	34	34	183
Arthurs paragalaxias	13	13	0	0	0	26
Shannon paragalaxias	15	22	15	10	10	72
Great Lake paragalaxias	0	19	8	0	0	27
Western paragalaxias	25	20	10	10	10	75
Dwarf galaxias	28	30	13	13	13	97
Total	**339**	**362**	**213**	**197**	**202**	**1313**

Biodiversity Benefits

Broader biodiversity benefits arising from implementation of this plan include conservation of aquatic communities sharing habitat with the threatened fish species through habitat protection actions, and increased public awareness of all types of aquatic fauna and habitats and their conservation needs.

Achievements of the previous recovery plan are detailed under each species but include:

- No further decline in extent of occurrence, area of occupancy or number of populations;
- Extension of the above by discovery of several previously unknown/ unidentified populations;
- Extension of the above by translocation to an additional site for Pedder galaxias;
- Increased habitat protection by negotiations with land managers;
- Increased security of populations at risk from trout invasion, by barrier construction;
- Increased security of populations at risk from human-induced trout introduction, by placement of informative signage;
- Population protection by trout removal;
- Increased knowledge of captive breeding methods;
- Increased public awareness of threatened freshwater fish and their needs.

1. Background Information

Freshwater fish of the family Galaxiidae are generally small (40-270 mm long), elongate scaleless freshwater fish with a single soft-rayed dorsal fin generally set well back on the body. Representatives of the family occur throughout the southern hemisphere, including South Africa, South America, New Zealand, Australia, Lord Howe Island and New Caledonia (McDowall 1996). There is a high diversity in Tasmania with 15 species (Fulton 1990).

This recovery plan includes all the freshwater fish species of the family Galaxiidae listed as threatened in Tasmania under the *Threatened Species Protection Act 1995* (11 species). This constitutes almost half of the 25 Tasmanian native freshwater fish species. All but one galaxiid species (*Galaxiella pusilla*) are endemic to Tasmania and all are non-diadromous (i.e. without a marine stage in the life cycle). Seven of the species are also nationally listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

This plan describes the species conservation status, distribution, biology and recovery objectives and actions necessary to ensure their long-term survival. It continues the recovery work for five species implemented under previous plans (Gaffney *et al.* 1992, Sanger 1993, Crook and Sanger 1997) and includes the five additional State-listed species and the nationally-listed dwarf galaxias. These additional species are not subject to any other conservation activities although some management procedures are in place to minimise some land and water use impacts. The land tenures on which the species occur are shown in Table 1. Land managers are Forestry Tasmania, Hydro Tasmania, Tasmanian Parks and Wildlife Service, DPIW (crown lands) and private owners. The Tasmanian Inland Fisheries Service is responsible for management of all inland aquatic fauna that throughout its ordinary life lives in water. Species distribution in relation to Tasmanian Natural Resource Management regions is shown in Figure 1. Indigenous communities involved in the regions affected by this plan have not yet been identified. Implementation of recovery actions under this plan will include consideration of the role and interests of indigenous communities in biodiversity conservation. The implementation of this plan is unlikely to cause significant adverse social and economic impacts. In cases where such impacts may potentially occur, they will be assessed as part of feasibility studies, as detailed under specific actions.

Table 1. Land tenure of catchment areas occupied by threatened galaxiid species (approximate %).

Species:	PG	SwG	CG	SmpG	SaG	GG	APa	SPa	GLPa	WPa	DwG
Reserve[1]	90	4	41	95.4	20	3	20	59.2	59.2	98	6
Other public[2]	10	0	0.07	3.3	41	1.5	41	23.8	23.8	1.6	13
S Forest[3]	0	85	48	1.3	10	26.5	10	0	0	0	30
Private	0	12	11	0	29	69	29	17	17	0.4	51
Total (ha)	200	18175	5704	48000	25000	13340	25000	27000[4]	27000[4]	25000	48000[5]

PG Pedder galaxias; SwG Swan galaxias; CG Clarence galaxias; SmpG swamp galaxias; SaG saddled galaxias; GG golden galaxias; APa Arthurs paragalaxias; SPa Shannon paragalaxias; GLPa Great Lake paragalaxias; WPa western paragalaxias; DwG dwarf galaxias.

1 Reserves include formal reserves such as National Parks, Conservation Areas and Forest Reserves.
2 Other public includes crown land, Hydro land etc. Recently sold Hydro land remains in this category although it is now private (details are not available).
3 State Forest includes areas that may be in informal management reserves.
4 Not including the Western Lakes catchment (see WPa), linked to Great Lake by Liawenee canal.
5 Areas are very approximate due to poorly defined drainage boundaries in flat topography.

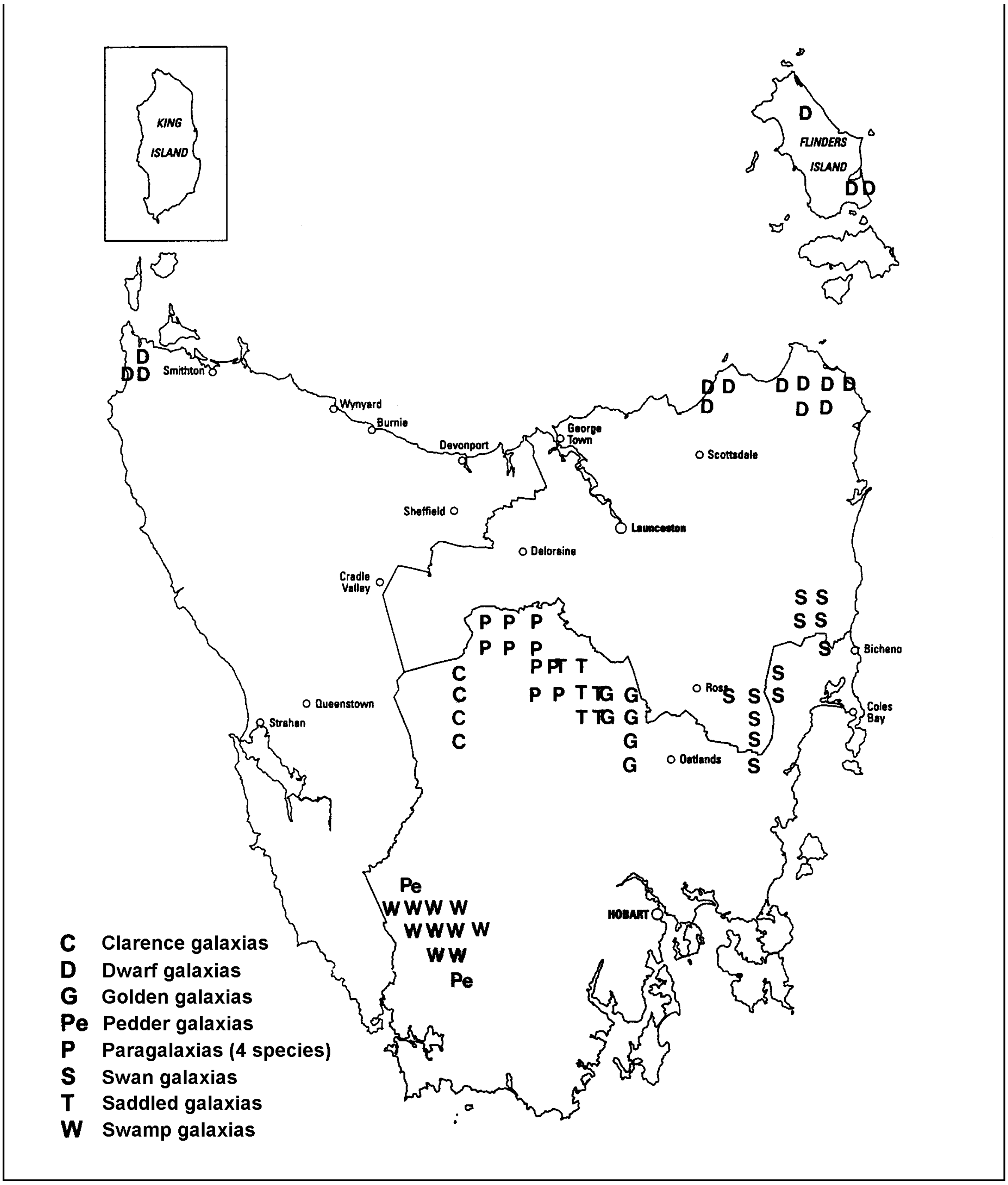

Figure 1. Distribution of threatened galaxiids, by 10 km^2 grid, in relation to Tasmanian Natural Resource Management Regions. Base map produced by Tasmap.

Broader biodiversity benefits arising from implementation of this plan include conservation of aquatic communities sharing habitat with the threatened fish species through habitat protection actions, and increased public awareness of all types of aquatic fauna and their conservation needs.

The plan is consistent with relevant legislation and management documents: Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Tasmanian *Threatened Species Protection Act 1995, National Parks and Reserves Management Act 2002, Inland Fisheries Act 1995,* Tasmanian Threatened Species Strategy (Parks and Wildlife Service 2000), Tasmania's Nature Conservation Strategy 2002-2006 (DPIWE 2002a), Tasmanian Wilderness World Heritage Area Management Plan (Parks and Wildlife Service 1999), Western Lakes Fishery Management Plan (IFS 2002), Great Lake Fishery Management Plan (IFS 2004), Draft Swan-Apsley Catchment Management Plan (D'Emden 2002), *Tasmanian Regional Forest Agreement 1997*.

Achievements of the previous plan are detailed under each species but include:

- No further decline in extent of occurrence, area of occupancy or number of populations;
- Extension of the above by discovery of previously unknown/unidentified populations;
- Extension of the above by translocation to an additional site for Pedder galaxias;
- Increased habitat protection by negotiations with land managers;
- Increased security of populations at risk from trout invasion, by barrier construction;
- Increased security of populations at risk from human-induced trout introduction, by placement of informative signage;
- Population protection by trout removal;
- Increased knowledge of captive breeding methods;
- Increased public awareness of threatened freshwater fish and their needs.

Recovery team

The Galaxias Recovery Team formed in 1996 includes representatives of the following stakeholders:

- Inland Fisheries Service (lead agency)
- Threatened Species Section DPIW (responsible agency)
- Anglers (community interest in freshwaters)
- Waterwatch (community interest in freshwaters)
- World Heritage Area managers DPIW and PWS (fauna & land managers)
- Hydro Tasmania (water & land managers)
- Forestry Tasmania (land managers)
- Forest Industries Association of Tasmania (forest industry)
- Forest Practices Authority (regulatory agency)
- Consultant (freshwater ecology expertise)

*1.1 Pedder galaxias (*Galaxias pedderensis*)*

1.1.1 Description of species

The Pedder galaxias is a slender, medium-sized galaxias species, growing to at least 170 mm in length. The colour of the upper body and sides is a light grey-brown with irregular dark blotches. Gold iridescence is often present on the back and sides. The ventral surface is a grey-white colour. The species is rather similar in appearance to the climbing galaxias (*Galaxias brevipinnis*), from which it differs in having a more bullet-shaped head with jaws of equal length rather than a dorsally-compressed wedge-shaped head with a distinctly undercut lower jaw, lack of the chevron-shaped markings on the side often seen in climbing galaxias, and relatively small pectoral fins rather than the large rounded ones of the climbing galaxias (Hamr 1992). In addition, Pedder galaxias is a fairly cryptic benthic species without the leaping and climbing behaviour of the climbing galaxias (Hamr 1992).

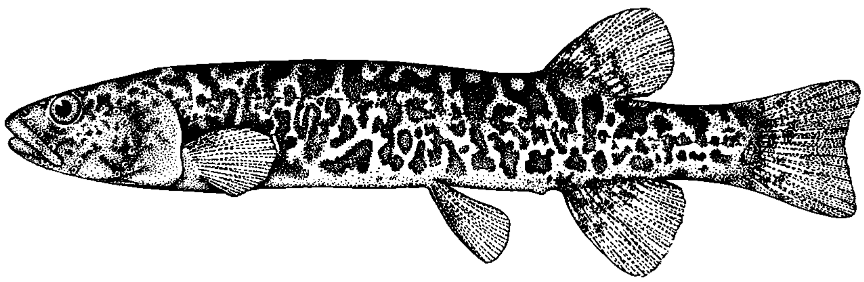

Figure 2. Pedder galaxias **Galaxias pedderensis**

1.1.2 Distribution

The Pedder galaxias is endemic to Tasmania and naturally occurred only in the original Lake Pedder and inflowing streams, tributaries of the upper Serpentine River and to a lesser extent in swampy pools near the lake (Andrews 1976, Frankenberg 1968, McDowall and Frankenberg 1981). These areas were shared with the swamp galaxias, *Galaxias parvus*. After inundation of Lake Pedder and most of the Serpentine River in 1972-74 for the Gordon Power Scheme, the Pedder galaxias was present in large numbers in the impoundment from 1975-80 and some tributaries (Figure 3) (Lake 1998, Hamr 1992) and was also recorded in McPartlan canal through which the Lake Pedder impoundment flows into the Gordon impoundment (IFS unpubl. data). However the species declined rapidly and could no longer be found in the impoundment after 1980 (Lake 1998).

The Pedder galaxias is now considered to be extinct in what remains of its natural habitat, i.e. tributaries of the Lake Pedder impoundment. Surveys in 1988-91 found Pedder galaxias in only 5 streams flowing onto Lake Pedder: Bonnet Bay creek 1 and 2; Pebbly Creek; Swampy Creek and Stillwater Rivulet. Only in the Bonnet Bay streams were more than one fish caught (Hamr 1992). Intensive surveys conducted under the previous recovery plans (Crook and Sanger 1997, Gaffney *et al.* 1992) have recorded only 10 individuals from the Bonnet Bay streams. Despite intensive annual electrofishing surveys of the impoundment and tributaries in good low flow conditions, no Pedder galaxias have been sighted or collected since 6th March 1996 (IFS unpubl. data), with annual surveys conducted until 2002.

A translocated population in Lake Oberon (43°09’S 146°16’E), established by introduction of 34 Pedder galaxias between 1991-1997, was confirmed to have become established in 1997 when juvenile fish were observed (Crook and Sanger 1997). Lake Oberon is outside the Lake Pedder catchment, in the Crossing-Davey catchment. This population is now thriving and Pedder galaxias also occur in a smaller lake

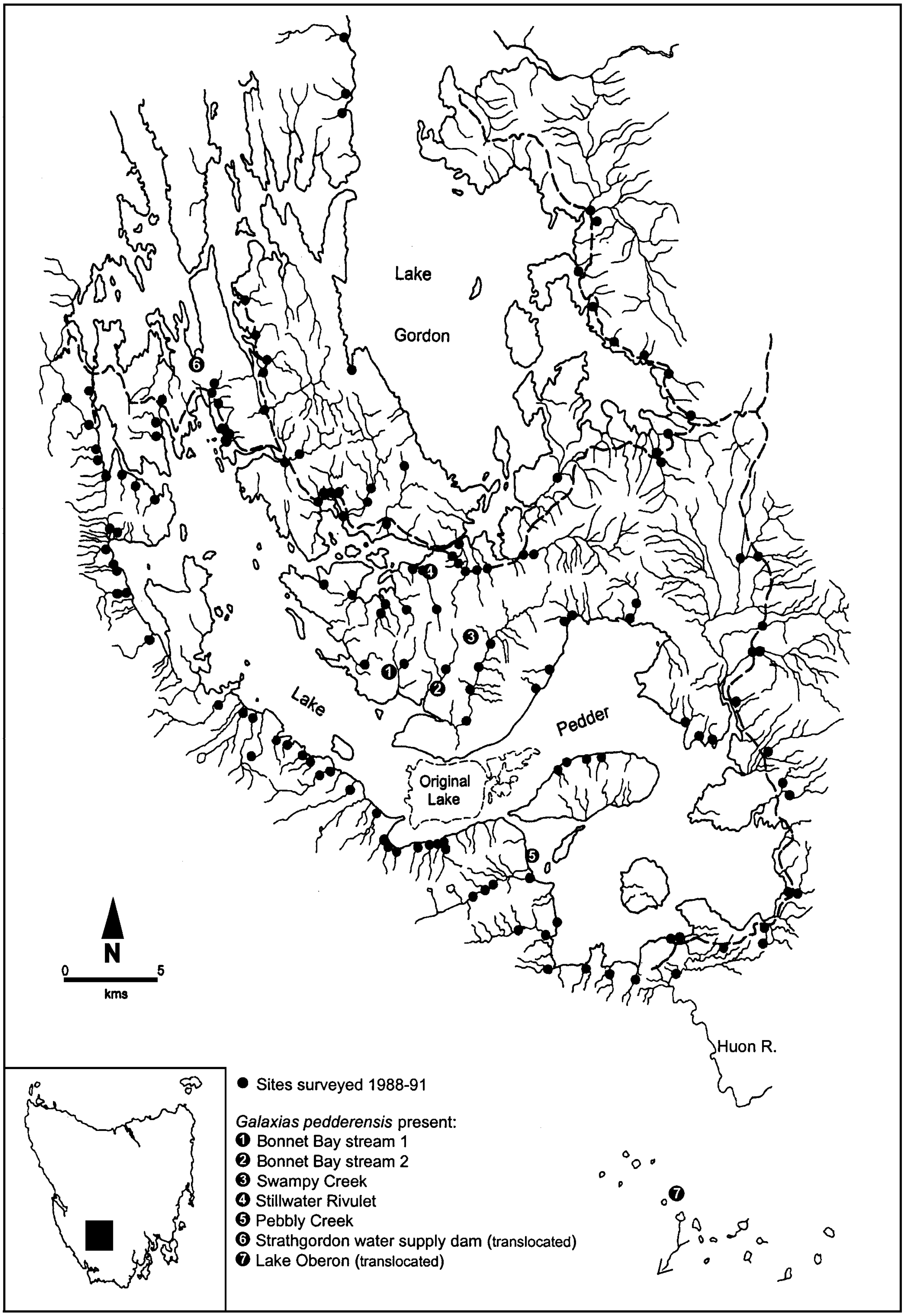

Figure 3. Distribution of Pedder galaxias

immediately downstream. It is not known whether they have also spread downstream to the Crossing River which appears to contain suitable habitat and is trout-free. Pedder galaxias have been moved from Lake Oberon to the Strathgordon water supply dam (42°45'40"S 146°03'20"E) with the aim of establishing a second population. No evidence of breeding has been observed there as of June 2004. Habitat critical to survival of the species is these two known localities including their surrounding catchments.

1.1.3 Habitat

The original Lake Pedder was shallow (depth approximately 3 m) with a predominantly sandy substrate, surrounded by swampy peaty plains. Most inflow streams were low gradient and meandering, as was the outflow Serpentine River. Several swampy pools occurred near the lake. Waters in the area are dark brown coloured by humic acids, of low turbidity and acidic (Buckney and Tyler 1973). Observations suggested that the lake acted as a nursery for juveniles while the adults lived mainly in the streams (Bayley *et al.* 1972).

Inundation of the lake along with the surrounding swamps, streams and upper Serpentine River resulted in a very large and relatively deep (> 20 m) impoundment. The steeper streams above inundation level were the only areas of natural habitat that remained unchanged after the flooding of Lake Pedder.

In the late 1970s before their decline, Pedder galaxias were reported to be abundant around the new impoundment, with schools of juveniles observed around the shores and adults common in inflowing streams (Frankenberg 1968, Andrews 1976). The natural habitat last occupied was the lower reaches of slow-flowing meandering streams, with generally sandy substrate, pools, overhanging banks and abundant cover, and dense overhanging vegetation (Hamr 1992).

Lake Oberon is an extremely deep lake (estimated up to 95 m) at 850 m altitude. Most of the shoreline is rocky and steep, except for two small sandy beaches on the north-western side. A meandering inflow stream flows into one of the beaches. Only two fish have been found in this stream during annual surveys, which have not been conducted at spawning time. The lake was chosen for translocation because it was free of fish, contained an abundant invertebrate food supply, has similar water chemistry and temperature to Lake Pedder, and has an inflowing stream which is thought necessary for spawning habitat (Hamr 1995).

The Strathgordon water supply dam was modified in 1997 by IFS and Hydro Tasmania to form suitable artificial habitat for Pedder galaxias. The dam was drained to confirm that no other fish species were present, the outflow was made secure from introduced fish invasion and screened to prevent escape of fish from the dam, an artificial inflow stream was constructed for spawning habitat and the dam shores were revegetated.

1.1.4 Life History and Ecology

The Pedder galaxias, like most stream-dwelling galaxias, is carnivorous and feeds primarily on terrestrial insects and aquatic insects and crustaceans. Spawning occurs in spring, as water temperatures begin to rise. It is thought that the original Lake Pedder served as nursery habitat for pelagic larvae and juveniles, with adults possibly requiring stream habitat for spawning. In an artificial stream, captive fish laid their eggs under flat rocks, aquatic vegetation and woody debris, with most batches laid in the stream section although a few were also laid in the pond section (Hamr 1992). In the Strathgordon water supply dam, a number of Pedder galaxias were observed in the artificial stream in September 2001. Pedder galaxias mature at approximately 2 years of age and most appear to breed at 3-4 years of age and live for up to 6 years. Females produce a relatively small number (200-1200) of large eggs (2.2-2.5 mm diameter). Eggs that were artificially fertilised after stripping took 22-30 days to hatch at 15-16°C. Larvae are approximately 10 mm long on hatching and in captivity fed on rotifers then small aquatic crustaceans (Hamr 1992).

1.1.5 Threats

The exact cause of the decline of Pedder galaxias is unclear but major impacts have come from loss of the lake and meandering stream habitat with inundation, introduction for recreational angling of predatory brown trout (*Salmo trutta*) to the new impoundment, and a dramatic expansion and increase in abundance of the native climbing galaxias *G. brevipinnis* in the impoundment and tributaries. The climbing galaxias is now the dominant fish in many of the impoundment tributaries (IFS unpubl. data) and can probably out compete Pedder galaxias for space and possibly food. The species has had negative impacts on similar non-migratory galaxiids after river impoundments in New Zealand (Allibone 1999). Having lost most of its original slow-flowing lowland habitat, Pedder galaxias is probably unable to compete against the introduced species in the remaining stream habitats (Gaffney *et al.* 1992). These threats continue to operate in what remains of the natural habitat.

The extant population in Lake Oberon is considered relatively secure but it may be threatened by genetic effects caused by the low number of fish from which the population is derived (34 individuals). The genetic structure of the species at present or before its decline has not been determined. Any long term changes to the food chain in Lake Oberon caused by the introduction of Pedder galaxias may also threaten the species. The current abundance in Lake Oberon may be a boom period, after which numbers may decline to sustainable levels as the food supply is depleted. Any introduction of other fish species would threaten the population but this is extremely unlikely to occur given the remote location of the lake.

The Pedder galaxias introduced into the Strathgordon water supply dam are not yet known to have established a breeding population. The site is fairly accessible and as such is at some risk of having other fish species illegally introduced.

1.1.6 Conservation status

In recent years the Pedder galaxias was in danger of becoming the first known Australian freshwater fish species to become extinct. It is now considered to be extinct in what remains of its natural habitat, i.e. tributaries of the Lake Pedder impoundment.

The survival and recovery of the species now depends on the ongoing success of *ex-situ* populations. Fish translocated to Lake Oberon in 1991-92 have established a thriving population estimated to include a minimum of 500 adults, and including the largest recorded specimens. A total of 74 adults were transferred in 2001 and 2002 to a second site approximately 45 km away, the Strathgordon water supply dam. Although some of these fish are surviving in the dam, there is no evidence that they have successfully reproduced there as of June 2004.

The Pedder galaxias is listed as Extinct in the wild under the EPBC Act. (see Appendix 1 for the listing criteria) The species is listed under the Tasmanian TSP Act as endangered due to its past decline and present restricted distribution.

1.1.7 Existing conservation measures

The Pedder galaxias is listed on State and Commonwealth threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. All fish on reserved land are protected under the *National Parks and Reserves Management Act 2002* and cannot be taken without authority under this Act. The Pedder galaxias has been included in two recovery plans (Gaffney *et al.* 1992, Crook and Sanger 1997). Actions in the plans included capture and transfer of stock to Lake Oberon, monitoring of the Bonnet Bay populations, monitoring of the Lake Oberon population and associated changes in lake fauna, captive breeding, establishment of another translocated population, and increasing public awareness. Lake levels continue to be managed by Hydro Tasmania to reduce the risk of redfin perch invading Lake Pedder via the canal connecting it to Lake Gordon (McPartlan canal).

A translocated population, now the only breeding population, was successfully established with the transfer of a total of 34 fish to Lake Oberon between 1991 and 1997. The population has been monitored annually to determine numbers and age structure. A second *ex-situ* habitat for the species was constructed by modification of the Strathgordon water supply dam in 1997. The abundance of Pedder galaxias in Lake Oberon enabled a total of 74 adult fish to be moved to Strathgordon in 2001 and 2002. At least some individuals are surviving in the dam but no successful breeding has been confirmed.

Limited success was obtained with captive breeding in 1990-91 with only 11 juveniles produced (Hamr 1992). These were included in the fish placed in Lake Oberon. No attempts at captive breeding have been conducted since due to lack of stock.

The remaining natural habitat of the species and the Lake Oberon population is on reserved land (Southwest National Park, part of the Tasmanian Wilderness World Heritage Area) and therefore protected from land management impacts. The Strathgordon water supply dam is on Hydro Tasmania land and is managed for the benefit of Pedder galaxias while still functioning as a water supply storage. The dam is fenced and an information sign has been placed near the dam.

The Pedder galaxias is included in activities and products aimed at increasing awareness of Tasmania's threatened galaxiids and their conservation needs. These include regular articles in the IFS newsletter, talks to interest groups, liaison with land and water managers, displays at relevant events including IFS Open Weekend and Threatened Species Day, production and distribution of a sticker, brochure and mini posters.

1.1.8 Future Conservation Strategy

The strategy for ongoing recovery builds on successes of previous strategies. As the species is considered extinct from the remaining natural habitat, recovery focuses on maintaining and establishing self-maintaining *ex-situ* populations. The translocation to Lake Oberon has proven to be a greater success than originally envisaged, with a potential risk of the species establishing outside the intended habitat. Recovery actions will be undertaken to monitor the Lake Oberon population for its ongoing viability and ability to supply fish for future translocations.

Actions necessary for establishing a second population have been initiated at the Strathgordon water supply dam. Ongoing actions will ensure that this population establishes, through monitoring, habitat improvement and additional fish transfers if necessary. Once established this site has potential for use in public education and studies on species habitat requirements and biology.

Once the species is established at two secure sites, the possibility of reintroduction to previous habitat may be considered. Successful reintroduction would require rehabilitation of habitat in one of the suitable tributary streams by barrier construction to prevent access by trout and climbing galaxias, followed by removal of these species from the stream. Both would be difficult, due to the flat stream topography, remoteness and pervasion of the streams by climbing galaxias. Feasibility and costs would need to be determined to enable an informed decision on whether to take the required action. In addition, it would need to be determined whether Pedder galaxias can maintain a stream population without being able to migrate to and from the lake.

Genetic studies on the species are required so that management can aim to maintain genetic diversity, for example when further translocations are considered.

The Pedder galaxias will continue to be included in activities and products aimed at increasing awareness of Tasmania's threatened galaxiids and their conservation needs.

*1.2 Swan galaxias (*Galaxias fontanus*)*

1.2.1 Description of species

The Swan galaxias is a small to medium-sized galaxias, growing to a maximum length of approximately 135 mm (Sanger and Fulton 1991). Colour is light olive-green on the back to silver-white on the ventral surface. The sides and back are speckled with light brown spots which may form bars or patches and the fins are unmarked (Fulton 1990). The dorsal fin is positioned above the vent and the caudal fin is only slightly forked. The head is broad and flattened dorsally and jaws are approximately equal in length.

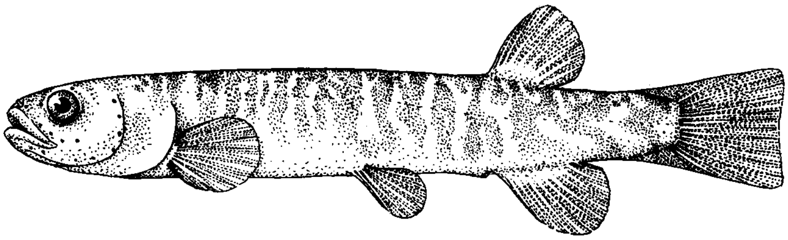

***Figure 4. Swan galaxias* Galaxias fontanus.**

1.2.2 Distribution

The Swan galaxias is endemic to Tasmania and occurs naturally only in the headwaters of the Swan River above Hardings Falls and tributaries of the Macquarie River in eastern Tasmania. As the species now occurs only in trout-free streams, its distribution prior to the spread of trout is likely to have been more widespread. Interestingly, these rivers are not geographically close and the Swan River drains east to the coast while the Macquarie drains west and north. There are currently nine known natural populations occupying a total of approximately 11 km of stream length (Table 2). All have brown trout populations downstream of the galaxias and Brodribb Creek contains redfin perch escaped from a dam upstream. Parramores Creek, Snaky Creek and Brodribb Creek contain an extremely small number of individuals due to trout or redfin invasion. The Swan River population, Brodribb Creek and Parramores Creek have suffered major declines since the late 1980s (Sanger 1993). The Brodribb Creek population has previously been considered extinct (Sanger 1993) but surveys in September 2002 and February 2004 found Swan galaxias still present in low numbers at this site.

Table 2. Swan galaxias natural populations.

Site name	**Length of stream occupied (km)**	**Status of population (estimated risk of extinction)**
Swan River tributary	2	moderate risk (susceptible to drying)
Blue Tier Creek	2.5 total	low risk
Parramores Creek	1.5	high risk (susceptible to drying, low numbers)
Tater Garden Creek east	1	low risk
Tater Garden Creek west	1.5	low risk
Snaky Creek	1	high risk (susceptible to drying, low numbers)
Brodribb Creek	1.5	high risk (redfin present, low numbers)
Macquarie Tier creek	unknown	unknown risk
Dairy Creek	unknown	unknown risk (possibly high)

Although known to landowners for many years, the last two populations were identified as Swan galaxias in early 2004. They are in the Macquarie River catchment but well outside the previously known range. They are in an unnamed Macquarie River tributary at Macquarie Tier and in Dairy Creek south of Cressy. The extent of these populations and their degree of security from threats is yet to be determined.

The species has also been successfully introduced to several fish-free streams in the general area for conservation purposes (Table 3). These nine populations are in the St Pauls, Cygnet, Lost Falls, South Esk, Macquarie and Little Swanport catchments. Stream length occupied is estimated at approximately 30 km. Total extent of occurrence for the species is approximately 960 km^2. All populations are important, particularly the natural populations as they contain the genetic diversity, and habitat critical to survival includes all areas occupied and the catchments affecting them.

Table 3. Swan galaxias translocation sites (IFS unpublished data).

Translocation site name	Source population	Number translocated	Date of translocation	Length of stream occupied (km)	Status of population
Blue Tier Creek upper	Blue Tier Creek lower	60 adults	June 1989	2.5 total	low risk
Lost Falls Creek	Swan River	approximately 50	17 May 1991	1.5	moderate risk (susceptible to drying)
Dukes River	Swan River	approximately 50	17 May 1991	10.5	low risk
Cygnet River	Swan River	approximately 50	23 April 1993	1.3	low risk
St Pauls River	Swan River	approximately 50	22 April 1993	6	low risk
Rocka Rivulet	Blue Tier Creek	approximately 50	23 April 1993	6	low risk
Green Tier Creek	Blue Tier Creek	87 (20 adults)	17 Aug 1995	2	high risk (redfin invasion from tributary
Tullochgorum Creek	St Pauls River	64 (14 adults)	Aug 1995	2	moderate risk (limited habitat, fluctuating numbers)
Coghlans Creek	Blue Tier Creek	56 (30 adults)	23 Aug 1995	1.2	moderate risk (limited habitat)
Wye River (failed to establish)	Swan River	50 (42 adults)	18 Aug 1995	-	-

1.2.3 Habitat

The Swan galaxias is the only Tasmanian galaxias that lives exclusively in freshwater streams, in contrast to lake-dwelling species or those with a marine migratory stage in the life cycle. All habitats occupied by healthy populations are free of other fish species except eels and are protected from trout invasion or establishment by some sort of barrier (waterfall, marsh, variable flow). Streams are in forested country, of low gradient and range in size from extremely small, spring-fed streams to larger rivers. Many of the streams do not flow all year but all contain permanent water. The frequent low-flow conditions can result in high temperatures, low oxygen and high chemical concentration in the remaining pools, to which the fish appear remarkably tolerant. The spawning habitat is not known as eggs have not been found in the wild, however, an egg mass deposited on the side of a pond during captive breeding trials (Jackson 2002) indicates that spawning sites may be on vertical structures or substrates rather than under rocks.

1.2.4 Life history and Ecology

Swan galaxias are an opportunistic carnivore and feed on terrestrial insects, aquatic insects and crustaceans (Crook and Sanger 1998a). The species is an active mid-water swimmer and both adults and juveniles can be observed swimming mid-water in pools. Fish mature at two years of age. Spawning takes place in spring between August and October and a small number (150-550) of relatively large eggs (2.2-2.5 mm) are produced (Crook and Sanger 1998a). Captive breeding trials indicate that eggs are strongly adhesive and are laid in masses, although the natural egg deposition site has not been discovered. Larvae on hatching are approximately 7 mm long. Small larvae are present in the wild around November-December and form schools. Populations typically include 3-4 year classes.

1.2.5 Threats

The major threat to the Swan galaxias is predation and/or competition from introduced fish species, in particular brown trout (*Salmo trutta*), redfin perch (*Perca fluviatilis*) and also from the native *Galaxias maculatus* (jollytail). The jollytail has become a recent threat to Swan galaxias populations in the Macquarie River catchment. The species has been introduced to Tooms Lake, either accidentally or deliberately and has established an abundant population in the lake and is spreading downstream. It has been found in large numbers in lower Tater Garden Creek and is likely to spread into other Macquarie River tributaries. The Swan galaxias is unable to coexist with these species as shown by its occurrence only in trout-free streams, all natural populations being limited by the downstream presence of brown trout, and local declines and extinctions of Swan galaxias being observed where brown trout or redfin perch have invaded their habitat. Recent actions taken to protect populations from invasion of introduced species need time to be proven effective, and human-induced introduction remains a threat.

The distribution of the Swan galaxias is extremely fragmented with all populations isolated by the presence of introduced fish. It is not known whether the populations are genetically distinct. All the natural populations are in small headwater streams which are vulnerable to the extreme fluctuations in stream flow characteristic of the area (Hughes 1987): the fish no longer have downstream refuge from floods or droughts affecting the headwaters, and temporary declines in numbers due to drought have been observed at some sites. Translocated populations have been successfully established but the proportion of natural genetic diversity they contain is not known.

The Swan galaxias is relatively secure from land management impacts due to its inclusion in Forest Practices threatened species management systems. However, potential hydrological effects from vegetation clearing (such as more frequent drying, higher or more frequent flood flows) remain a concern due to the lack of data to determine likely water yield responses. The longer term effect of climate change may also be a threat if conditions become drier, as the small headwater streams are at risk of drying out. The 2000-2001 summer was the driest on record for the area, and several monitoring reaches were totally dry.

Construction of water storages in or near Swan galaxias populations is likely to threaten them through inundation of habitat, introduction of introduced fish to storages, destruction of existing barriers that prevent introduced fish invading Swan galaxias habitat, and alteration of flow regimes. Several dams have been proposed in areas where Swan galaxias may be affected.

1.2.6 Conservation status

The Swan galaxias is listed as Endangered under both the EPBC Act and the Tasmanian TSP Act. The species has experienced past decline, distribution is limited and in fragmented populations, and it is under threat of continuing decline mainly due to introduced fish species. However, due to the success of the translocation program, the species conservation status has shifted from Critically Endangered to Endangered. Unless extensive additional translocations are made, most populations will remain fragmented, and despite recovery actions to protect existing populations the risk of trout or redfin invasion or introduction cannot be entirely eliminated. The species was identified as a Category 1 fauna species (requiring protection of all populations and habitat within the known range) under the Tasmanian comprehensive regional assessment process (PLUC 1997). It was subsequently listed as a 'priority species requiring consideration' under the *Tasmanian Regional Forest Agreement 1997* and is therefore to be protected through the CAR (Comprehensive, Adequate and Representative) reserve system or relevant management prescriptions.

1.2.7 Existing conservation measures

The Swan galaxias is listed under State and Commonwealth threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without a permit. The distribution, biology and environmental requirements of the Swan galaxias were studied by Sanger and Fulton (1991). Based on the information obtained, the species has been included in two recovery plans (Sanger 1993, Crook and Sanger 1997). Actions contained in the plans were a translocation program, the construction of barriers to introduced fish, monitoring of populations, the establishment of refuge captive populations and actions to increase public awareness of threatened fish.

Surveys have located the upstream and downstream limits of population distributions and determined their security from introduced fish. Four previously unknown populations (Macquarie Tier, Dairy Creek, Snaky Creek and Tater Garden west) and two presumed extinct by Crook and Sanger (1997) (Parramores Creek, Brodribb Creek) have been discovered. Translocation has proved successful with nine self-maintaining populations established between 1987-1995. Barriers have been constructed at four natural sites to stop introduced fish (mainly brown trout) moving into these streams. Any trout above the barriers have been removed by electrofishing and netting. The Tater Garden Creek barrier will enable three isolated populations to reconnect when trout above the barrier have been removed (Tater Garden east, west and Snaky Creek). It is hoped that the Parramores Creek barrier and trout removal will enable the population to recover from near extinction. Options for protecting the Brodribb Creek population from redfin have been put forward but feasibility and costs are yet to be assessed.

The Swan galaxias is included in the Forest Practices Authority threatened fauna management system, whereby relevant localities and catchments are flagged and management prescriptions applied to minimise impacts of forestry operations. Under Forestry Tasmania planning, catchments above known downstream limits are designated as Special Management Zones, where fauna conservation takes priority over wood production. Proposals for any dams that may potentially affect Swan galaxias are reviewed by IFS under dam assessment processes, and advice is given on measures required for species protection. A proposed dam on the Swan River above Hardings Falls has not been recommended for further investigation (DPIWE 2002b).

All known habitats have been nominated for definition as 'critical habitat' to provide legislative protection against damaging activities under the Tasmanian TSP Act. However, the Act has recently been amended so that an interim protection order can be applied without having the habitat defined as critical. Captive breeding trials conducted by IFS in 2000-2001 were largely unsuccessful, producing only 4 juveniles. However, further information was obtained on captive requirements and breeding methods (Jackson 2002).

The Swan galaxias is included in activities and products aimed at increasing public awareness of Tasmania's threatened galaxiids and their conservation needs. These include regular articles in the IFS newsletter, talks to interest groups, liaison with land and water managers, displays at relevant events including IFS Open Weekend and Threatened Species Day, production and distribution of a sticker, brochure and posters.

1.2.8 Future Conservation Strategy

The strategy for the further recovery of the Swan galaxias focuses on protection of known populations (natural and translocated). Natural populations are particularly important as they contain the remaining natural genetic diversity, and the long-term viability of all the translocated populations is not yet assured. Regular population monitoring will enable detection of any incursions by introduced fish so appropriate action can be taken. To minimise impact from forestry operations on both State Forest and private land, notifications of proposed operations will continue to be reviewed and management recommendations made. IFS will ensure that it continues to be included in the assessment process for proposed dam construction and can represent threatened fish interests. Risks of illegal introductions of introduced fish can be reduced through control of access to trout for stocking, increasing community awareness of the impacts of such actions, and informing visitors that particular sites are sensitive.

In addition to protection of known populations, actions will be taken to increase the number of populations and/or the area of occupancy. Surveys for additional populations and potential habitat will be continued. Rehabilitation of habitat known or likely to have been occupied by the species, to enable population expansion or reintroduction, will be undertaken where feasible. This may require exclusion and removal of introduced fish, and/or physical habitat rehabilitation. Increasing public awareness of the species and threats is an important aspect to minimise risks from illegal introductions and habitat damage. The Swan galaxias will continue to be included in activities and products aimed at increasing awareness of Tasmania's threatened galaxiids and their conservation needs.

Genetic studies of the species are required to determine genetic structure and diversity, so that management can aim to conserve diversity and any genetically distinct groups (e.g. by ensuring translocated populations are established using an adequate number of fish). Knowledge of species genetics may also influence decisions on priorities for population protection. The Swan and Macquarie catchments are isolated and may contain genetically distinct Swan galaxias. The diversity contained within the translocated populations compared with the natural ones is also unknown.

*1.3 Clarence galaxias (*Galaxias johnstoni*)*

1.3.1 Description of species

The Clarence galaxias is a small to medium-sized galaxias that grows up to approximately 140 mm in length. Adults are usually dark brown on the back with brown bars and patches extending down the sides and lightening to a yellowish belly. Small black spots are often present but these are parasites in the skin rather than markings (Fulton 1990).

The species is quite similar in appearance to the climbing galaxias *Galaxias brevipinnis*, which occurs in the same general area. Distinguishing features in live Clarence galaxias are: head rounded and blunt with jaws approximately equal in length, unlike the flat wedge-shaped head with the distinctly shorter lower jaw of climbing galaxias; the yellowish colour of the belly; and the smaller pectoral fins rather than the large, rounded, low-set fins of climbing galaxias. In addition, Clarence galaxias has short stout gill rakers rather than the long slender ones of climbing galaxias, and 10-13 pectoral fin rays rather than 13-16 in climbing galaxias (McDowall 1996). Vertebral counts for the two species overlap, with 51-56 in Clarence galaxias

(IFS unpubl. data) and 56-62 in climbing galaxias (with the exception of the Great Lake population which has 54-59 vertebrae) (Hamr 1992, McDowall and Frankenberg 1981).

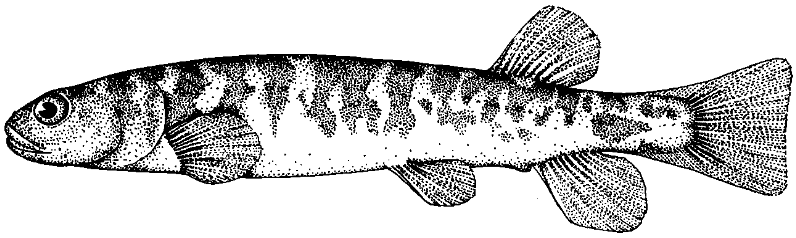

***Figure 5. Clarence galaxias* Galaxias johnstoni**

1.3.2 Distribution

The Clarence galaxias is endemic to Tasmania and occurs only in small isolated parts of the upper Derwent catchment in the southeastern Central Plateau, including the Nive, Clarence and Little River subcatchments. There are seven known populations. The largest populations are in Clarence Lagoon and Johnsons Lagoon. Four of the populations were discovered by surveys undertaken during the previous recovery plan, and there is potential for discovery of additional populations. These discoveries were highly significant as they extended the known range of Clarence galaxias from the Clarence catchment to the Nive, Little and Derwent catchments. Interestingly, all known populations are outside the extent of ice during the Last Glacial Maximum approximately 19 000 years ago as mapped by Colhoun *et al*. (1996) and Kiernan (1999).

Clarence galaxias does not co-occur with any other fish species, except brook trout in Clarence Lagoon. All populations are limited downstream by the presence of brown trout and/or physically unsuitable habitat. The species was formerly more widespread, as shown by its relatively recent disappearance (since 1934) from the type locality Brown Marsh Creek, which is now occupied by brown trout (IFS unpubl. data). The original pre-trout distribution of the species is not known. All populations are important and habitat critical to survival includes all areas occupied and the catchments affecting them.

1.3.3 Habitat

Clarence galaxias occupies high altitude lake, marsh and stream habitats. Deep pools are preferred although fish may spread into other areas when water levels are high enough. All habitats occupied are free of other fish species (except brook trout in Clarence Lagoon) and are protected from brown and rainbow trout invasion or establishment by some sort of barrier (e.g. a waterfall or fluctuating water levels).

1.3.4 Life history and Ecology

Clarence galaxias feeds mainly on benthic crustaceans and insects as adults, and planktonic crustaceans as juveniles (Crook and Sanger 1998b). Spawning occurs in spring. Eggs have been found laid in masses adhering to the underside of rocks in the Wentworth Hills lagoon and inflow stream. In captivity, fertilised eggs were deposited under rocks resting directly on aquarium gravel, rather than rocks with space under them (Jackson 2002). A relatively small number (300-2000) of large, strongly adhesive eggs (1.6 mm) are laid (Crook and Sanger 1998b). Eggs in captivity took 42-52 days to hatch at 4-12^{o}C (Jackson 2002). Larvae are approximately 8 mm long when hatched and swim in schools in open water. Populations normally include at least 4 year classes.

1.3.5 Threats

The major threat to Clarence galaxias is predation and/or competition by brown and rainbow trout. Other predatory introduced species such as redfin perch are also likely to be a threat if introduced to the area.

Clarence galaxias is not known from any areas containing brown trout, and its disappearance from the Brown Marsh Creek type locality indicates that it cannot survive where trout become established. Heavy predation on Clarence galaxias by recently introduced rainbow trout has been observed in Johnsons Lagoon. Johnsons, Clarence and Wentworth Hills lagoons are under particular threat from illegal trout introductions, as they are attractive and relatively accessible lagoons. The Dyes Marsh population is also under significant threat from brown trout invasion. The effectiveness of a recently installed downstream barrier is yet to be proven and trout removal above it is required.

1.3.6 Conservation status

The Clarence galaxias is listed as Endangered under the EPBC Act and the Tasmanian TSP Act. The species has experienced past decline, its distribution is limited and in fragmented populations, and it is under threat of continuing decline mainly due to introduced fish species. Unless extensive translocations are made, all populations will remain isolated, and despite recovery actions to protect existing populations the risk of trout invasion or introduction cannot be entirely eliminated. The species was identified as a Category 1 fauna species (requiring protection of all populations and habitat within the known range) under the Tasmanian comprehensive regional assessment process (PLUC 1997). It was subsequently listed as a ‘priority species requiring consideration’ under the *Tasmanian Regional Forest Agreement 1997* and is therefore to be protected through the CAR (Comprehensive, Adequate and Representative) reserve system or relevant management prescriptions.

1.3.7 Existing conservation measures

Clarence galaxias is listed under State and Commonwealth threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without a permit. All fish on reserved land are protected under the *National Parks and Reserves Management Act 2002* and cannot be taken without permit under this act. The distribution, biology and environmental requirements of the Clarence galaxias were studied by Sanger and Fulton (1991). Based on the information obtained, the species was included in a recovery plan (Crook and Sanger 1997). Actions contained in the plan were monitoring of populations, the establishment of translocated populations, captive breeding trials, habitat management including nomination of critical habitats under the TSP Act and maintenance of brown trout-free habitats, and public information and education.

The most important conservation measure is protecting populations from introduction or invasion of trout (rainbow or brown). A trial temporary barrier placed below the Dyes Marsh population was removed as it was ineffective and potentially harmful, as it became clogged and raised water levels. A permanent barrier has been constructed further downstream. The Johnsons Lagoon population has been severely threatened by an illegal introduction of domestic-stock rainbow trout. Fortunately they were discovered before maturity and every effort is being made to eradicate them. To reduce the risk of further illegal introductions, the IFS are reviewing stocking procedures and availability of trout. Public awareness activities focus on the impacts of introduced fish and discouraging any unauthorised transfer of fish between waters.

The IFS maintains the population of brook trout in Clarence Lagoon to provide a relatively benign alternative to brown trout for anglers. Signage has been erected at the lagoon and at other sites most at risk from illegal introductions to inform visitors of the risk of introducing other species.

No translocations of Clarence galaxias have been undertaken. Potential sites surveyed have been found to be either occupied by trout or other galaxias species, physically unsuitable, unsuitable due to their reserved status, or already occupied by Clarence galaxias. The discovery of four additional natural populations reduced the need for establishment of translocated populations.

Only one very small population is entirely on formally reserved land in the Central Plateau Conservation Area (part of the World Heritage Area). While Clarence Lagoon itself is entirely within the Central Plateau Conservation Area and WHA, the southern boundary is State Forest and a small part of the headwaters is on private land. Johnsons Lagoon is within the WHA but part of the headwaters and shore are on private land. Other sites are entirely State Forest or private. All known habitats have been nominated for definition as 'critical habitat' to provide legislative protection against damaging activities under the Tasmanian TSP Act. However, the Act has been amended so that an interim protection order can be applied without having the habitat defined as critical.

The Clarence galaxias is included in the Forest Practices Authority threatened fauna management system, whereby relevant localities and catchments are flagged and management prescriptions applied to minimise impacts of forestry operations. Under Forestry Tasmania planning, catchments above known downstream limits are designated Special Management Zones, where fauna conservation takes priority over wood production. Private landowners have been informed of the species' occurrence and how to protect its habitat.

Captive breeding trials were conducted by IFS in 2000-2001 with little success, with only a few short-lived larvae produced. However, further information was obtained on captive requirements and breeding methods (Jackson 2002).

The Clarence galaxias is included in activities and products aimed at increasing public awareness of Tasmania's threatened galaxiids and their conservation needs, and this will continue.

1.3.8 Future Conservation Strategy

Like the Pedder and Swan galaxias, recovery for the Clarence galaxias focuses on protection of all populations from brown or rainbow trout colonisation. This requires regular monitoring of the trout-free status of populations with barrier construction and trout removal as necessary. Opportunities for increasing the area of occupancy include surveys to look for new populations and rehabilitation of habitat known or likely to have been occupied followed by translocation. Habitat rehabilitation may require exclusion and removal of introduced fish, and/or physical habitat rehabilitation.

IFS trout stocking management will aim to reduce the risk of illegal introductions. The brook trout fishery in Clarence Lagoon will be maintained to reduce the risk of illegal introduction of brown or rainbow trout. Procedures for stocking of farm dams will be reviewed to ensure stocking occurs only at the localities intended by IFS.

Habitat protection through liaison with the Forest Practices Authority and other land managers will continue. Public awareness activities including the species will continue, with particular focus on threats from introduced fish.

Genetic studies of Clarence galaxias are required so that management can aim to maintain genetic diversity and structure. The populations (all isolated) are likely to be genetically distinct, as the Wentworth Hills population appears morphologically distinct and the Tibbs Plain population in the Derwent catchment has probably been isolated from the Clarence and Nive catchment populations for considerable time. Knowledge of the species' genetics is required to determine priorities for population protection, number of fish required for translocation, and management of captive breeding if this is undertaken in future.

1.4 *Swamp galaxias (*Galaxias parvus*)*

1.4.1 Description of species

The swamp galaxias is a small stout galaxias reaching a maximum length of approximately 105 mm (IFS unpubl. data). Adults are light brown on the back with irregular small spots and flecks over the body and the underside is pale. The head is blunt and the tail rounded (Fulton 1990, McDowall 1996).

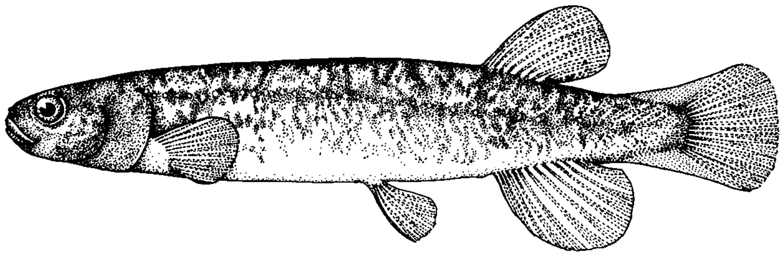

***Figure 6. Swamp galaxias* Galaxias parvus**

1.4.2 Distribution

The swamp galaxias is endemic to Tasmania. Before the inundation of Lake Pedder in 1972-74, the swamp galaxias was known from the small streams and extensive swamps that surrounded the original lake, and around the shores of the lake itself. Unlike the Pedder galaxias, swamp galaxias also occurred in the Wedge River, which flows into Lake Gordon, and tributaries of the Huon River (Andrews 1976, Frankenberg 1968). After an initial increase following flooding of the original lake, numbers of swamp galaxias declined to the point where they were rarely seen in the impoundment (Fulton 1987). Regular sampling of the new impoundment by Lake (1998) recorded swamp galaxias as 'moderately abundant' in 1977 but it was not collected in the impoundment after that.

The present distribution of swamp galaxias is in swampy areas and suitable streams surrounding the Lake Pedder impoundment, a few streams draining to Lake Gordon near McPartlan Pass (part of the Wedge catchment prior to flooding) and some small streams in the Huon River catchment upstream of the Pedder impoundment (Figure 7). The species is not found in the main body of the Lake Pedder impoundment and is absent from Lake Gordon (Fulton 1990, Hamr 1992). Existing information is not adequate to determine whether a particular part of the area occupied is critical to the species' survival, and until shown otherwise, all areas and catchments occupied should be considered habitat critical to the species' survival.

1.4.3 Habitat

The swamp galaxias inhabits slow-flowing swampy streams with sandy or silty substrate, ranging in size from large deep streams to small runnels. It has also been found in swampy, soft-bottomed pools and in the shallow flooded edges of Lake Pedder (Hamr 1992). Larvae have been observed in backwaters of Lake Pedder tributary streams.

1.4.4 Life history and Ecology

The diet of swamp galaxias consists mainly of terrestrial insects and aquatic insects and crustacea (Hamr 1992). The swamp galaxias spawns in early spring when temperatures are approximately 8^{o}C and larvae are present in November. The wild spawning site is not known, but in captivity eggs were deposited onto gravel under shelter and took 26-30 days to hatch at 10-15^{o}C. A small number (70-500) of large eggs (1.6 2.6 mm) are produced. The newly hatched larvae were approximately 7 mm long. The smallest mature adults recorded by Hamr (1992) were 36 mm (one year old) for males and 56 mm (2 years old) for females.

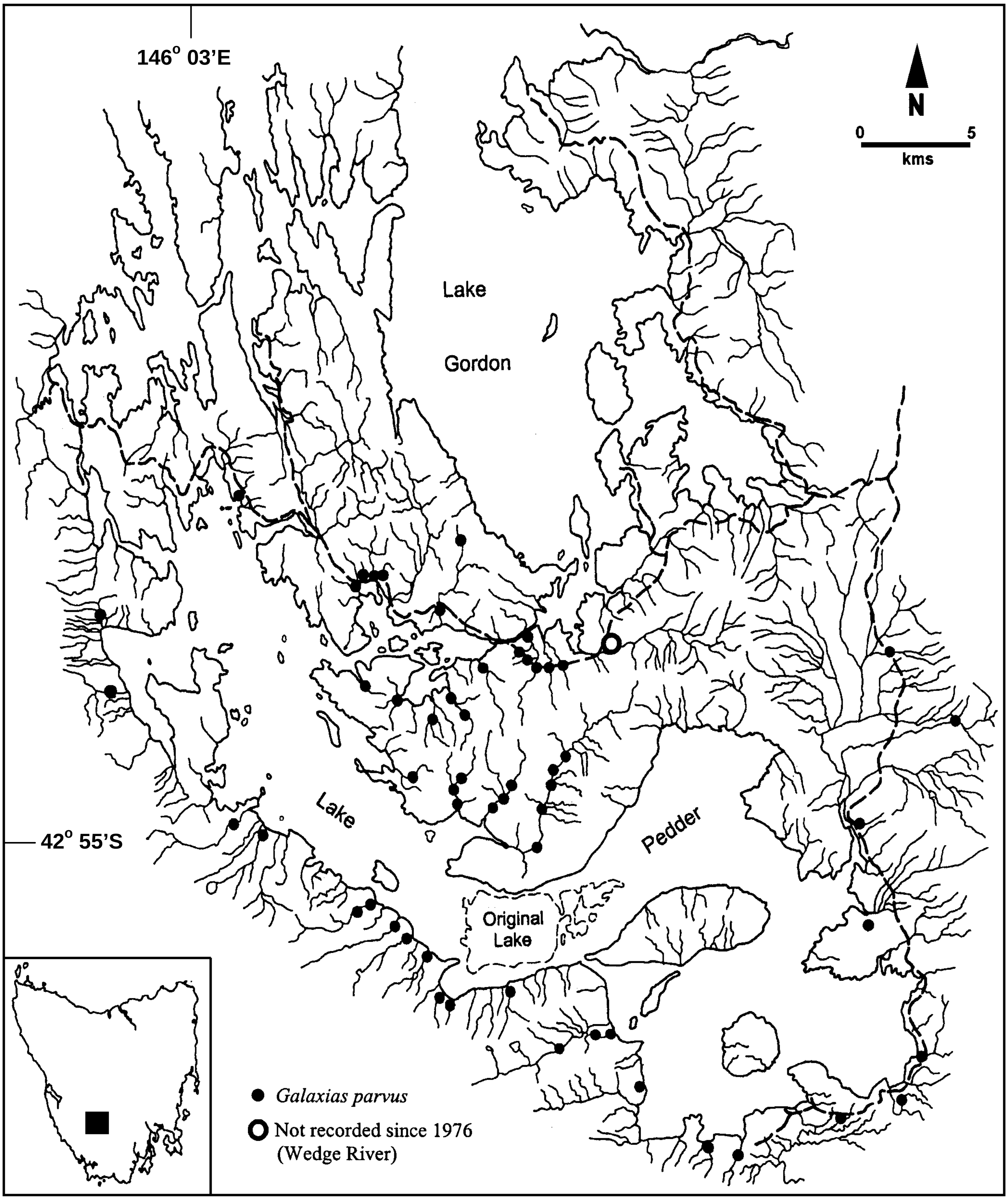

Figure 7. Distribution of swamp galaxias.

1.4.5 Threats

Species decline has probably resulted from effects of introduced species, as well as direct physical loss of habitat by inundation of the swamps and lower reaches of streams preferred by the species. Swamp galaxias is subject to ongoing competition and predation from introduced brown trout (*Salmo trutta*) and climbing galaxias (*Galaxias brevipinnis*). Trout were stocked into the new Lake Pedder impoundment and the climbing galaxias, reported from the Serpentine River prior to flooding by Andrews (1976), has dramatically increased in numbers and distribution (Sanger 1988). The climbing galaxias is now the dominant fish in many of the Lake Pedder tributaries (IFS unpubl. data). Both trout and climbing galaxias are implicated in the severe decline of Pedder galaxias (Hamr 1992) and have also had negative impacts on similar non-diadromous galaxiids after river impoundments in New Zealand (Allibone 1999).

Self-maintaining populations of swamp galaxias have survived despite the presence of trout and climbing galaxias since Lake Pedder was flooded. This may be due to its habitat preference, its life history (without a migratory juvenile stage requiring a lake), and its ability to colonise swampy areas which are not suitable for trout, climbing galaxias or Pedder galaxias (Hamr 1992). In addition, some populations outside the Serpentine drainage may not have been affected by the flooding of the area. However, a potential threat which is expected to cause future decline of swamp galaxias if it occurs is the risk of introduced redfin perch (*Perca fluviatilis*) reaching the Lake Pedder impoundment, either through invasion from Lake Gordon (where they are numerous) or by illegal introduction for angling purposes. Redfin are an aggressive piscivore, and have almost eliminated two populations of another threatened galaxias, Swan galaxias (Sanger 1993, IFS unpubl. data). They can occur at very high population densities, and are likely to be able to move into slow flowing and swampy areas which are relatively inaccessible to trout and climbing galaxias and have therefore been refuges for swamp galaxias.

Available habitat has also been reduced by road culverts creating barriers to upstream movement in some of the streams occupied by swamp galaxias, resulting in its occurrence downstream of the culvert only (IFS unpubl. data).

1.4.6 Conservation status

The swamp galaxias is listed as rare under the Tasmanian *Threatened Species Protection Act 1995* due to its limited distribution at risk. The species has undergone past decline, has a limited distribution and is subject to potential continuing decline as threats are not adequately controlled.

1.4.7 Existing conservation measures

The swamp galaxias is listed on Tasmanian threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. All fish on reserved land are protected under the *National Parks and Reserves Management Act 2002* and cannot be taken without authority under this act. Most of the distribution of the swamp galaxias is on land reserved within the Southwest National Park, part of the Tasmanian Wilderness World Heritage Area, with very small areas on land vested in Hydro Tasmania. All known habitats have been nominated for definition as 'critical habitat' to provide legislative protection against damaging activities under the Tasmanian TSP Act. However, the Act has been amended so that an interim protection order can be applied without having the habitat defined as critical.

A study of Pedder galaxias distribution and biology by Hamr (1992) also obtained information on swamp galaxias distribution, biology and environmental requirements. The swamp galaxias is included in a recovery plan (Crook and Sanger 1997), with actions to conduct a distributional survey with assessment of security from introduced fish, establish additional secure populations if necessary, trial captive breeding and increase public awareness.

Surveys have extended the known range slightly. There are presently only 6 swamp galaxias sites considered relatively secure from introduced fish invasion (trout and redfin). Five potential translocation sites in artificial dams have been identified and a trial translocation has been conducted. If successful, this trial will indicate that swamp galaxias do not require an inflow or outflow stream to establish a population and therefore assist with assessment of other potential translocation sites.

Since 1996 the canal connecting Lake Pedder and Gordon has been managed by Hydro Tasmania to minimise the risk of redfin movement upstream into Pedder. The radial gate on the canal is opened only if the level of Lake Pedder is sufficiently higher than the level in the canal to make flows through the gate too high for redfin to swim against. However, during extremely dry conditions in 2002, lowering the level of Lake Pedder was considered by Hydro Tasmania. The absence of redfin from the canal could not be established, and further analysis of lake levels is required before any changes to the current rule are considered.

Captive breeding of swamp galaxias was attempted by Hamr (1992) and resulted in successful rearing of larvae from both naturally spawned and artificially fertilised eggs.

Swamp galaxias is included in education activities which aim to raise public awareness of the impacts of illegal transfers of introduced fish.

1.4.8 Future Conservation Strategy

The recovery strategy for swamp galaxias focuses on prevention of further decline by protection of existing populations from introduced species, and preparing contingency plans to enable establishment of additional secure populations if required. Further surveys have potential to extend the known range, for example swamp galaxias may potentially occur in tributaries of the upper Gordon River, and Huon River below the Huon dam.

To protect existing populations of swamp galaxias it is important to maintain the management of McPartlan canal gate so that risk of redfin invasion of Lake Pedder is minimised. Any variation to the existing management needs to be approved by the recovery team. To protect the populations in tributaries of Lake Gordon near McPartlan canal, water levels in Lake Gordon need to be kept below the falls on the streams, or some other kind of barrier to redfin needs to be constructed. Hydro Tasmania has planned studies to further assess existing barriers protecting the McPartlan swamp galaxias populations, and examine the effects of road culverts on swamp galaxias movement. Project proposals will be reviewed by the recovery team.

The swamp galaxias will be included in communication actions aimed at increasing public awareness of Tasmania’s threatened galaxiids and their conservation requirements.

Genetic studies on swamp galaxias are required so that management can aim to maintain genetic diversity and structure. The populations in the Serpentine, Huon and Wedge catchments may be genetically distinct. Knowledge of the species’ genetics is required to determine priorities for population protection, number of fish required for translocation, and management of captive breeding if this is undertaken in future.

1.5 *Saddled galaxias (*Galaxias tanycephalus*)*

1.5.1 Description of species

The saddled galaxias grows to a maximum length of approximately 150 mm. Markings appear as a series of dark saddles along the back and down the sides. Large oval spots are sometimes present on the sides and may resemble the pattern seen in golden galaxias. Smaller specimens have less distinct markings with an olive back and silvery belly. A purplish sheen may be present and the dorsal, anal and caudal fins may be amber coloured with darker edges. The head is long and tapering (Fulton 1990, McDowall 1996).

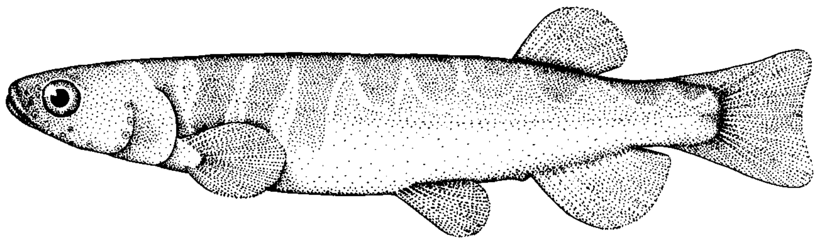

***Figure 8. Saddled galaxias* Galaxias tanycephalus**

1.5.2 Distribution

The saddled galaxias is endemic to Tasmania. It occurs only in Woods Lake and Arthurs Lake on the Central Plateau (Figure 9). The species is abundant in Woods Lake and less common in Arthurs Lake. It has been suggested that the high water clarity, low planktonic productivity and large trout population in Arthurs Lake results in greater trout predation and less larval recruitment. In comparison, Woods Lake is usually very turbid, which may reduce predation by trout, and the higher plankton productivity may increase recruitment of larvae into the adult population (Sanger and Fulton 1991). Habitat critical to survival is all the areas where the species occurs. i.e. Woods Lake and catchment upstream of the dam (42°04.7'S 147°01.5'E) and Arthurs Lake and catchment upstream of the dam (42°02.0'S 146°55.0'E).

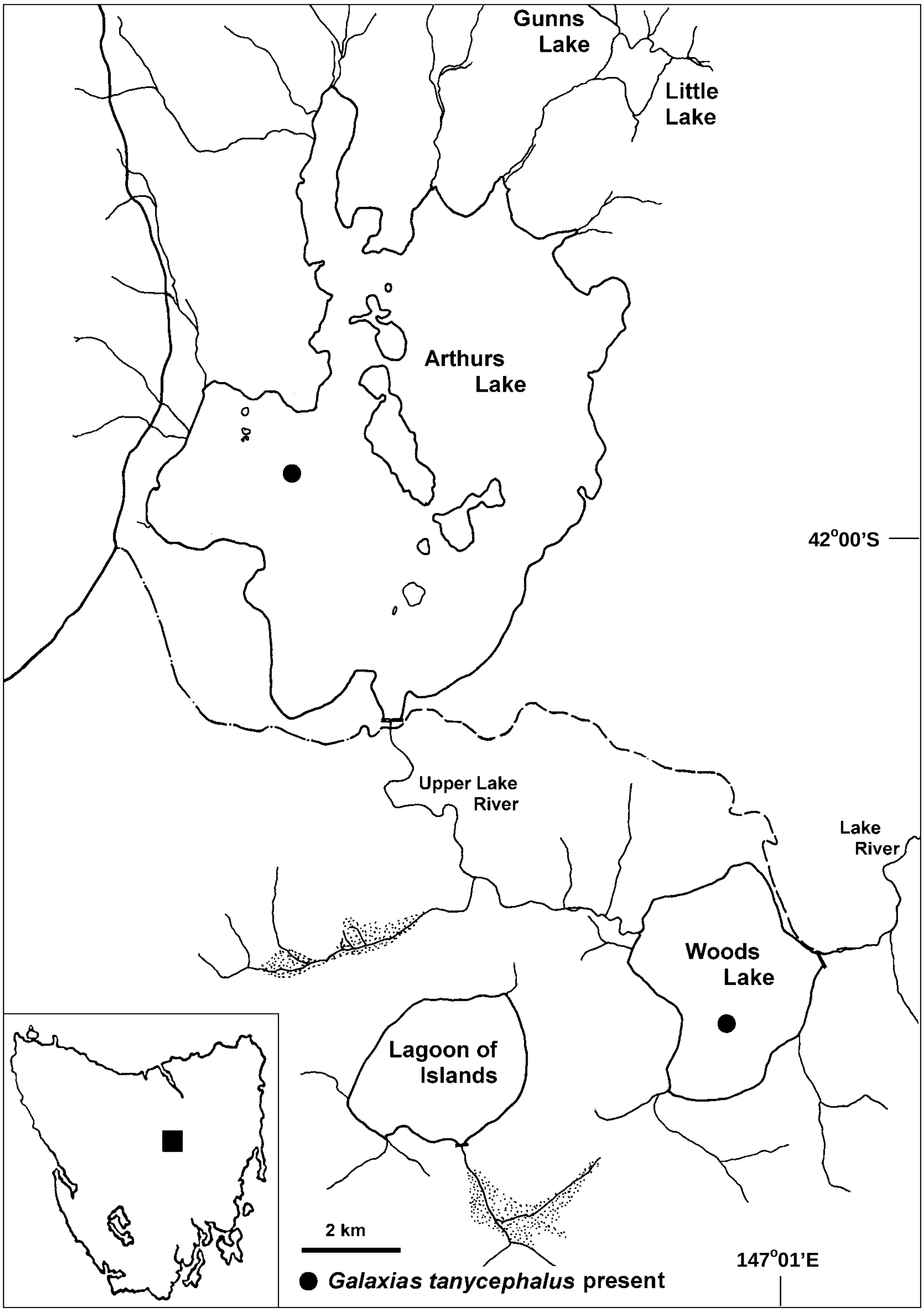

Figure 9. Distribution of saddled galaxias

1.5.3 Habitat

The saddled galaxias is mainly lacustrine with only a few individuals found in the lower reaches of inflow streams. Within the lakes adults can be found in areas where rocks and aquatic vegetation provide shelter. Larvae and juveniles form schools in open water.

1.5.4 Life history and Ecology

Saddled galaxias feed mainly on crustaceans (benthic and planktonic) and some aquatic insects are also eaten (Sanger and Fulton 1991). There appears to be an extended spawning season from late winter to autumn. Pelagic larvae are found in Woods Lake all year round, with a peak in spring - summer. Recruitment appears to be variable between years (IFS unpubl. data). A large number (800-5400) of small eggs (1.5 mm water hardened) are produced. In contrast to most other galaxias, the eggs are not strongly adhesive. The spawning site in the wild has not been found and the eggs may be scattered rather than laid in adhesive clumps. Artificially fertilised eggs took 19-24 days to begin hatching at 10^{o}C (Jackson 2002). Most of the population consists of fish less than two years old, with few larger specimens found, particularly in Woods Lake.

1.5.5 Threats

Both of the lakes in which the saddled galaxias occurs were natural lakes that were inundated by dams constructed by Hydro Tasmania. Brown trout are abundant in the lakes and have been present for more than a century. They predate heavily on saddled galaxias and although this potentially limits the abundance of saddled galaxias (Sanger and Fulton 1991), it is apparently sustainable as the galaxias remain common. The species is absent from two small lakes above Arthurs Lake which contain no refuge habitat, but also occasionally have very low water levels and are isolated from recolonisation from Arthurs Lake by a small metal weir. The possibility of introduction of additional introduced fish species poses an ongoing threat to the saddled galaxias. European carp (*Cyprinus carpio*) are present in lakes Crescent and Sorell 8 km west of Woods Lake, and redfin perch (*Perca fluviatilis*) are abundant in Lagoon of Islands 2 km to the south-west. This risk can be reduced through increasing public awareness of the impacts, but cannot be fully eliminated at present. There is an additional risk of unwanted introductions through stocking of Woods Lake with wild-caught elvers for commercial eel fishing purposes, as these stocks have potential for being contaminated with other native or pest species.

Deteriorations in water quality and habitat availability are also of concern. Both lakes are subject to manipulation of water levels, Arthurs Lake for hydro power generation and Woods Lake for irrigation supply. Woods Lake has experienced high turbidities and nutrients when the lake has been drawn down and receives high nutrient inputs from Ripple Creek diversion (Crook 1995, Hydro Tasmania 1999, Hydro Tasmania 2001). High turbidities may damage fish gills (IFC 1994), affect fish feeding (Rowe *et al.* 2002) and affect the algal-based food chain. Drawdowns also dewater saddled galaxias habitat and if eggs are laid in shallow water they are particularly vulnerable.

Construction of Arthurs dam has fragmented the two populations, previously connected by flow from Arthurs Lake to Woods Lake via the Upper Lake River. It is likely that the majority of saddled galaxias movement was in a downstream direction. The dam, constructed in 1965, totally blocks flow under normal conditions.

1.5.6 Conservation status

The saddled galaxias is listed as Vulnerable under the EPBC Act and endangered under the Tasmanian TSP Act. The species has a limited distribution, occurring in only two fragmented localities, and is at risk of continuing decline due to threats from introduced fish and habitat quality changes. The species was identified as a Category 1 fauna species (requiring protection of all populations and habitat within the known range) under the Tasmanian comprehensive regional assessment process (PLUC 1997). It was subsequently listed as a 'priority species requiring consideration' under the *Tasmanian Regional Forest Agreement 1997* and as such is to be protected through the CAR (Comprehensive, Adequate and Representative) reserve system or relevant management prescriptions.

1.5.7 Existing conservation measures

The saddled galaxias is listed on Tasmanian and Commonwealth threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. The distribution, biology and environmental requirements of the saddled galaxias were studied by Sanger and Fulton (1991). Based on the information obtained, the species was included in a recovery plan (Crook and Sanger 1997). Actions contained in the plan were monitoring of populations, establishment of refuge translocated populations, habitat management, captive breeding trials and actions to increase public awareness of threatened fish.

A study of saddled galaxias conservation (Sanger and Fulton 1991) recommended that the conservation status should remain as Vulnerable, habitat protection measures (particularly maintenance of water quality) should be pursued, no enhancement of the brown trout population in Woods Lake should occur (natural limitations to spawning such as log jams should be allowed), and populations of saddled galaxias should be established by translocation to suitable habitats.

Regular monitoring indicates that the species remains abundant in Woods Lake and relatively common in Arthurs Lake. No translocations have been conducted due to the lack of suitable habitats. An informal minimum lake level agreement between IFS and Hydro Tasmania since 1995 is intended to keep Woods Lake above a minimum water level of 735.40 m asl to reduce the risk of high turbidity events (Hydro Tasmania 1999). However, the high water levels and low turbidities of recent years may increase predation pressure on saddled galaxias from trout. A minimum lake level agreement in place for Arthurs Lake to maintain angling amenity (Hydro Tasmania 1999) also reduces the potential for extensive habitat dewatering. Water quality including turbidity is monitored by Hydro Tasmania. The lakes and fish populations were included in technical studies conducted by Hydro Tasmania for development of a Water Management Plan under the *Water Management Act 1999* (Hydro Tasmania 2003a, 2003b).

A recent honours study, supported by Hydro Tasmania, aimed to clarify habitat requirements in relation to water management (Davis 2004). It concluded that the species appears vulnerable to changes in lake level due to their apparent concentration in lake margin habitats.

The IFS has implemented grading procedures to minimise the risk of elver stocks being contaminated with other species.

Woods and Arthurs lakes have been nominated for definition as ‘critical habitat’ to provide legislative protection against damaging activities under the Tasmanian TSP Act. However, the Act has been amended so that an interim protection order can be applied without having the habitat defined as critical.

The saddled galaxias is included in the Forest Practices Authority threatened fauna management system, whereby relevant localities and catchments are flagged and management prescriptions applied to minimise impacts of forestry operations.

1.5.8 Future Conservation Strategy

The strategy for recovery of the saddled galaxias focuses on protection of the existing populations. Actions will aim to ensure that both populations remain free of undesirable introduced species. Increasing public awareness of impacts is important to reduce the risk of intentional or accidental introductions. Management of access to Woods Lake should consider the increased risk of pest fish introductions with increased visitation. Regular monitoring will aim to detect any undesirable species and if found every effort will be made to eradicate them. Monitoring will also enable detection of any decline in saddled galaxias numbers.

Additional refuge populations should be established in case the main populations suffer catastrophic decline. Sites suitable for translocation need to be in the Arthurs-Woods catchment, free of introduced fish (or any present are able to be removed), and with similar habitat characteristics to the natural habitat. Artificial dams or the two lakes north of Arthurs will be considered in consultation with relevant stakeholders.

Population management and translocation actions should aim to maintain genetic diversity and conserve any genetically distinct groups. Genetic studies are required to determine these characteristics. Preliminary work by Elliott and Sanger (1994) indicates that there may be some degree of genetic separation between spring and autumn-spawned larvae in Woods Lake. The degree of distinctness between Woods and Arthurs populations is not known.

Habitat quality can be maintained through management of water levels and nutrient inputs to maintain water quality and habitat availability. Continued liaison with Hydro Tasmania will aim to continue, improve and formalise lake management strategies that take account of the requirements of the saddled galaxias.

Reduction of predation by trout in Woods Lake may potentially be achieved by managing and marketing it as a water for large trout. As recommended by Sanger and Fulton (1991), the brown trout population should not be enhanced by stocking or increasing spawning facilities, and any natural limits to spawning such as log jams or low flows should be allowed to occur. Similar trout management in Arthurs Lake is not considered feasible at present due to social and practical factors.

The saddled galaxias will be continued to be included in communications actions to increase awareness of Tasmania's unique galaxias and support for recovery programs.

*1.6 Golden galaxias (*Galaxias auratus*)*

1.6.1 Description of species

The golden galaxias is a large deep-bodied galaxias, with a maximum length of approximately 240 mm. Colour is golden-amber with dark elliptical spots on the sides and back and a silvery-grey belly. Fins are amber to light orange with black edges on the dorsal, anal and pelvic fins (Fulton 1990). The head is long and tapering and tail is forked. Colouring differs between the two lakes where the species occurs, with individuals from Lake Sorell being paler in colour than those from Lake Crescent (Hardie 2003). The golden galaxias is somewhat similar in appearance to the saddled galaxias, but is generally stouter with more distinct spots and darker fin edges.

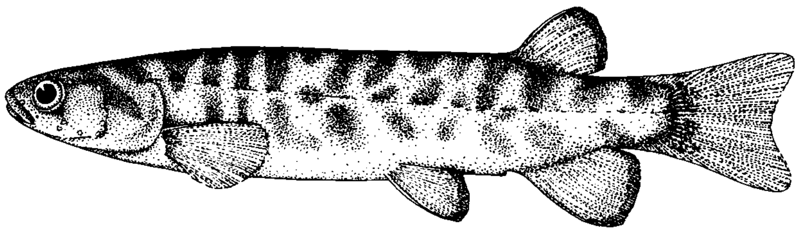

Figure 10. Golden galaxias **Galaxias auratus**

1.6.2 Distribution

The golden galaxias is endemic to Tasmania. It occurs naturally only in lakes Sorell and Crescent and associated streams and wetlands on the Central Plateau. It is common in both lakes but is much more abundant in Lake Crescent, at approximately ten times the density found in Lake Sorell (Hardie 2003). In recent years two small refuge translocated populations have been established in farm dams in the Clyde River catchment (Figure 11) (Hardie 2003). Habitat critical to survival is all areas where the species naturally occurs, i.e. Lake Sorell, Lake Crescent and their catchments upstream of the Lake Crescent screens (42°10.3'S 147°09'E).

1.6.3 Habitat

The golden galaxias is primarily a lake-dwelling species that prefers still or gently flowing waters. Adult fish prefer rocky lake shore habitat (Hardie 2003) and to a lesser degree, marsh habitat. Juvenile fish live in open water until 4-5 months old (40 mm in length) and then move to the inshore benthic habitat. Wetlands adjacent to the lakes are thought to provide an important nursery area for juvenile fish, but are available only when they contain water (Hardie 2003).

1.6.4 Life history and Ecology

Adult golden galaxias feed on aquatic and terrestrial insects, small aquatic crustaceans and molluscs. Larvae feed on plankton and small insect larvae in the water column (Frijlink 1999, Hardie 2003). Spawning occurs in late autumn to winter (Hardie 2003), in contrast to most other entirely freshwater or landlocked galaxias species which spawn in spring (Humphries 1989, Fulton 1990). Eggs are small (1.5 mm) and adhere to rocky substrate or aquatic vegetation and appear scattered rather than laid in clumps. A large number of eggs are produced, around 1 000-15 000 depending on the size of the female. Males mature in their first year (when

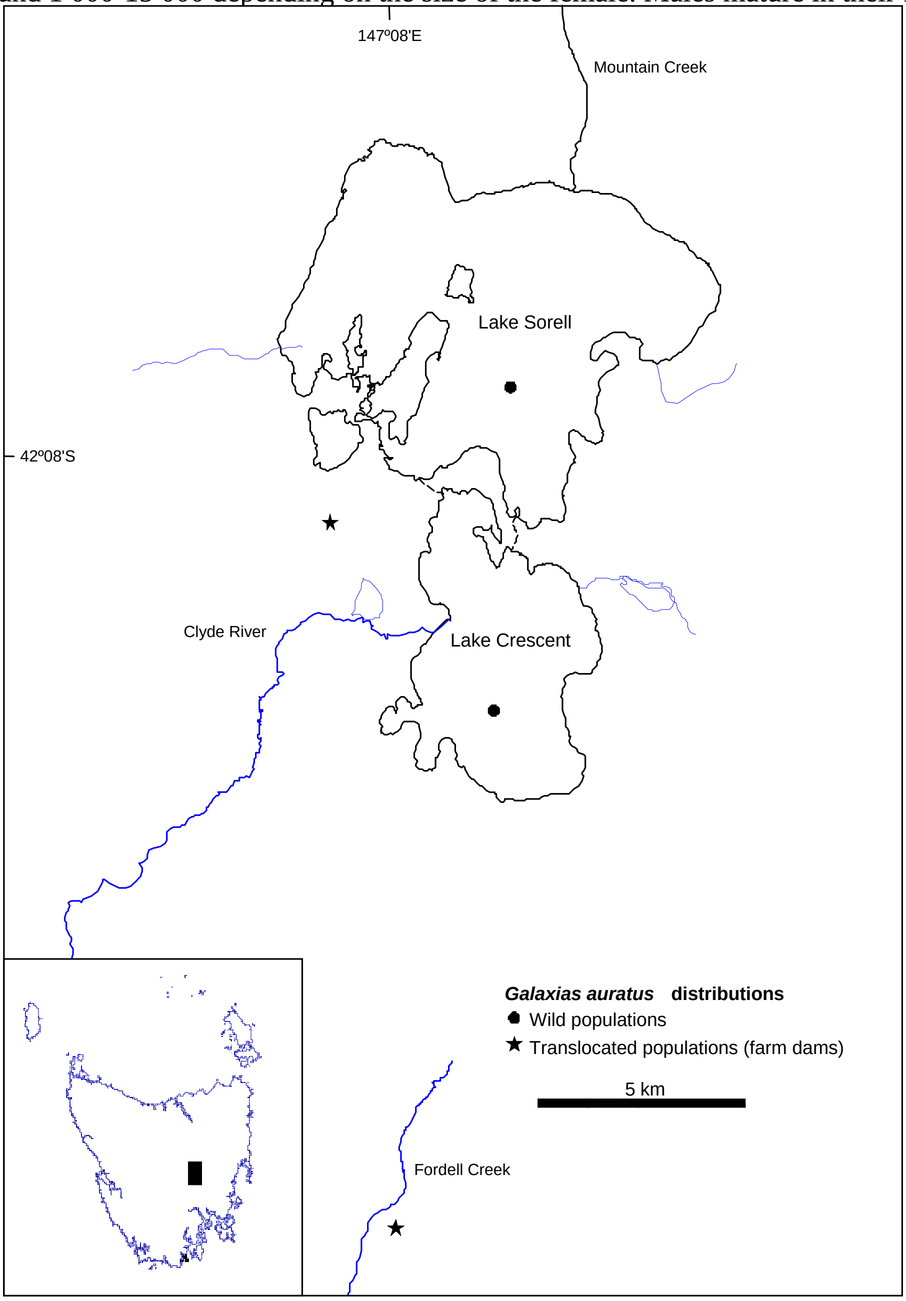

Figure 11. Distribution of golden galaxias

>50 mm in length), and females in their second year (when >70 mm in length) (Hardie 2003). Most of the population lives for 3-4 years, although some live for more than 6 years. Newly hatched larvae are 5-6 mm long and pelagic (Hardie 2003).

1.6.5 Threats

Golden galaxias currently remains abundant despite being a major food item for trout. Brown trout in Lake Crescent feed almost exclusively on golden galaxias (IFS unpubl. data). The difference in density of golden galaxias between lakes Crescent and Sorell is thought to be due to the difference in trout populations (Hardie 2003): Lake Sorell has good trout recruitment producing a large population of medium-sized trout, so that high levels of predation from adult trout and competition from juvenile trout are likely. In comparison, Lake Crescent has poor recruitment, resulting in fewer larger trout and therefore lower predation and competition.

The lakes occupied by golden galaxias are managed for irrigation and town water supply as well as maintaining a trout fishery. Dry conditions for several years and low lake levels have caused deterioration in habitat quality and availability. Water quality has declined, particularly with increased turbidity (Uytendaal 2003), which may damage fish gills (IFC 1994), affect feeding (Rowe *et al.* 2002) and decrease the abundance of aquatic macrophytes. Golden galaxias habitat has been lost due to the drying out of large areas of shallow lakeside marshes and inflow streams, and exposure of rocky shore habitat.

Draining and grazing of wetlands around the lakes threatens the golden galaxias by damaging and reducing the availability of wetland habitat (Hardie 2003).

European carp (*Cyprinus carpio*) have been present in both lakes since at least the early 1990s. An eradication program has greatly reduced their numbers so they are not believed to be affecting golden galaxias. However, if carp were to become abundant then competition for space and food and likely macrophyte destruction could impact on golden galaxias. Another non-indigenous fish occurring in both lakes is the native common jollytail (*Galaxias maculatus*), thought to have been accidentally introduced. It does not appear to have established breeding populations (Hardie 2003) but if established could compete for food and habitat. The lakes are also at risk of other undesirable species being introduced deliberately or accidentally, with the piscivorous redfin perch (*Perca fluviatilis*) a particular concern. There is an additional risk of unwanted introductions through stocking of the lakes with wild-caught elvers for commercial eel fishing purposes, as these stocks have potential for being contaminated with other native or pest species.

Golden galaxias populations have recently been partly fragmented by the construction of carp containment screens on the canal through which Lake Sorell flows into Lake Crescent. The 5 mm mesh prevents movement of all but very small galaxias downstream, and no fish can move up from Lake Crescent to Sorell. The implications for species genetic structure are not known, and the ability to recolonise if either population suffered a decline is greatly reduced. Carp containment screens on the outflow of Lake Crescent have also prevented galaxias utilising downstream habitats and recolonising rehabilitated downstream marshes.

1.6.6 Conservation status

The golden galaxias is listed as rare on the Tasmanian TSP Act and Endangered on the EPBC Act 1999 (see Appendix 1 for the listing criteria). The species was identified as a Category 3 fauna species (whose conservation needs can be met by management prescriptions) under the Tasmanian comprehensive regional assessment process (PLUC 1997). It was listed as a ‘priority species requiring consideration’ under the *Tasmanian Regional Forest Agreement 1997*, identified as requiring further research to determine its management requirements.

1.6.7 Existing conservation measures

The golden galaxias is listed on Tasmanian threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. Research on the species abundance, life history, diet and habitat requirements has been conducted as part of a Natural Heritage Trust-funded project on rehabilitation of lakes Sorell and Crescent (project no. NRC20851). The resulting management plan for the lakes recommends measures required to protect the species, including water level management (IFS 2004b). The species is included in Forest Practices Authority threatened fauna management systems.

Two translocated populations have been established in farm dams on private land in the Clyde River catchment. The larger of these has been protected by a Conservation Management Agreement and habitat improvement works are in progress.

The IFS has implemented grading procedures to minimise the risk of elver stocks being contaminated with other species.

1.6.8 Future Conservation Strategy

The health of the existing populations needs to be ensured with regular monitoring and action to reduce threats as necessary. Regular monitoring will increase chances of early detection of any undesirable species and thereby improve chances of successful eradication.

Water level management is the most important aspect for maintaining habitat quality and availability. Recommendations on levels and rates of change which meet the needs of golden galaxias will be incorporated into a Water Management Plan being prepared as part of the Natural Heritage Trust project. Implementation of these recommendations will be supported under the recovery plan.

Genetic studies of golden galaxias are required so that management can aim to maintain genetic diversity and structure within the species (e.g. by ensuring translocated populations are established using an adequate number of fish).

The golden galaxias will be included in communications activities to increase awareness of Tasmania's threatened galaxiids and their conservation requirements.

*1.7 Arthurs paragalaxias (*Paragalaxias mesotes*)*

1.7.1 Description of species

Arthurs paragalaxias is a small, stout galaxiid, growing to around 80 mm in length. The head slopes to a blunt long snout. Like other paragalaxias species it has a large dorsal fin originating almost above the pelvic fins. The tail is slightly forked or almost straight. Coloration is bold, usually dark greenish brown on the back, extending down the sides as bands and patches with a paler yellowish background and silvery-grey belly. The fins are clear with some amber pigmentation along the rays (Fulton 1990, McDowall 1996).

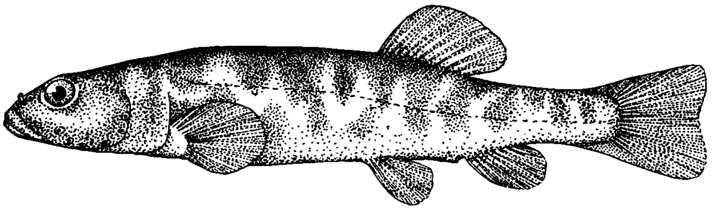

Figure 12. Arthurs paragalaxias **Paragalaxias mesotes**

1.7.2 Distribution

The paragalaxias genus is endemic to Tasmania. Arthurs paragalaxias occurs only in Woods Lake and Arthurs Lake on the Central Plateau (Figure 13), a distribution it shares with the saddled galaxias. It has also been recorded from the artificial canal which carries water from Arthurs Lake to Great lake (Hydro Tas, unpublished data). Arthurs paragalaxias has not been collected recently from Woods Lake despite several years of intensive sampling. In August and November 2002, 174 individuals collected from Arthurs Lake were released into Woods Lake to try to re-establish the population there. Habitat critical to survival is all the areas where the species occurs. i.e. Woods Lake and catchment upstream of the dam (42°04.7'S 147°01.5'E) and Arthurs Lake and catchment upstream of the dam (42°02'S 146°55'E).

1.7.3 Habitat

Arthurs paragalaxias is a lacustrine species and inhabits rocky and macrophyte-covered areas around the lake shores. It has also been collected in fyke nets at depths of 4-5 m in Arthurs Lake (Hydro Tasmania unpubl. data) indicating that it probably occurs throughout the lake.

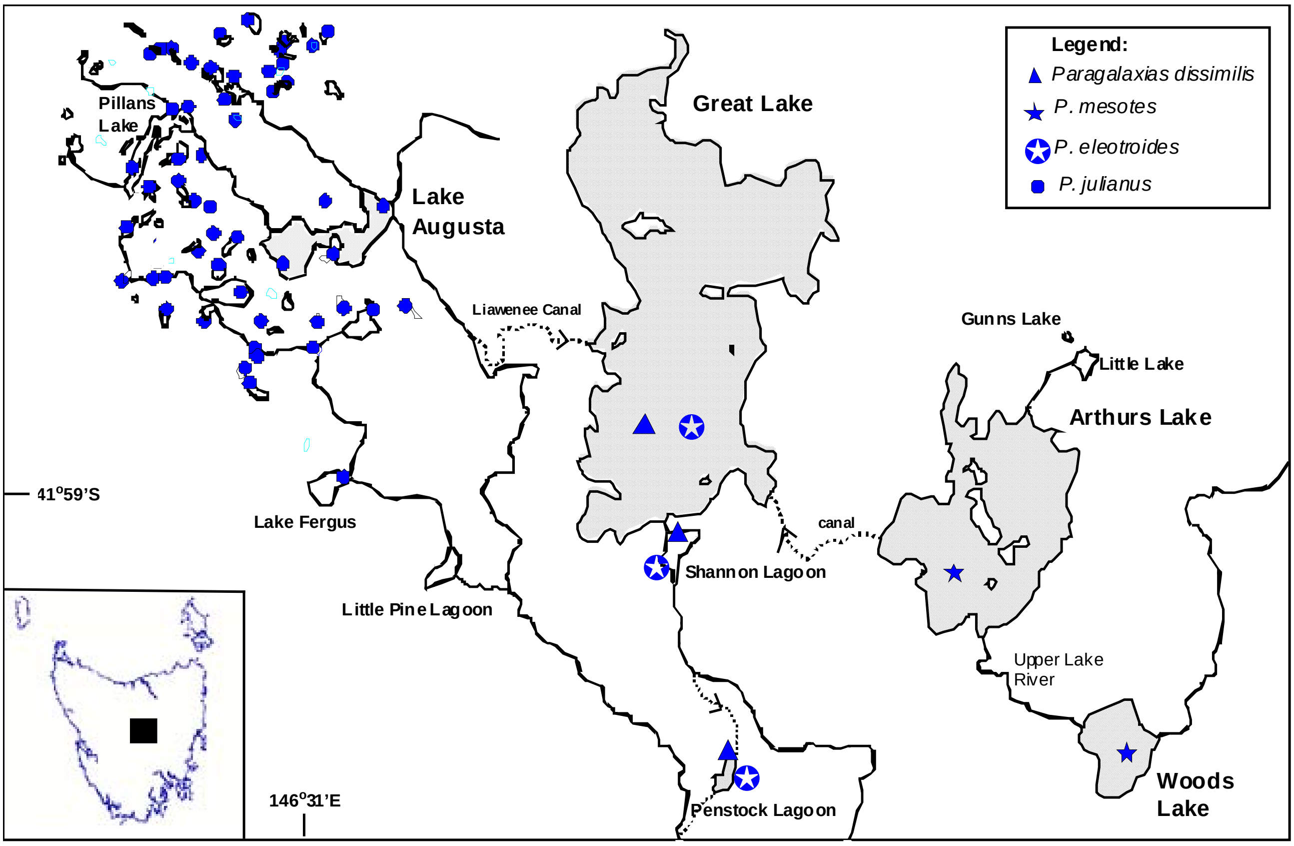

Figure 13. Distribution of the four paragalaxias species

1.7.4 Life history and Ecology

The diet of Arthurs paragalaxias consists of a range of aquatic animals including insect larvae and crustaceans (Fulton 1982). Little is known of the species' life history. Ripening females have been observed in September. Eggs and milt have been stripped from ripe fish in early November and several of the eggs hatched 25 days later (IFS unpubl. data). Larvae were approximately 9 mm long soon after hatching, and were distinctly stouter than larvae of saddled galaxias. Larvae have never been collected in the wild. There are 3-4 size classes present in the Arthurs Lake population (IFS unpubl. data).

1.7.5 Threats

Threats to the species are the same as those applying to the saddled galaxias. Changes in Woods Lake are of particular concern as the species has not been collected there since approximately 1995 despite intensive sampling from 1998 - 2002. The cause of this decline is not known. It may relate to a fairly recent event, such as the large drawdown in 1995, or longer term changes since impoundment of Woods Lake for irrigation supply in 1962. The lake is prone to periods of high turbidity and nutrients, caused by wind-driven suspension of sediments, with the risk directly related to lake level (Crook 1995). Damage to fish gills, changes to feeding behaviour, changes to the algal-based food chain, and loss of macrophytes may result.

Low water levels also dewater galaxiid habitat and as Woods Lake has a gently sloping bed, a slight drop in water level results in exposure of a large width of shoreline. This reduces the area of rocky refuge habitat and may therefore result in increased predation by trout. The life history of Arthurs paragalaxias is poorly known but other paragalaxias lay eggs under rocks in shallow water (Fulton 1982), where they are vulnerable to drying out if water level drops at a critical time. Most of the population may spawn only once or twice, therefore failure of recruitment for a year is likely to severely reduce the adult population.

The two populations were fragmented by construction of Arthurs Dam in 1965, which totally blocks flow from Arthurs Lake to Woods Lake under normal conditions. Movement of fish would probably have been in the downstream direction.

Introduced brown trout have probably been in Woods and Arthurs lakes for more than 100 years. They are likely to prey on Arthurs paragalaxias and may limit the species' abundance, but the species nevertheless remains common in Arthurs Lake.

1.7.6 Conservation status

Arthurs paragalaxias is listed as Endangered under the Tasmanian TSP Act and the EPBC Act (see Appendix 1 for the listing criteria). The species was identified as a Category 1 fauna species (requiring protection of all populations and habitat within the known range) under the Tasmanian comprehensive regional assessment process (PLUC 1997).

1.7.7 Existing conservation measures

Arthurs paragalaxias is listed on Tasmanian threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. Arthurs paragalaxias is a 'priority species requiring consideration' under the *Tasmanian Regional Forest Agreement 1997*, identified as requiring further research to determine its management requirements. Arthurs and Woods lakes and their fish populations are included in technical studies being conducted by Hydro Tasmania for development of a Water Management Plan under the *Water Management Act 1999* (Hydro Tasmania 2003a, 2003b).

An informal minimum lake level agreement between IFS and Hydro Tasmania since 1995 is intended to keep Woods Lake above a minimum water level of 735.40 m asl to reduce the risk of high turbidity events (Hydro Tasmania 1999). A minimum lake level agreement in place for Arthurs Lake to maintain angling amenity (Hydro Tasmania 1999) also reduces the potential for extensive habitat dewatering. The IFS has implemented grading procedures to minimise the risk of elver stocks being contaminated with other species.

Arthurs paragalaxias was reintroduced to Woods Lake in late 2002, with 174 individuals released at two adjacent rocky sites. The success of this reintroduction is not known, as subsequent surveys have not recorded any *P. mesotes* in Woods Lake.

1.7.8 Future Conservation Strategy

The strategy including habitat management, monitoring of populations, trout management, genetic research and communication is as outlined for saddled galaxias. Research into the habitat requirements and life history of Arthurs paragalaxias is needed to determine appropriate habitat management, particularly of water levels. Woods Lake requires monitoring designed to determine whether the reintroduced fish establish a breeding population there. If sites suitable for translocation of saddled galaxias are found then Arthurs paragalaxias can also be translocated to establish additional populations.

Arthurs paragalaxias will be included in communication actions aimed at increasing public awareness of Tasmania's threatened galaxiids and their conservation requirements.

1.8 *Shannon paragalaxias (*Paragalaxias dissimilis*)*

1.8.1 Description of species

The Shannon paragalaxias is a small galaxiid, growing up to approximately 75 mm in length. The snout is tapered. The dorsal fin is quite long and positioned above the pelvic fins and the tail is forked. Colouring is variable, with olive-brown to almost black on the back and indistinct dark bands and elliptical spots extending down the sides and a greyish-white belly. Fins are olive coloured but clear (Fulton 1990, McDowall 1996).

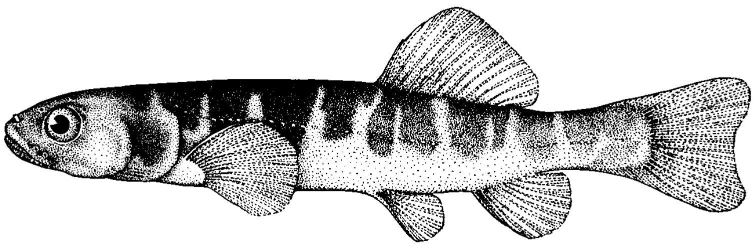

***Figure 14. Shannon paragalaxias* Paragalaxias dissimilis**

1.8.2 Distribution

The Shannon paragalaxias is endemic to Tasmania. It occurs only in Great Lake, Shannon Lagoon and Penstock Lagoon on the Central Plateau. Shannon and Penstock lagoons are artificial impoundments downstream from Great Lake, and their populations are likely to be derived from Great Lake. Habitat critical to survival is all areas where the species occurs, i.e. Penstock Lagoon and catchment upstream of the dam (42°06'S 146°45.5'E), Shannon Lagoon and catchment upstream of the dam (42°0.6'S 146°44.2'E), and Great Lake and catchment between Miena dam (41°59'S 146°44'E) and the Liawenee canal (41°54'S 146°41'E).

1.8.3 Habitat

Shannon paragalaxias occurs around the rocky margins of Great Lake and in the macrophyte beds of Penstock Lagoon. It is also abundant in the submerged algal (charophyte) beds of Great Lake to the maximum sampled depth of 7 m (Hydro Tasmania 2003c). In aquariums it swims in midwater rather than resting on the bottom (McDowall 1996).

1.8.4 Life history and Ecology

The main food of Shannon paragalaxias is small aquatic insect larvae and planktonic crustaceans (Fulton 1982). It breeds in summer (December- January) at one year of age. A small number (up to approximately 300) of very large eggs (2 mm) are produced and deposited in masses on sheltered rocks in shallow shore waters around Great Lake. Hatching takes at least 14 days; the larvae are approximately 8 mm long and are apparently pelagic for about 6 months. Shannon paragalaxias probably live up to approximately 3 years of age (Fulton 1982, 1990).

1.8.5 Threats

Management of water levels of Shannon Lagoon and Great Lake for hydro-electricity generation causes fluctuations in habitat quality and availability, particularly for the largest population in Great Lake. Penstock Lagoon is no longer used for power generation. Raising of the level of Great Lake several times in the 1900s has had major effects on the previously shallow lake habitat, particularly with loss of the dense macrophyte beds (Hydro Tasmania 2003c). The rocky shallows occupied by Shannon paragalaxias are subject to dewatering and the known spawning sites are within this area, although deeper areas have not been surveyed for eggs. Most of the lake bed at greater depth is soft sediment (Fulton 1983) which is poor fish habitat. The other important habitat, the algal beds in Great Lake, are also vulnerable to degradation by rapid and/or extensive water level fluctuations which can cause dewatering, erosion or light deprivation. There is no lake level agreement constraining levels of Great Lake and the level may vary over the operating range of 21.34 m (Hydro Tasmania 1999). Extremely dry conditions in 2002 resulted in a large drop in lake level and loss of the majority of algal bed area (Hydro Tasmania 2003c). The effect of this on galaxiid populations is not known.

A project designed to improve the water quality of Shannon Lagoon for angling purposes has been proposed. Planned works include reducing sediment-laden runoff to the lagoon and raising the water level. The resulting reduced turbidity may have a detrimental effect on the galaxiids by increasing trout predation. However, additional rocky refuge habitat may become available if the level is raised. The trout stocking regime for the lagoon is also being reviewed by the IFS with large numbers of adults and fry stocked in 2001 (IFS 2002b).

There is a possibility that redfin perch have reached Great Lake, from a small inflowing dam at Miena. As yet their presence has not been confirmed. From Great Lake the species is likely to reach Shannon and Penstock lagoons via connecting canals, if they can survive passage through the Miena dam outlet valve. Redfin are an aggressive piscivore and likely to have a major impact on the small galaxiids of Great Lake. Also present in all Shannon paragalaxias localities are brown and rainbow trout, introduced in 1870 and 1910 (Davies and Fulton 1987). Trout are known to prey on Shannon paragalaxias and may limit its abundance although the species has remained common.

Another potential threat is interactions (e.g. hybridisation or competition) with other non-indigenous fish species introduced to Great Lake through hydro-electric canals. Field survey has found that Arthurs paragalaxias and saddled galaxias are present in the canal through which water is pumped from Arthurs Lake to Great Lake (Hydro Tasmania unpubl. data), although it is not known whether these species can survive passage through the Todds corner power station before it discharges into Great Lake. There is also potential for western paragalaxias to move down Liawenee canal to Great Lake. It is not known whether any of these species have established populations in Great Lake. None were recorded in short surveys at Canal Bay and Tods Corner in 2004 (IFS unpubl. Data).

1.8.6 Conservation status

The Shannon paragalaxias is listed as vulnerable on the Tasmanian TSP Act. It has a limited distribution, a small number of fragmented localities and is at risk of future decline due to deterioration in habitat quality and potential for introduction of undesirable fish species.

1.8.7 Existing conservation measures

The Shannon paragalaxias is listed on Tasmanian threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. Great Lake and its fish populations are included in technical studies by Hydro Tasmania for development of a Water Management Plan under the *Water Management Act 1999*. Under informal lake level agreements with the IFS, Hydro Tasmania operates Shannon Lagoon and Penstock Lagoon at levels appropriate for angling requirements and turbidity mitigation (Hydro Tasmania 2001), which limit the extent of drawdown and associated habitat dewatering.

IFS have prepared a Great Lake Fishery Management Plan (IFS 2004a) which includes recommendations on management and research required for conservation of the native fish of Great Lake.

The abundance, habitat preferences and habitat distribution of the Shannon paragalaxias in Great Lake have recently been studied (Hydro Tasmania 2003c). Recommendations for water level management based on the results are being further studied by Hydro Tasmania and survey work is continuing. In addition, Hydro Tasmania have supported surveys to determine the status of redfin in Great Lake, and a single-night survey to search for non-indigenous paragalaxias species (Arthurs and Western paragalaxias) that may have been translocated through hydro infrastructure.

1.8.8 Future Conservation Strategy

Protection of existing populations requires regular monitoring to determine that they remain healthy and free of additional introduced fish species. Contingency plans need to be prepared in case redfin are discovered in Great Lake, including plans for galaxiid translocation and redfin containment and eradication. Shannon paragalaxias status in Shannon Lagoon and Penstock Lagoon needs to be monitored to determine whether reduced turbidity or possible changes in trout stocking regime have an affect on abundance or structure of the populations.

Water level management required to protect habitat will be determined and continued liaison with Hydro Tasmania for implementation will be undertaken.

Genetic studies of the species are required so that management can aim to conserve genetic diversity, e.g. by ensuring that any translocated populations are established with the required number of fish to contain representative diversity.

The Shannon paragalaxias will be included in communication actions aimed at increasing public awareness of Tasmania’s threatened galaxiids and their conservation requirements.

1.9 Great Lake paragalaxias (Paragalaxias eleotroides)

1.9.1 Description of species

The Great Lake paragalaxias is a small, stout galaxiid, growing up to approximately 60 mm in length. The snout has a steep profile curving down to the mouth low on the head. The dorsal fin is long and originates above the pelvic fins and the tail is emarginate or only very slightly forked. Coloration is light brownish gold on the back with irregular brown speckled patches becoming diffuse down the sides, and a pale yellow to white belly. Fins are amber with distinct black specks along the rays (Fulton 1990, McDowall 1996).

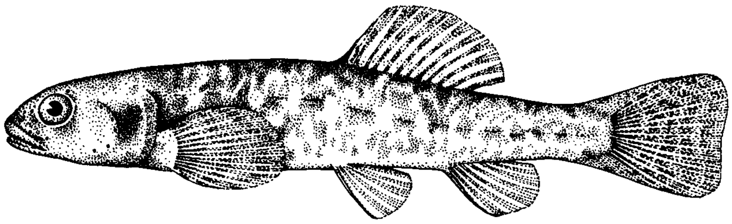

Figure 15. Great Lake paragalaxias **Paragalaxias eleotroides**

1.9.2 Distribution

The Great Lake paragalaxias is endemic to Tasmania. It has the same distribution as Shannon paragalaxias, occurring only in Great Lake, Shannon Lagoon and Penstock Lagoon on the Central Plateau. Habitat critical to survival is the same as for Shannon paragalaxias.

1.9.3 Habitat

The species occurs in the rocky shallows and algal beds around the shores of Great Lake, sheltering under rocks and vegetation. It is less abundant than the Shannon paragalaxias in this Hydro Tasmania 2003c). Although it was thought to be more abundant at depth (Fulton 1990), it was not found in recent surveys of algal and rocky habitats from 1-7 m depth (Hydro Tasmania 2003c). Its habitat preferences in Shannon and Penstock lagoons have not been determined. It is largely benthic in habit, unlike the more mid-water Shannon paragalaxias (McDowall 1996).

1.9.4 Life history and Ecology

Diet of the Great Lake paragalaxias consists mainly of benthic aquatic insect larvae, with planktonic crustaceans and some algae also eaten. It matures at one year old and breeding takes place in spring with females laying up to 150 eggs of approximately 2 mm diameter. The spawning site has not been found (Fulton 1982).

1.9.5 Threats

Threats to the Great Lake paragalaxias are similar to those of the Shannon paragalaxias as they occupy the same localities and share the rocky shore and algal bed habitat. The habitat requirements of the Great Lake paragalaxias are not well understood as the spawning site is not known and the species may be more common at greater depths than have been sampled.

1.9.6 Conservation status

The Great Lake paragalaxias is listed as vulnerable on the Tasmanian TSP Act It has a limited distribution, a small number of fragmented localities and is at risk of future decline due to deterioration in habitat quality and introduced fish species.

1.9.7 Existing conservation measures

The Great Lake paragalaxias is listed on Tasmanian threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. Great Lake and its fish populations are included in technical studies by Hydro Tasmania for development of a Water Management Plan under the *Water Management Act 1999* (Hydro Tasmania 2003c). Lake level agreements apply as for Shannon paragalaxias.

IFS have prepared a Great Lake Fishery Management Plan (IFS 20041) which includes recommendations on the management and research required for conservation of the native fish of Great Lake.

The abundance, habitat preferences and habitat distribution of the Great Lake paragalaxias in Great Lake have recently been studied (Hydro Tasmania 2003c). Recommendations for water level management based on the results are being further studied by Hydro Tasmania and surveys are continuing. Hydro Tasmania has also supported several surveys to determine whether redfin occur in Great Lake.

1.9.8 Future Conservation Strategy

Regular monitoring of populations and preparation of threat abatement contingency plans is required as described for Shannon paragalaxias. Any water level management rules implemented to protect Shannon paragalaxias habitat in Great Lake are also likely to minimise impact on the Great Lake paragalaxias.

Research is required to determine the species’ habitat requirements (including spawning habitat) so that habitat can be managed appropriately. In particular, sampling at depth is required to confirm reports of occurrence of Great Lake paragalaxias at depth. Genetic studies are required to enable management for maintenance of genetic diversity as for Shannon paragalaxias.

The Great Lake paragalaxias will be included in communication actions aimed at increasing public awareness of Tasmania’s threatened galaxiids and their conservation requirements.

*1.10 Western paragalaxias (*Paragalaxias julianus*)*

1.10.1 Description of species

The western paragalaxias is a small, stout fish. The snout is tapering. It is the largest paragalaxias species and may reach approximately 100 mm in length. The dorsal fin is small and originates slightly behind the pelvic fin origin, and the tail is slightly forked. Coloration varies with habitat and is usually dark brown to black markings on the back and sides ranging from irregular patches to distinct bars, with a silvery-olive belly and clear fins (Fulton 1990, McDowall 1996).

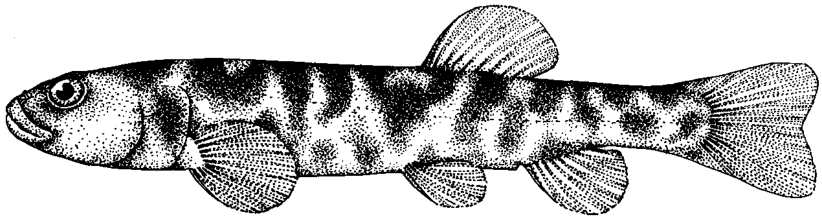

***Figure 16. Western paragalaxias* Paragalaxias julianus**

1.10.2 Distribution

The western paragalaxias is endemic to Tasmania. Until recently it was known only from lakes in the upper Ouse and Little Pine catchments in the area of the Central Plateau known as the Western Lakes (Fulton 1990). Surveys for the species conducted in early 2003 expanded the known range further south, to Lake Fergus, and into the James River catchment including Pillans Lake, although it was not found in the catchment above Pillans Lake (Nelson 2004). It is not yet known which of the areas occupied should be considered habitat critical to species survival. Further examination of survey data is required to determine important populations: these will include, but not be limited to, Lake Fergus (at the southern range extremity), Lake Augusta (a large population), Pillans Lake (at range extremity), Julian Lakes and above (at range extremity, low trout abundance in catchment above), populations across the range and any trout-free populations that may exist.

1.10.3 Habitat

The western paragalaxias lives in shallow rocky areas around the lake margins (Fulton 1990). It doesn't appear to inhabit flowing riverine environments, although it has once been found in a large still riverine pool (Nelson, in press).

1.10.4 Life history and Ecology

The western paragalaxias feeds on a variety of aquatic animals including insect larvae and small planktonic crustaceans (Fulton 1982). Spawning occurs in spring with eggs laid in masses on the sheltered, inland-facing side of rocks in shallow water. Larvae are pelagic (P. Davies pers. comm.).

1.10.5 Threats

Most of the lakes where the species occurs are remote and not subject to human-induced habitat degradation. The largest locality, Lake Augusta, has been dammed and is managed for hydro-electricity generation. The shallow areas occupied by the western paragalaxias and used for spawning are vulnerable to dewatering by lake drawdowns. Increases in water levels could allow trout access to refuge habitat. There is no lake level agreement for Lake Augusta and levels can vary over the operating range of 8.99 m (Hydro Tasmania 1999), with occasional greater maintenance drawdowns.

Introduced brown trout are widespread throughout the area and occur in and between all known populations of western paragalaxias. Trout prey on the paragalaxias and the pelagic larvae are particularly vulnerable, which may limit the species abundance. Trout predation or competition may reduce habitat availability by restricting the paragalaxias to shallow backwaters and deterring them from moving into open water (P. Davies pers. comm.). This may restrict exchange of individuals between populations in different lakes. No trout-free populations are known but they may exist.

1.10.6 Conservation status

The western paragalaxias is listed as rare on the Tasmanian TSP Act. It has a limited distribution, with recent surveys finding it to be widely distributed within a limited range, and is at risk of decline due to introduced species and changes in habitat quality.

1.10.7 Existing conservation measures

The western paragalaxias is listed on Tasmanian threatened species protection legislation. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit. All fish on reserved land are protected under the *National Parks and Reserves Management Act 2002* and cannot be taken without authority under this act. Lake Augusta and its fish populations are included in technical studies by Hydro Tasmania for development of a Water Management Plan under the *Water Management Act 1999* (Hydro Tasmania 2000).

Recommendations on the management and research required for conservation of the native fish of the Western Lakes area is included in the Western Lakes Fishery Management Plan (IFS 2002a). Recommendations include restriction of bait fishing to reduce the risk of pest fish introduction, determining and minimising the risk of pest fish invasion from other waters, research to identify habitat requirements of adults and juveniles, surveys to determine distribution, and monitoring of key waters with management as required for protection.

All known locations of the western paragalaxias are in the Central Plateau Conservation Area (part of the Tasmanian Wilderness WHA) and are therefore protected from most human-induced land degradation.

A fish barrier has been constructed in Liawenee canal by Hydro Tasmania to prevent upstream movement of redfin perch, or other pest fish, from Great Lake to Lake Augusta if they become established in Great Lake.

1.10.8 Future Conservation Strategy

The distribution of the species will be determined through strategic surveys complementing those conducted in 2003 (Nelson, in press). Geographic limits, abundance, habitat types and existence of any trout-free populations should be determined. Management of any trout-free waters will aim to ensure that they remain trout-free. These populations may provide information on the impact of brown trout on existing populations. The feasibility of rehabilitating some habitat by removal of trout will be examined.

Protection of existing populations requires regular monitoring to determine whether they remain healthy and free of additional introduced fish species. Contingency plans should be prepared detailing actions required to protect the species in the event that pest fish are discovered in the area.

Research into the habitat requirements and life history of the western paragalaxias is needed to determine appropriate habitat management, particularly of water levels in the artificial impoundments inhabited. As for the other species, genetic studies are required so that management can aim to maintain diversity and conserve any genetically distinct stocks.

The western paragalaxias will also be included in communication actions aimed at increasing public awareness of Tasmania’s threatened galaxiids and their conservation requirements.

*1.11 Dwarf galaxias (*Galaxiella pusilla*)*

1.11.1 Description of species

The dwarf galaxias is a very small galaxiid, with females growing up to approximately 40 mm in length and males approximately 35 mm. The fins are small, the dorsal fin originates behind the anal fin and the tail is rounded with strong flanges almost joining the tail to the dorsal and anal fins. Coloration is more or less transparent olive-amber with three longitudinal black stripes and silvery-white belly. Males have a bright orange stripe between the middle and lower dark stripes which females lack (Fulton 1990, McDowall 1996).

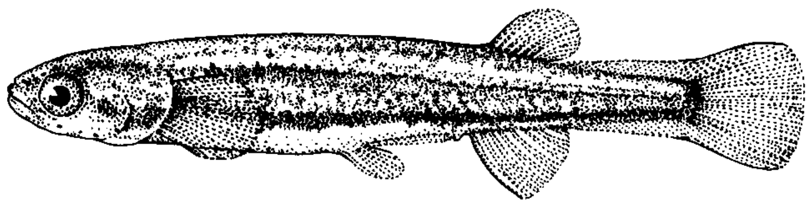

***Figure 17. Dwarf galaxias* Galaxiella pusilla**

1.11.2 Distribution

The dwarf galaxias occurs in lowland areas in the north-east and north-west of Tasmania, on Flinders Island and in southern Victoria and South Australia (Figure 18) (Chilcott and Humphries 1996, Fulton 1990). The species was not found on King Island during targeted IFS surveys in 2001. All known populations are important, as the species has declined and although it has a wide geographic range, distribution is patchy and populations are fragmented. It can be locally abundant. The species' genetic structure within the distribution is not yet known. Therefore, habitat critical to survival is all areas where the species occurs and the catchments affecting them. Known sites are listed in Table 4.

1.11.3 Habitat

The dwarf galaxias lives in still or slow-flowing waters such as ponds, swamps, drains and backwaters of streams, often containing dense aquatic or emergent plants. Waterbodies may be permanent, or temporary waters connected to permanent water. It is thought that dwarf galaxias may be able to take refuge in crayfish (*Geocharax* or *Engaeus*) burrows if pools dry up, or aestivate in small depressions in mud or under rocks (Humphries 1983 cited in Chilcott and Humphries 1996, Beck 1985). Known Tasmanian sites appear to be associated with Holocene sand, gravel and alluvium deposits (Chilcott and Humphries 1996).

1.11.4 Life history and Ecology

Dwarf galaxias are a generalist carnivore and feed mostly in the water column on a variety of aquatic invertebrates including insect larvae and small crustaceans, as well as terrestrial invertebrates (Humphries 1986, McDowall 1996). Spawning occurs in spring, with eggs deposited singly on aquatic plants and fertilised by a following male. Females carry up to approximately 250 eggs which appear to be laid over a period of several days. Eggs are approximately 1.3 mm when water hardened and the 4.5 mm long larvae hatch after 2-3 weeks (McDowall 1996). The dwarf galaxias appears to be an annual species with adults dying after spawning, as populations contain only one year class (Humphries 1986).

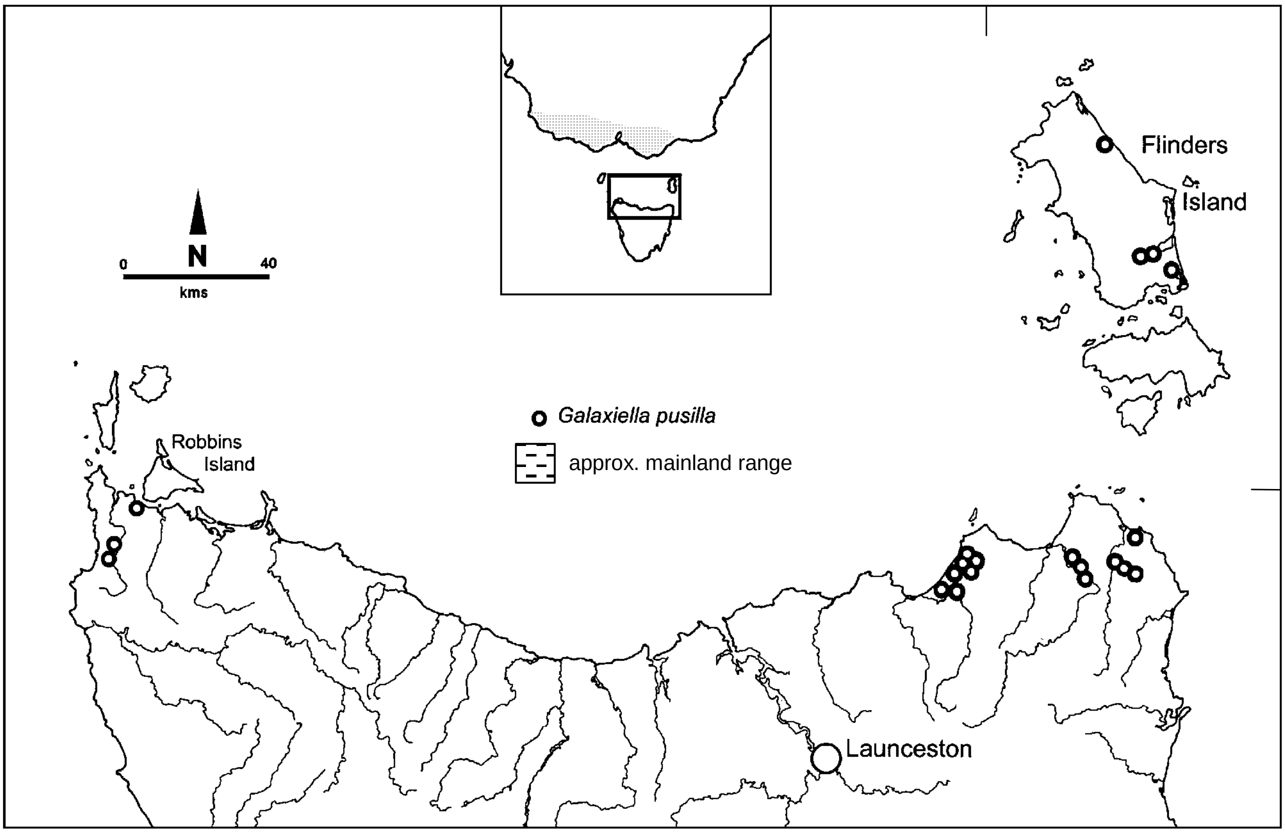

Figure 18. Distribution of dwarf galaxias in Tasmania.

Table 4. Known sites where dwarf galaxias occurs in Tasmania.

Site name	Topographic map	Grid reference*	Latitude longitude
Big Waterhouse Lake wetlands	Waterhouse	551600 5472800	40°53.7'S 147°36.8'E
near Little Waterhouse Lake ?	Waterhouse	552000 5475100	40°52.4'S 147°37'E
Blackmans Lagoon	Waterhouse	550200 5471000	40°54.6'S 147°35.8'E
creek at Lowly	Oxberry	549100 5469100	40°55.7'S 147°35'E
drain, Forester Lodge	Oxberry	544400 5462400	40°59.3'S 147°31.7'E
pool, Marengo ?	Oxberry	547900 5466100	40°57.3'S 147°34.2'E
pool, Forester Lodge	Oxberry	543000 5463600	40°58.7'S 147°31.4'E
pool, Mt William	Naturaliste	600700 5478200	40°50.5'S 148°11.7'E
pool, Rushy Lagoon property	Tomahawk	579700 5473200	40°53.3'S 147°56.8'E
lagoon, Gladstone	Gladstone	585000 5467200	40°56.5'S 148°0.6'E
Great Musselroe River	Gladstone	591400 5467700	40°56.3'148°05.2'E
The Marsh Creek ?	Musselroe	583500 5470800	40°54.6'S 147°59.5'E
Icena Creek	Musselroe	593500 5470000	40°55'S 148°06.6'E
Icena Creek	Gladstone	596200 5466400	40°56.8'S 148°08.6'E
trib., Icena Creek, Tarrabah Park property	Gladstone	597000 5463100	40°56.7'S 148°09.1'E
Logan Lagoon	Logan	610000 5552000	40°08.6'S 148°17.9'E
pool, Lackrana	Logan	603000 5559900	40°06.1'S 148°12.9'E
pool, near Chew Tobacco Ck	Logan	601000 5554900	40°08.8'S 148°11.5'E
pool, near Hogans Lagoon	Wingaroo	589900 5587800	39°51'S 148°03.6'E
Wingaroo	Wingaroo	586800 5588400	39°50.6'S 148°01.5'E
pool, near Marrawah[e]	Cameron	311000 5476900	40°50.1'S 144°45.4'E
Blue Bog	Cameron	307900 5470100	40°53.7'S 144°43.2'E
Jims Plain	Cameron	314536 5478188	40°49.4'S 144°47.9'E
Horsepiss Creek	Studland	319900 5482000	40°47.6'S 144°51.9'E

* Australian Geodetic Datum 1966 [e] extinct ? possibly extinct

1.11.5 Threats

Habitat loss and fragmentation through wetland degradation is a major cause of decline of the dwarf galaxias. Wetland habitat is degraded by drainage, inundation by damming, trampling and fouling by stock, pollution by chemicals or silt, ploughing of temporary wetlands, surface and groundwater abstraction, and changes to catchment hydrology by tree plantations, clearing of vegetation and urbanisation.

Introduced aquatic species are also a threat. The species rarely co-occurs with trout. Where both species are present, the dwarf galaxias are found only in the shallow margins with thick aquatic vegetation inaccessible to trout (S. Chilcott pers. comm.). Gambusia (*Gambusia holbrooki*) is widespread in south-eastern Australia and is likely to cause declines in native fish by predation on eggs and juveniles and aggressive fin-nipping (Koehn and O'Connor 1990, Baker *et al.* 2004). It is recognised as a threat to dwarf galaxias by Wager and Jackson (1993). In Tasmania, gambusia is a relatively recent introduction and is still restricted to a relatively small area although it has spread beyond the first sites. Spread of the species is a risk as long as it is present in Tasmania, through natural dispersal and activities such as illegal bait use or transfer into dams. As such it is considered a threat to Tasmanian native fish species. Predation on dwarf galaxias by redfin perch (*Perca fluviatilis*) is also a threat if it colonises dwarf galaxias habitat. The introduced mainland yabby (*Cherax destructor*) is becoming more widespread in Tasmania, despite being declared a controlled (noxious) species, and has potential to degrade dwarf galaxias habitat by destroying macrophytes and increasing turbidity (Elvey *et al.* 1996) if introduced to these sites.

1.11.6 Conservation status

The dwarf galaxias is listed as rare on the Tasmanian TSP Act and as Vulnerable on the EPBC Act. It has a limited distribution in Tasmania and is subject to threats described above. The degree of decline in Tasmania is unknown due to a lack of survey and monitoring. However, some decline has occurred with the loss of the only known site in north-west Tasmania (two other sites have since been found) and several north-east sites appear to be extinct (IFS unpubl. data). In Victoria it has 'undoubtedly declined because of wetland drainage' (Koehn and Morison 1990). The dwarf galaxias was identified as a Category 2 species (requiring protection of some areas within high quality habitats) under the Tasmanian comprehensive regional assessment process (PLUC 1997). It was then listed as a 'priority species requiring consideration' under the *Tasmanian Regional Forest Agreement 1997* and is therefore to be protected through the CAR (Comprehensive, Adequate and Representative) reserve system or relevant management prescriptions.

1.11.7 Existing conservation measures

The dwarf galaxias is listed on threatened species protection legislation in Tasmania, Victoria and the Commonwealth. The Tasmanian *Inland Fisheries Act 1995* prohibits collecting of any freshwater species without permit.

Distribution surveys for the species were conducted by IFS staff in the north-east and Flinders Island in 1992, and in the north-west and King Island in 2000 and 2001 respectively. One of the sites in the north-west is on land managed for forestry purposes and the managers have been informed of the species locality. The catchment is largely undisturbed at present and the site should be protected from any future forestry operations under Forest Practices prescriptions. The current status of most of the north-east populations is not known and landowners may be unaware of the species presence and its management requirements.

Of the 24 known localities, only four are on reserved land and the others are on private land. The species is included in the Forest Practices Authority threatened fauna management system, whereby all localities and catchments are flagged and management prescriptions applied to minimise impacts of forestry operations.

Eradication of gambusia from Tasmania is being attempted, with dams being poisoned and investigations into methods for eradication from the Tamar River wetlands in progress.

1.11.8 Future Conservation Strategy

The conservation strategy for dwarf galaxias is to initially conduct surveys to determine the species distribution, the status of populations and extent of any decline. Appropriate action to protect populations can then be taken. In particular, liaison with landowners to inform them of the presence of the species, its significance and habitat management recommendations is required. Reservation of sites under voluntary programs applicable to private lands will be encouraged. A program of ongoing monitoring of populations and habitat condition throughout the species' range will be implemented. Options for expansion of the area of occupancy for the species by reintroduction to previously occupied habitat will be assessed. Rehabilitation of habitat may require exclusion and removal of introduced fish, and/or physical habitat rehabilitation.

Measures recommended to reduce the impact of introduced fish include avoiding trout stocking into waters where dwarf galaxias occurs and consideration of trout removal from priority sites (Koster 2003). Liaison with IFS staff responsible for trout management will be undertaken to implement these measures. Eradication of gambusia from Tasmania is of critical importance and every possible effort should be made to achieve this.

Genetic studies are required so that management can aim to conserve genetic diversity and any distinct groups. Genetic studies of southern pygmy perch (*Nannoperca australis*), which has a similar but more widespread distribution, have revealed the occurrence of two groups in Tasmania and Victoria (Hammer 2001). Dwarf galaxias may show a similar pattern with as-yet-unrecognised species or subspecies (Hammer pers. comm.).

The dwarf galaxias will be included in communication actions aimed at increasing public awareness of Tasmania's threatened galaxiids and their conservation requirements. It will be promoted in any wetland conservation programs.

2. Recovery Objectives and Criteria

The overall objective of recovery actions for all species in this plan is to ensure the long-term survival of the species in the wild (or in *ex-situ* sites for Pedder galaxias), by minimising the effects of threatening processes. Conservation status will be improved by ensuring no further decline in the extent of occurrence, area of occupancy, number and connectivity of populations, and number of mature individuals, and by increasing these values where feasible. For species with a naturally restricted distribution where threats cannot be completely controlled, downlisting is unlikely. They will continue to meet the criteria for listing with the same status. This applies to all the species in this plan, including the dwarf galaxias throughout its Tasmanian range. The general Objectives, Criteria and Actions of this plan are given in Table 5 below.

Table 5. General Recovery objectives and performance criteria.

Recovery Plan Objectives	Performance Criteria	Actions
1.To protect existing populations.	No decline in area of occupancy, extent of occurrence, number or connectivity of populations or number of mature individuals.	• Coordinate implementation of recovery program. • Monitor populations for health and security from threats. • Research to determine habitat requirements. • Manage habitat to minimise threats. • Manage recreational and commercial fisheries and pest fish to minimise threats.
2. To increase public awareness and involvement in the recovery process.	The local community is aware of and involved in the recovery process.	• Develop and implement a communications strategy. • Maintain the recovery team links with the community.
3. To maximise area of occupancy (as appropriate within environmental and practical constraints).	Area of occupancy (number and/ or size of populations) has increased.	• Survey for new populations and/or suitable translocation sites. • Undertake habitat rehabilitation (e.g. removal and exclusion of introduced species). • Reintroduce/allow expansion into rehabilitated sites. • Prepare translocation proposals and implement if required.
4. Maintain genetic structure and diversity.	Intraspecific genetic structure and diversity has been determined and used to inform conservation management.	• Research species genetics. • Consider genetic implications in management decisions.

Detailed recovery objectives and the criteria against which recovery will be assessed are given for each species below (Table 6). It is not considered feasible to give quantitative values such as number or size of populations or percent increase in area for most species. For example, population size will reach the carrying capacity of the habitat providing habitat is protected, and population sizes for some species can fluctuate markedly on a seasonal basis (e.g. dwarf galaxias) or according to environmental conditions (e.g. Swan galaxias). It is not possible to anticipate how many new populations or potential translocation sites may be discovered, or how much habitat can actually be rehabilitated. ‘Population’ is used according to the EPBC

Act definition, rather than the IUCN (2001) equivalent term ‘subpopulation’, i.e. a population means an occurrence of the species in a particular area.

Table 6. Recovery objectives and performance criteria. (Dots indicate where each applies, √ indicates where the criterion is already met, no symbol indicates "not applicable").

Species	**PG**	**SwG**	**CG**	**SmpG**	**SaG**	**GG**	**APa**	**SPa**	**GLPa**	**WPa**	**DwG**
Objectives											
1. To protect existing populations.	•	•	•	•	•	•	•	•	•	•	•
2. To increase public awareness and involvement in the recovery process.	•	•	•	•	•	•	•	•	•	•	•
3. To maximise the number of populations and/or area of occupancy.	•	•	•	•	•	•	•	•	•	•	•
4. To maintain species genetic structure and diversity.	•	•	•	•	•	•	•	•	•	•	•
Criteria against which recovery will be assessed											
1a: There has been no further decline in the extent of occurrence, area of occupancy, number of populations and number of mature individuals.		•	•	•	•	•	•	•	•	•	•
1b Extensive surveys for new populations have been conducted.	√	•	•	•						√	•
1c: All populations are free of introduced fish and secure from introduced fish invasion.	•	•	•								
1d: Risk of human-induced fish introductions to populations has been minimised.	•	•	•	•	•	•	•	•	•	•	•
1e: Measures to reduce the risk of pest fish invasion by other means are maintained.	√	•	•	•							
1f: Species habitat requirements for conservation are understood.	•	√	√	•	•	√	•	•	•	•	√
1g: All populations are secure from land management impacts (e.g. changes to hydrology, sedimentation, etc).	√	•	•	√	•	•	•	•	•		•
1h: All populations are secure from water management impacts (e.g. damming, water level changes).	•	•	•	•	•	•	•	•	•	•	•
Species	**PG**	**SwG**	**CG**	**SmpG**	**SaG**	**GG**	**APa**	**SPa**	**GLPa**	**WPa**	**DwG**

Objectives, continued											
1i: Management of recreational and commercial fisheries aims to minimise impacts on galaxiid populations.			•		•	•	•	•	•	•	•
2a The local community is aware of and involved in the recovery process.	•	•	•	•	•	•	•	•	•	•	•
2b Land managers are aware of species presence and management requirements.	√	√	√	√	√	√	√	√	√	√	•
3a Number of populations, area of occupancy and extent of occurrence have been restored to pre-decline levels.							•				
3b At least two secure self-maintaining populations exist.	•						•				
3c Extensive surveys for potential translocation sites have been conducted.	•			•	•			•	•		
3d Habitat suitable for establishment of at least one additional population has been identified.	•			•	•	√	•	•	•		
3e Feasibility of rehabilitating previously occupied habitat has been determined.	•	•	•								
3f Translocation proposals have been prepared.	•	•	•	•	•		•	•	•		
4 The genetic structure of the species has been determined and is used to guide protection priorities and translocation proposals.	•	•	•	•	•	•	•	•	•	•	•

PG Pedder galaxias; SwG Swan galaxias; CG Clarence galaxias; SmpG swamp galaxias; SaG saddled galaxias; GG golden galaxias; APa Arthurs paragalaxias; SPa Shannon paragalaxias; GLPa Great Lake paragalaxias; WPa western paragalaxias; DwG dwarf galaxias.

3. Actions

The plan includes seven actions necessary to meet the recovery objectives. Although the actions are generic, they apply in slightly different ways to each species, so individual actions 3-7 are specified below for each species. This enables species or actions to be included according to resources available. Operational details including recommended methods and sites will be described in the review on the 1998-2002 recovery plan (Jackson in prep.). The two actions encompassing all the species are recovery coordination and reporting, and increasing public awareness.

1. Recovery coordination and reporting
2. Increase public awareness and involvement
3. Monitor existing populations
4. Survey for new populations and potential translocation sites
5. Habitat and threat management
6. Determine habitat requirements
7. Determine species genetic structure.

All Species

3.all.1 Recovery coordination and reporting

A project officer is required to coordinate the recovery program. This includes maintaining the recovery team, seeking funding to implement the actions, coordinating implementation of the actions and participating in carrying out actions. Reporting to stakeholders on progress with actions and seeking stakeholder input are required. Finally, coordination of evaluation and review of the recovery plan is required.

Costs are for salary (60%) and office accommodation and support costs.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	48	48	48	48	48	240

3.all.2 Increase public awareness

Actions to increase public awareness and involvement in Tasmania's freshwater fish and their conservation requirements, particularly threatened species, are important for success of several aspects of the plan. Increased awareness is necessary to increase community involvement and support for the recovery program. Public awareness of activities affecting freshwater systems is vital to reducing key threats, particularly the spread of introduced fish species.

A communications plan will be developed for the recovery program, detailing the key messages, audiences and means of communicating the messages. Activities will include displays at public events such as IFS Open Weekend, Agfest and Threatened Species Day. Regular articles will be included in the IFS and DPIW Threatened Species Section newsletters, and other publications as opportunity arises. Threatened fish material on the IFS website (www.ifs.tas.gov.au) will be updated. Printed education materials may include brochures, a poster and/or sticker. Options for increasing involvement with schools and the wider non-angling community, such as through Waterwatch groups, will be a priority. Informative signage will be placed at key sites with the aim of reducing risks of illegal fish introductions –see Action 5.

Costs are for salary (10%), travel (vehicle costs and travel allowance) to events and presentations, design and printing of information materials. Signage costs are included under Action 5 for each species.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	14	8	8	8	8	46

Pedder galaxias

3.1.3 Monitor existing populations

The two populations of Pedder galaxias will be regularly monitored to check that they are breeding, numbers don't decline, and they remain free of introduced fish, and are not subject to habitat degradation. Monitoring is required to detect any problems so that appropriate action can be taken to protect populations. Lake Oberon will be visited every one to two years, with fish counts and invertebrate monitoring samples taken (Hamr 1992, Jackson in prep.). The Crossing River downstream of Lake Oberon will be surveyed to determine whether Pedder galaxias may have unintentionally established there.

The Strathgordon water supply site will be visited at least twice a year as the Pedder galaxias population has not yet established there. With no sign of breeding three seasons after initial introduction, possible reasons for failure should be addressed before additional transfers of fish from Lake Oberon are conducted. The annual invertebrate and tadpole sampling program in Strathgordon dam will be continued to monitor the impact of fish introduction and the abundance of food supply for the fish.

Costs are for staff time, travel (helicopter, vehicle costs, accommodation and travel allowance) to Lake Oberon, Crossing River and Strathgordon, sampling consumables, invertebrate identification and purchase/hire and maintenance of monitoring equipment (invertebrate nets, boat).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	19	19	19	19	19	95

3.1.4 Survey for potential translocation sites

To establish another *ex-situ* population of Pedder galaxias, a suitable site needs to be found. Several artificial dams in the Strathgordon area have been identified as potential sites and these require more thorough assessment of the habitat suitability and potential impact of fish introduction on the invertebrate fauna. Modification may be required to create suitable habitat (e.g. addition of shelter or inflowing spawning habitat). Natural sites identified by Hamr (1992) are unlikely to be suitable due to their reservation status.

Costs are for staff time, travel to the Strathgordon area, sampling consumables and invertebrate identifications. Cost estimates for any construction works which may be required are not included.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	5	5	-	-	-	10

3.1.5 Habitat and threat management

Protection of existing populations of Pedder galaxias now focuses on the translocated populations. Lake Oberon is remote and reserved and is managed to minimise impacts from visitors. No additional habitat management of Lake Oberon is required to maintain suitable habitat for the Pedder galaxias.

Options for screening the lake outflow will be examined to prevent them moving downstream into the undisturbed Crossing River system.

The Strathgordon water supply dam requires management to maintain suitable spawning conditions in the artificial inflow stream and keep the outflow screens clean to avoid unscreened overflow and maintain suitable water levels. To maintain the dam free of other fish species, management will aim to minimise the risk of fish introduction (e.g. with additional signage) and remove any that are found.

To increase the area of occupancy of Pedder galaxias, proposals for translocation to any suitable sites identified under Action 3.1.3 will be prepared and translocation conducted if approved. Management of these sites to create or maintain suitable habitat for Pedder galaxias may also be required.

Costs are for staff time and additional travel to Strathgordon.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	3	3	3	3	3	15

3.1.6 Determine habitat requirements

More information is required on the types of habitat needed for Pedder galaxias to be able to establish and maintain populations, to determine which sites may be suitable for translocation, and whether a population could be re-established in one of the previously occupied Lake Pedder tributary streams if other species were excluded. In particular, the degree of dependence on a stream for spawning and a pond for juveniles need to be clarified. Surveys of fish habitat use will be made during population monitoring. Spawning sites will be searched for in the Strathgordon dam. Manipulations such as holding fish in ponds or enclosures will be considered if numbers of fish allow.

Costs of this action are for staff time and travel for additional trips to Strathgordon.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	4	4	-	-	-	8

3.1.7 Determine genetic structure

The genetic structure of the Pedder galaxias translocated populations will be monitored to determine whether diversity is being maintained in all populations and whether additional fish transfers are required. Methods using a small sample of tissue from non-lethal fin clips are probably most suitable. The work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxias.

Costs are materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	5	-	-	-	5	10

Swan galaxias

3.2.3 Monitor existing populations

The 18 known Swan galaxias populations will be monitored at least once per year to determine whether they are breeding and maintaining numbers, remain secure from introduced fish, and are secure from habitat degradation.

Costs are for staff time, travel (vehicle costs, accommodation and allowances) and purchase/hire and maintenance of monitoring equipment (electrofisher, fyke nets).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	7	6	6	6	6	31

3.2.4 Survey for new populations and translocation sites

There is potential for discovery of additional populations of Swan galaxias as the area has not been fully surveyed. Tributaries of the Swan and Macquarie rivers which are potentially trout-free and with suitable habitat will be surveyed to determine whether they contain Swan galaxias or are suitable as potential translocation sites. If any new Swan galaxias populations are found, their geographical extent and degree of security from threats will be determined. Any potential translocation sites will be documented to enable consideration if further translocations are required in future.

Costs are for staff time and travel additional to monitoring trips.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	5	5	-	-	-	10

3.2.5 Habitat and threat management

Population monitoring (Action 3.2.2) will indicate whether existing natural and artificial barriers to trout invasion require improvement. All known populations have been secured from trout invasion but illegal introduction remains a risk. Any introduced fish including *Galaxias maculatus* found in Swan galaxias sites will be removed. Informative signage will be placed at sites considered most at risk from illegal fish introductions. The effectiveness of new IFS trout stocking procedures to reduce the risk of illegal introductions will be assessed. If required, implementation of measures to further reduce the risk will be encouraged.

Liaison with land managers (Forest Practices Authority, Forestry Tasmania, private) regarding management prescriptions and habitat protection will continue. Information on habitat improvement and rehabilitation of riparian vegetation for galaxiids will be provided to existing programs such as Rivercare, Landcare and Waterwatch.

Brodribb Creek (below Lake Yalleena) urgently requires a feasibility study to examine and cost options for prevention of redfin access to the stream (such as effective screens or diverting the dam outflow out of the catchment) and removal of redfin present. Streams likely to have been previously occupied by Swan galaxias will be assessed for feasibility of rehabilitation and reintroduction. Options for extending and reconnecting existing habitats, e.g. by placing trout barriers further downstream, will also be assessed. Rehabilitation may require removal and exclusion of introduced fish and/ or physical habitat restoration. Rehabilitation and reintroduction will be undertaken at any sites considered suitable.

Costs are for staff time, equipment (fyke nets), travel and signage. Costs of any rehabilitation works cannot be estimated until sites are assessed.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	10	6	6	4	4	30

3.2.6 Determine habitat requirements

Habitat requirements for the conservation of the Swan galaxias are reasonably well known with the species occupying sites without other fish species (except eels) that contain permanent water and have low gradient areas with pools. However, the site for spawning is not known. Searches for eggs will be conducted in spring. Studies of captive fish may be included.

The effects of vegetation clearing and regrowth (particularly forestry operations) on hydrological regimes of Swan galaxias streams is not well understood and management prescriptions are currently based on general patterns derived from elsewhere. Most of the Swan galaxias populations occur on State Forest and information on the effects of forestry operations on catchment water yield and flow patterns is required to avoid drying up of streams or increasing the frequency and size of high flows. Continued liaison with Forestry Tasmania will aim to increase knowledge of the area’s hydrological responses to operations.

Costs are for time and travel to enable egg surveys in spring.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	2	2	-	-	-	4

3.2.7 Determine genetic structure

Knowledge of the genetic structure of Swan galaxias is needed to inform decisions on population protection, translocation and captive breeding, to ensure that genetic structure and diversity is maintained. Swan galaxias populations are all isolated from each other and the 9 translocated populations were established from only two of the natural populations. Genetic studies are required to determine whether populations are genetically distinct and whether the translocated populations contain all the genetic diversity. Methods using a small sample of tissue from non-lethal fin clips are probably most suitable. The work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxias.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	10	-	-	-	10

Clarence galaxias

3.3.3 Monitor existing populations

The seven known Clarence galaxias populations will be monitored at least once per year to determine whether they are breeding and maintaining numbers, remain free of introduced fish, and are secure from habitat degradation.

Costs are for staff time, travel (vehicle costs, accommodation and allowances) and purchase/hire and maintenance of monitoring equipment (electrofisher, fyke nets).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	7	6	6	6	6	31

3.3.4 Survey for new populations and potential translocation sites

There is potential for discovery of additional Clarence galaxias populations, as the area is remote and has not been fully surveyed. The recent discovery of populations in catchments outside the Clarence greatly increases the known area in which the species may occur. Sites that may be free of trout and contain suitable habitat will be surveyed for the presence of Clarence galaxias. Any new populations found will be surveyed to determine their geographical extent and degree of security from trout invasion. If any sites are considered suitable as potential translocation sites, invertebrate fauna will be assessed to determine if rare or threatened species are present. Translocation proposals will then be prepared according to ANZECC guidelines as contingency plans to be used if translocation is required in the future.

Costs are for staff time, travel (including helicopter), sampling consumables and invertebrate identifications.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	10	5	-	-	-	15

3.3.5 Habitat and threat management

Two populations continue to be threatened by trout presence or invasion. Actions to confirm the success of the eradication of the illegally introduced trout from Johnsons Lagoon will continue. At Dyes Marsh, trout removal above the installed barrier and assessment of the effectiveness of the barrier will be undertaken. Existing signage will be maintained and signs placed at any additional sites considered at risk from illegal fish introduction.

IFS has implemented new trout stocking procedures and their effectiveness in reducing the risk of illegal introductions will be assessed. If required, implementation of measures to further reduce the risk will be encouraged. The existing brook trout fishery at Clarence Lagoon will continue to be maintained by IFS as an alternative to brown trout and no new waters will be stocked by IFS.

Liaison with land managers regarding management prescriptions and habitat protection will continue. Information on habitat improvement and rehabilitation of riparian vegetation for galaxiids will be provided to existing programs such as Rivercare, Landcare and Waterwatch.
Waterbodies known or likely to have been previously occupied by Clarence galaxias will be assessed for feasibility of rehabilitation and reintroduction. Options for extending existing habitats, e.g. by placing trout barriers further downstream, will also be assessed. Rehabilitation may require removal and exclusion of introduced fish and/ or physical habitat restoration. Rehabilitation and reintroduction will be undertaken at any sites considered suitable.

Costs are for staff time, travel, consultant advice on barriers, signs. Costs for barrier materials are not included as they depend on barrier design.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	18	14	5	5	5	47

3.3.6 Determine habitat requirements

Research on habitat requirements of Clarence galaxias is not a high priority as it is known that the primary conservation requirement is for trout free habitat. All sites occupied are relatively undisturbed and further information on habitat requirements is not required for management at present. Information will be obtained opportunistically and studies of captive fish may be included. There are no additional costs for this action.

3.3.7 Determine genetic structure

All populations of Clarence galaxias are isolated from each other. Knowledge of the genetic diversity and population genetics of the species is required to ensure that this diversity is maintained. The population genetics may also shed light on the species' biogeography. Methods using a small sample of tissue from non-lethal fin clips are probably most suitable. The work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxias.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	10	-	-	-	10

Swamp galaxias

3.4.3 Monitor existing populations

Regular monitoring of selected swamp galaxias sites is needed in order to detect any population decline and possible spread of introduced fish. Swamp galaxias occurs in many individual streams. A monitoring program will be set up with sites selected to indicate swamp galaxias abundance and population structure in sites accessible to and isolated from trout, and to indicate if redfin perch invade swamp galaxias habitat from Lake Gordon or Pedder.

Monitoring of the trial translocated population near Strathgordon will show whether swamp galaxias can establish a population without an inflowing stream for spawning.

Costs are for staff time, travel (vehicle costs, accommodation and allowances) and purchase/hire and maintenance of survey equipment.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	6	5	5	5	5	26

3.4.4 Survey for new populations and potential translocation sites

There are several areas that may contain swamp galaxias where they will be isolated from any potential redfin invasion of Lake Pedder, or that will expand their known range considerably. Priority areas for survey include tributaries of the upper Gordon River (above Lake Gordon) and the Huon catchment below the Lake Pedder impoundment. The geographical extent and degree of security from introduced fish will be assessed for any new populations found. Any sites which are suitable as potential translocation sites will be surveyed for the presence of significant invertebrate species that would be affected by introduction of fish. Natural sites are unlikely to be considered suitable due to their reservation status. Translocation proposals will be prepared for use as contingency plans should redfin perch be found in Lake Pedder.

Costs are for staff time, travel and invertebrate identifications.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	5	5	-	-	-	10

3.4.5 Habitat and threat management

Liaison with Hydro Tasmania regarding protection of populations through water level management and barriers will continue.

Signage and brochures will be produced to inform visitors, to reduce the risk of accidental or deliberate introduction of redfin or other undesirable species to Lake Pedder, and to increase the chance of early detection of any such species.

Habitat management to increase security of populations from introduced fish will be undertaken where possible. This may include barrier enhancement, trout removal or translocations of swamp galaxias to secure artificial sites.

Costs are for staff time, signs, travel to place signs and work on securing populations, Hydro water level management.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	9	6	5	5	5	30

3.4.6 Determine habitat requirements

More knowledge of swamp galaxias habitat requirements is needed for assessment of their degree of risk from introduced fish invasion and suitability of potential translocation sites (e.g. whether they can establish a population without an inflow stream). Information will be obtained during monitoring surveys and from the trial translocation. Studies of captive fish may be included. Student research into the species will be encouraged.

Costs are covered by Action 3.4.3 Monitoring.

3.4.7 Determine genetic structure

Prior to flooding, the swamp galaxias occurred in the Huon, Serpentine and Wedge catchments. Some exchange of swamp galaxias between the Huon and Serpentine across the swampy Huon plains may have been possible, but the Wedge catchment was probably isolated. To maintain genetic diversity and any population differences within the species, a genetic study examining representative populations from each of the three catchments is required. Methods using a small sample of tissue from non-lethal fin clips are probably most suitable. The work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxias species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	10	-	-	-	10

Saddled galaxias

3.5.3 Monitor existing populations

Regular monitoring of the existing saddled galaxias populations in Woods Lake and Arthurs Lake will be conducted to detect any decline in the health of populations and presence of any additional introduced fish species. If any translocations are conducted the sites will be monitored to determine whether self-maintaining populations establish.

Costs are for staff time, travel (vehicle costs, accommodation and allowances), field consumables and purchase/ hire and maintenance of equipment (boat, nets, electrofisher etc).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	10	7	7	7	7	38

3.5.4 Survey for new populations and potential translocation sites

To provide refuge populations of saddled galaxias free of introduced fish, potential translocation sites will be assessed and translocations conducted if approved by the recovery team. Artificial waterbodies (dams) in the catchment will be targeted for assessment.

Costs are for staff time, and travel to survey and assess potential sites.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	3	3	-	-	-	6

3.5.5 Habitat and threat management

Public awareness actions will aim to reduce the risk of accidental or deliberate introduction of further introduced species. Signage will be placed at lake access points to inform visitors of the significance of the native fish present and of the impacts of introduced species. Elvers stocked into Woods Lake for commercial fishery purposes will be graded using IFS protocol to ensure that they are free of other species. If any introduced fish species additional to the present trout species are discovered in Woods or Arthurs lakes, every effort will be made to eradicate or control them.

To reduce predation pressure from the trout already present in Woods Lake, feasibility of reduction of trout numbers by restriction of access to spawning habitat in the Upper Lake River and smaller streams will be investigated. Natural processes which limit spawning access such as log jams or low flows should be allowed to occur. Implementation of any spawning restriction will be negotiated with recreational fishery managers. Arthurs Lake is not suitable for similar manipulations as it is a large lake with many spawning streams and reducing trout numbers there is also likely to be unacceptable socially. Levels of eel stocking to Woods Lake for commercial fishing will aim to avoid potential impact on the galaxiid species.

Habitat improvement will be carried out as necessary at potential translocation sites. Actions may include removal and exclusion of introduced fish, and addition of refuge habitat such as piles of rocks or artificial substrates.

Liaison with Hydro Tasmania will aim to continue the water level management and water quality monitoring for species protection, including maintaining and formalising the minimum agreed level in Woods Lake to maintain water quality. Further refinement of water level management (e.g. any critical times at which to avoid drawdowns) requires more information about species habitat requirements (Action 3.5.6).

Costs are for staff time, signs, travel to install signs, assessment of trout spawning restrictions, Hydro water quality and level management, addition of habitat to translocation sites.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	17	15	15	14	14	75

3.5.6 Determine habitat requirements

This is important for determining appropriate habitat management, particularly of water levels. The location of spawning sites (substrate type and depth) will be determined by searching for eggs. Duration of the spawning period will be determined by life history studies and egg searches. Preferred habitat of adults will be determined by surveys across a range of substrates, depths and exposures. Studies of captive fish may be included. Student projects in this area will be encouraged.

Costs are for staff time, travel and survey equipment.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	13	8	-	-	-	21

3.5.7 Determine genetic structure

Allozyme studies (Elliott and Sanger 1994) indicate that there may be two genetically distinct ‘spawning populations’ in Woods Lake, spring spawners and autumn spawners. This work will be continued to obtain conclusive information about the species’ genetic structure so that it can be considered in management decisions. Methods using a small sample of tissue from non-lethal fin clips are probably most suitable. The work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxias species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	5	-	-	-	5

Golden galaxias

3.6.3 Monitor existing populations

Regular monitoring of the two natural and two translocated populations will be conducted to determine whether they remain healthy and free of additional introduced species, and whether habitat management action is required. Baseline abundance and size-frequency data has been obtained during the Lakes Crescent and Sorell Rehabilitation Project (Hardie 2003).

Costs are for staff time, travel (vehicle costs, accommodation and allowances), field consumables and purchase/hire and maintenance of equipment (boat, nets, electrofisher etc).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	9	7	7	7	7	37

3.6.4 Survey for new populations and potential translocation sites

Surveys of surrounding streams and wetlands in wet conditions will determine whether they are important habitat. Many artificial waterbodies in the Clyde catchment have already been surveyed to determine their suitability as potential additional translocation sites (Hardie 2003). Translocation proposals will be prepared for consideration by the recovery team and additional translocations conducted if approved.

Costs are for additional staff time and travel.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	4	-	-	-	4

3.6.5 Habitat and threat management

Public awareness actions will aim to reduce the risk of accidental or deliberate introduction of further introduced species. Signage will be placed at lake access points to inform visitors of the significance of the native fish present and of the impacts of introduced species. Elvers stocked into the lakes for commercial fishery purposes will be graded using IFS protocols to ensure that they are free of other species. If any additional introduced fish species are discovered in Lake Sorell or Crescent, every effort will be made to eradicate or control them. The recovery plan supports continuation of the current carp eradication program.

To minimise predation and competition pressure from the trout already present, the recovery plan supports implementation of recommendations on stocking resulting from the Lakes Crescent and Sorell Rehabilitation Project (Hardie 2003).

The plan also supports implementation of recommendations on water level management to maintain habitat quality and availability, made as part of the lakes rehabilitation project.

Habitat improvement will be carried out as necessary at potential translocation sites. Actions may include removal and exclusion of introduced fish, addition of refuge habitat such as piles of rocks or artificial substrates, and rehabilitation of riparian and catchment vegetation. Information on habitat improvement and rehabilitation of riparian vegetation for galaxiids will be provided to existing programs such as Rivercare, Landcare and Waterwatch.

Costs are for signs, staff time and travel to install signs, and water level control. Costs of other possible actions cannot be estimated until details are known.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	29	27	27	27	27	137

3.6.6 Determine habitat requirements

The basic habitat requirements for golden galaxias have been determined as part of the Lakes Crescent and Sorell Rehabilitation Project, to enable appropriate management (Hardie 2003). No further research is required at this stage.

3.6.7 Determine genetic structure

The genetic structure of the species will be determined so that management decisions can consider maintenance of structure and diversity. All four populations should be included. Methods using a small sample of tissue from non-lethal fin clips are probably most suitable. The work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxias species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	5	-	-	-	5

Arthurs paragalaxias

3.7.3 Monitor existing populations

The population in Arthurs Lake will be regularly monitored so that any decline or introduction of additional introduced species can be detected, and appropriate action taken. Woods Lake will be monitored to determine whether the recently reintroduced fish establish a breeding population.

Costs are included with monitoring of saddled galaxias, Action 3.5.3.

3.7.4 Survey for new populations and potential translocation sites

Artificial waterbodies in the catchment will be surveyed for potential as translocation sites where refuge populations free of introduced fish could be established. This action is included with 3.5.4 for saddled galaxias.

3.7.5 Habitat and threat management

Habitat and threat management are as for the saddled galaxias which shares Woods and Arthurs lakes. There are no extra costs for Arthurs paragalaxias.

3.7.6 Determine habitat requirements

This is important for determining appropriate habitat management, particularly of water levels. The location of spawning sites (substrate type and depth) will be determined by searching for eggs. Duration of the spawning period will be determined by life history studies and egg searches. Preferred habitat of adults should be determined by surveys across a range of substrates, depths and exposures. Studies of captive fish may be included. Student projects in this area will be encouraged.

Costs are for staff time, travel and survey equipment.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	13	8	-	-	-	21

3.7.7 Determine genetic structure

Determining the genetic structure of Arthurs paragalaxias will show how many fish should be reintroduced to Woods Lake to maintain genetic diversity in the population there. As for the other species, methods using a small sample of tissue from non-lethal fin clips are probably most suitable and the work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxiid species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	5	-	-	-	5

Shannon paragalaxias

3.8.3 Monitor existing populations

The three populations in Great Lake, Shannon and Penstock lagoons will be regularly monitored so that any decline or introduction of additional introduced species can be detected, and appropriate action taken. Monitoring of Shannon Lagoon will aim to detect any population changes if conditions in the lagoon change as a result of rehabilitation activities or trout stockings.

Costs are for staff time, travel (vehicle costs, accommodation and allowances), field consumables and purchase/hire and maintenance of equipment (boat, nets, electrofisher etc).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	9	7	7	7	7	37

3.8.4 Survey for new populations and potential translocation sites

Artificial waterbodies in the catchment will be surveyed for potential as translocation sites where refuge populations free of introduced fish could be established. Translocation proposals for any suitable sites will be prepared as contingency plans for action should redfin perch or other undesirable species be discovered in Great Lake.

Costs are for additional staff time and travel.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	5	5	-	-	10

3.8.5 Habitat and threat management

Public awareness actions will aim to reduce the risk of accidental or deliberate introduction of further introduced species. Signage will be placed at lake access points to inform visitors of the significance of the native fish present and of the impacts of introduced species. If any introduced fish species additional to the present trout species are discovered in Great Lake, Penstock or Shannon lagoons, every effort will be made to eradicate or control them.

Stocking of trout into waters where Shannon paragalaxias occurs will be reviewed with consideration of the potential impact of trout predation and competition pressure on Shannon paragalaxias populations.

Surveys near Tods Corner, where the water pumped from Arthurs Lake enters Great Lake, will be conducted to determine whether saddled galaxias or Arthurs paragalaxias have established populations in Great Lake. Surveys in Liawenee canal or near its outflow will search for any western paragalaxias that may come down the canal to Great Lake. Feasibility of eradication of any introduced populations will be assessed. Options for reducing the risk of species transfer from Arthurs Lake and Lake Augusta will be explored with Hydro Tasmania.

Habitat improvement will be carried out as necessary at potential translocation sites. Actions may include removal and exclusion of introduced fish, and addition of refuge habitat such as piles of rocks or artificial substrates.

Liaison with Hydro Tasmania will examine management of Great Lake water levels for habitat protection. Further refinement of water level management (e.g. any critical times at which to avoid drawdowns) requires more information about species habitat requirements (Action 3.8.6).

Costs are for staff time, travel for surveys, signs and travel to install signs.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	6	4	3	3	3	19

3.8.6 Determine habitat requirements

The surveys conducted in Great Lake (Hydro Tasmania 2003c) and life history studies of Fulton (1982) provide the basic information on habitat requirements of Shannon paragalaxias in Great Lake needed for determining appropriate habitat (water level) management. Further details of species requirements, such as maximum depth of spawning and species occurrence, and what habitat is used when the lake is at low levels with rocky and weedy areas exposed, would allow further refinement of water level management but is not a high priority for targeted studies at present. Studies of captive fish may be included.

3.8.7 Determine genetic structure

The populations in Shannon and Penstock lagoons would have been derived from Great Lake, but each population is now isolated. The genetic structure of each population will be determined so that diversity can be maintained if any population decline occurs. As for the other species, methods using a small sample of tissue from non-lethal fin clips are probably most suitable and the work will need to be conducted by an organisation with the necessary expertise, perhaps as a student project, and could be combined with work on other galaxiid species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	6	-	-	-	6

Great Lake paragalaxias

3.9.3 Monitor existing populations

This action and the following two (**3.9.4** and **3.9.5**) will be conducted in conjunction with those for the Shannon paragalaxias which occupies the same waterbodies. No additional costs are involved.

3.9.4 Survey for new populations and potential translocation sites

3.9.5 Habitat and threat management

3.9.6 Determine habitat requirements

Habitat requirements of Great Lake paragalaxias are not well understood. Spawning site and time, and whether the species lives at depth need to be determined to inform water level management. Targeted surveys will be conducted and studies of captive fish may be included.

Costs are for additional travel and specialist depth surveys.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	13	8	-	-	21

3.9.7 Determine genetic structure

Genetic structure will be determined as for Shannon paragalaxias.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	6	-	-	-	6

Western paragalaxias

3.10.3 Monitor existing populations

Regular monitoring of selected populations will be conducted to detect any decline or presence of additional introduced species, so that appropriate action can be taken.

Costs are for staff time, travel (vehicle costs, accommodation and allowances), field consumables and purchase/hire and maintenance of equipment (boat, nets, electrofisher etc).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	7	6	6	6	6	31

3.10.4 Survey for new populations

Surveys will aim to determine the extent of western paragalaxias distribution (which catchments; upstream and downstream limits), whether it occurs in any trout-free waters, types of habitat occupied, any factors limiting distribution, and security of sites from threats. Major surveys conducted in 2003 (Nelson, in press) provide the basis for targeted surveys.

Costs are for additional staff time and travel (including helicopter).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	12	-	-	-	-	12

3.10.5 Habitat and threat management

Public awareness actions will aim to reduce the risk of accidental or deliberate introduction of further introduced species. Signage will be placed at access points to inform visitors of the significance of the native fish present and of the impacts of introduced species. If any introduced fish species additional to the present trout species are discovered in the Western Lakes, every effort will be made to eradicate or control them. Feasibility of trout removal and exclusion from selected sites will be assessed during distribution surveys, and removal conducted if approved by stakeholders.

The degree of habitat degradation due to water level fluctuations in Lake Augusta will be assessed and if significant, negotiations with Hydro Tasmania will determine whether any impact can be reduced.

Costs are for signage, staff time and travel to place signs and survey Lake Augusta.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	6	4	4	4	4	22

3.10.6 Determine habitat requirements

During monitoring and distribution surveys, habitat characteristics will be recorded. Standardised surveys will compare abundances and population structure between sites with and without trout, and sites with and without water level manipulations. Studies of captive fish may be included. Student projects in this area will be encouraged.

Costs are covered in population monitoring (3.10.3) and distribution surveys (3.10.4).

3.10.7 Determine genetic structure

Genetic structure of selected populations will show whether there are differences between catchments and the degree of population isolation. This is not currently a high priority due to the relatively large number of populations and because translocations are not planned as a potential recovery action at present. It could be combined with work on other galaxiid species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	10	-	-	-	10

Dwarf galaxias

Actions for dwarf galaxias in this plan are restricted to Tasmania. As the species also occurs in mainland Australia, information on species status and management that can assist actions will be sought from agencies and biologists in Victoria and South Australia during plan implementation. In preparation of this plan, advice was sought from experts on the species in Victoria and South Australia (W. Koster pers. comm. and M. Hammer, pers.comm.).

3.11.3 Monitor existing populations

All known sites will be visited to determine their status and security from threats. Sites across the species range will be selected for regular monitoring of population health and habitat condition so that species conservation status can be monitored and threat management can be undertaken as necessary. Principles of site selection from DOC (2003) can be used. It is important that surveys are conducted at an appropriate time of year, as populations experience annual cycles and may appear to be absent at certain times (Wager and Jackson 1993).

Costs are for staff time, travel (vehicle costs, accommodation and allowances), field consumables and purchase/hire and maintenance of equipment (nets, traps, electrofisher etc).

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	13	7	7	7	7	41

3.11.4 Survey for new populations and potential translocation sites

Surveys will be conducted at new sites in the north east, north west (including Hunter and Three Hummock islands) and on Flinders Island, to better determine species distribution, habitat use, habitat condition and conservation status.

Costs are for extra time and travel to be linked with Action 3.11.3.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	7	7	-	-	-	14

3.11.5 Habitat and threat management

Land managers such as private landowners, the Forest Practices Authority and Water Development Branch of DPIW will be informed of any new sites found so they can be added to management databases, with recommendations for site management. Private landowners of all sites will be contacted to ensure they are aware of the species presence, its significance and management recommendations for conservation. They will be encouraged to consider participating in private land reserve programs to protect dwarf galaxias habitat. The Tasmanian Wetlands Strategy, in preparation by DPIW, may provide additional means of protecting wetland habitats. Opportunities will be sought to expand or target any existing wetlands restoration projects for the benefit of dwarf galaxias.

Management prescriptions for forestry operations will continue to be revised as necessary with the Forest Practices Authority to protect dwarf galaxias habitat. Information on habitat improvement and rehabilitation of riparian vegetation for galaxiids will be provided to existing programs such as Rivercare, Landcare and Waterwatch.

Public awareness actions will aim to reduce the risk of accidental or deliberate introduction of further introduced species. Signage will be placed at access points of relevant sites to inform visitors of the significance of the native fish present and of the impacts of introduced species. If any introduced fish species additional to the present trout are discovered, every effort will be made to eradicate or control them. Efforts to eradicate gambusia from Tasmania will be supported. Stocking of trout into waters where dwarf galaxias is known or could potentially occur will be reviewed to reduce or remove trout predation pressure on dwarf galaxias populations. Removal of trout and other introduced species will be considered as a threat management option.

Options for increasing the area of occupancy of dwarf galaxias will be assessed, for example by reintroduction to rehabilitated sites, expansion of existing sites, or translocation to new sites.

Costs are for signs, additional time and travel to liaise with landowners and place signs.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	8	6	6	6	6	32

3.11.6 Determine habitat requirements

Artificial dams within the species range will be surveyed to determine whether dwarf galaxias can occupy this habitat type. Any dams at or near previously known sites will be a priority. During distributional surveys, physical habitat characteristics, other fish species present and the presence of introduced yabbies will be recorded. Studies of captive fish may be included.

Costs are covered by the monitoring and distributional surveys above.

3.11.7 Determine genetic structure

Knowledge of the genetic structure and diversity of dwarf galaxias in Tasmania and south-eastern Australia is required to enable management for maintenance of diversity. Genetic implications should be considered prior to any translocations. The work could be combined with genetic studies of other galaxiid species.

Costs are for materials and external staff time.

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Cost ($000s)	-	10	-	-	-	10

4. Management Prescriptions

General management prescriptions for protection of populations and habitat are given below. For all species, keeping populations free of trout and/ or pest fish species is the highest priority. Management documents and tools containing further details are available. For species occurring in the WHA, the WHA management plan (Parks and Wildlife Service 1999) describes general management prescriptions and monitoring and evaluation of native and exotic fauna in the World Heritage Area. The Tasmanian Reserve Management Code of Practice (2003) guides management of reserves. The threatened fauna handbook (Bryant and Jackson 1999) contains habitat protection recommendations for general community use. For forest industry use, the Forest Practices Code (Forest Practices Board 2000) contains general provisions for operations around waterbodies and the Threatened Fauna Advisor (Forest Practices Board 2002) contains management recommendations for threatened species agreed between the industry, regulatory government departments and species specialists.

4.1 Pedder galaxias

- Maintain all Pedder galaxias populations free of other fish species, with the exception of possible future translocation of swamp galaxias to the Strathgordon water supply dam.
- Remove any other fish species found.
- Clean the Strathgordon water supply dam outflow screens at least twice a year, outside the September-December period when eggs may be present in the artificial stream, to avoid fluctuations in water levels during the breeding season and unscreened outflows.
- Ensure availability of clean spawning substrate in the Strathgordon water supply dam and inflow stream.
- Activities in the catchment of Strathgordon water supply dam should not impact on water quality of the inflow streams or dam, or water supply to the dam.

4.2 Swan galaxias

- Ensure existing barriers to trout and pest fish invasion are maintained by physical enhancement and/or maintaining flow patterns as required.
- Maintain the trout-free status of Swan galaxias habitat by not stocking, or approving for stocking, any sites in or near known Swan galaxias populations, or areas potentially containing Swan galaxias.
- Manage public availability of trout to reduce the risk of illegal stockings.
- Implement public awareness programs to reduce the risk of illegal trout stockings and transfer of pest species.
- Remove any introduced fish species that invade Swan galaxias populations.
- Maintain undisturbed riparian vegetation on and upstream of Swan galaxias populations.
- Avoid vegetation clearing or plantation establishment in catchments of Swan galaxias populations, or limit it to levels that do not affect catchment water yields or flow patterns.
- Avoid disturbance to stream beds and channels on or upstream of Swan galaxias populations.
- Other activities in the catchments of Swan galaxias populations should not impact on stream water quality or flow patterns, or affect free movement of Swan galaxias.
- Undiscovered populations may exist, therefore surveys may be required to determine Swan galaxias occurrence anywhere in the entire Swan River and upper Macquarie River catchments, prior to activities which may affect stream habitat.

4.3 Clarence galaxias

- Ensure existing barriers to trout invasion are maintained by physical enhancement and/or maintaining flow patterns as appropriate.

- Maintain the trout-free status of Clarence galaxias sites by not stocking, or approving for stocking, any sites in or near known Clarence galaxias populations, or areas potentially containing Clarence galaxias.
- The exception is that the brook trout fishery in Clarence Lagoon should be maintained as a more benign alternative to a brown trout fishery. Stocking rates will be such that significant impact on Clarence galaxias is avoided.
- Manage public availability of trout to reduce the risk of illegal stockings.
- Implement public awareness programs to reduce the risk of illegal trout stockings and transfer of pest species.
- Manage access to Clarence galaxias sites to reduce the risk of illegal fish introductions.
- Remove any introduced fish species that invade Clarence galaxias populations (except brook trout in Clarence Lagoon).
- Maintain undisturbed riparian vegetation on and upstream of Clarence galaxias populations.
- Avoid vegetation clearing or plantation establishment in catchments of Clarence galaxias populations, or limit it to levels that do not affect catchment water yields or flow patterns.
- Avoid physical disturbance to streams or waterbodies on or upstream of Clarence galaxias populations.
- Other activities in the catchments of Clarence galaxias populations should not impact on water quality or flow patterns, or affect free movement of Clarence galaxias.
- Undiscovered populations may exist, therefore surveys may be required to determine Clarence galaxias occurrence anywhere in the Clarence, upper Nive and upper Derwent River catchments, prior to activities which may affect stream habitat.

4.4 Swamp galaxias

- Pest fish must not be introduced to Lake Pedder.
- Implement public awareness programs to reduce the risk of transfer of pest species.
- Manage water levels in Lake Pedder, Gordon and McPartlan canal so that McPartlan canal gate is opened only when Lake Pedder is sufficiently high to prevent redfin swimming through the gate.
- Maintain barriers on McPartlan canal tributaries to prevent redfin invasion.
- Activities impacting on stream water quality or flow patterns, or affecting free movement of swamp galaxias should not occur in the catchments of swamp galaxias populations.

4.5 Saddled galaxias

- Pest fish must not be introduced to Arthurs Lake or Woods Lake.
- Implement public awareness programs to reduce the risk of transfer of pest species.
- Attempt eradication of any pest fish found in these lakes.
- Manage lake water levels and inflows to Woods Lake and Arthurs Lake to maintain water quality and habitat availability.
- The trout population in Woods Lake should not be enhanced in any way, including by stocking, improving spawning habitat or improving access to spawning habitat. Processes limiting spawning, such as log jams or low flows in the Upper Lake River, should be allowed to occur.
- Manage public availability of trout to reduce the risk of illegal stockings.
- Manage stocking of elvers into Woods Lake so that significant impact on saddled galaxias is avoided.
- Ensure elver stocks used are not contaminated with other species.
- Manage access to Woods Lake with consideration given to risk of pest fish introduction or illegal trout stocking.
- Activities causing decline in water quality, habitat quality or availability should not occur in the catchments of Woods and Arthurs lakes.

4.6 Golden galaxias

- Additional pest fish must not be introduced to lakes Sorell and Crescent.
- Implement public awareness programs to reduce the risk of transfer of pest species.
- Attempt eradication of any additional pest species found and continue the carp eradication program.
- Manage lake levels of lakes Sorell and Crescent for maintenance of water quality and habitat availability. Golden galaxias requirements are detailed by Hardie (2003).
- Manage trout stocking into lakes Sorell and Crescent so that significant impact on the golden galaxias is avoided. Numbers, sizes and timing are recommended by Hardie (2003).
- Manage public availability of trout to reduce the risk of illegal stockings.
- Manage stocking of elvers into lakes Sorell and Crescent so that significant impact on golden galaxias is avoided.
- Ensure elver stocks used are not contaminated with other species.
- Vegetation management in the catchments should aim to avoid impacts on catchment water yield.
- Activities causing decline in water quality, habitat quality or availability should not occur in the catchments of lakes Sorell and Crescent.

4.7 Arthurs paragalaxias

- Habitat management prescriptions are as for 5.5 saddled galaxias.

4.8 Shannon paragalaxias

- Pest fish must not be introduced to Great Lake, Shannon or Penstock lagoons.
- Implement public awareness programs to reduce the risk of transfer of pest species.
- Attempt eradication of any pest or non-indigenous fish found in these waters.
- Manage water levels of Shannon Lagoon and Penstock Lagoon for maintenance of water quality and habitat availability.
- Manage water levels in Great Lake as required to ensure maintenance of the threatened endemic fish species and their habitat.
- Manage trout populations of Great Lake, Shannon and Penstock lagoons so that significant impact on Shannon paragalaxias is avoided.
- Manage public availability of trout to reduce the risk of illegal stockings.
- Activities causing decline in water quality, habitat quality or availability should not occur in the catchments of Great Lake, Shannon and Penstock lagoons.

4.9 Great Lake paragalaxias

- Habitat management prescriptions are as for 5.8 Shannon paragalaxias.

4.10 Western paragalaxias

- Pest fish must not be introduced to the Western Lakes area.
- Implement public awareness programs to reduce the risk of transfer of pest species.
- Attempt eradication of any pest fish found in these waters and prevent their spread.
- Manage trout populations so that significant impact on western paragalaxias is avoided.
- Do not stock trout into new waters and consider trout removal from selected sites.
- Manage public availability of trout to reduce the risk of illegal stockings.

- Manage water levels of Lake Augusta for maintenance of water quality, habitat quality and availability.

4.11 Dwarf galaxias

- Pest fish must not be introduced to dwarf galaxias habitat.
- Implement public awareness programs to reduce the risk of transfer of pest species.
- Attempt eradication of any pest fish found in these waters.
- Vegetation management in catchments where dwarf galaxias occurs should not cause changes in catchment water yields or flow patterns.
- Maintain undisturbed riparian vegetation on and upstream of dwarf galaxias habitat.
- Maintain water quality of dwarf galaxias habitats.
- Avoid physical disturbance of waterbodies in or near dwarf galaxias populations.
- Avoid changes to drainage patterns in areas containing dwarf galaxias populations.
- Manage trout populations to avoid significant impact on dwarf galaxias populations.
- Do not stock trout into waters not already containing trout and consider trout removal from selected sites.
- Manage public availability of trout to reduce the risk of illegal stockings.
- Activities causing decline in water quality, catchment water yield, habitat quality or availability should not occur in catchments where dwarf galaxias occurs.
- Undiscovered populations may exist, therefore surveys may be required to determine dwarf galaxias occurrence in areas of potential habitat in northern Tasmania, prior to activities which may affect habitat.

5. Implementation and cost schedule

Task	Description	Priority	Feasibility	Costs ($000s) Year 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
3.all.1	**Recovery coordination and reporting**	1	100%	48	48	48	48	48	**240**
3.all.2	**Increase public awareness**	1	100%	14	8	8	8	8	**46**
3.1.	**Pedder galaxias**								
3.1.3	Monitor populations	1	100%	19	19	19	19	19	**95**
3.1.4	Survey for translocation sites	1	100%	5	5	-	-	-	**10**
3.1.5	Habitat and threat management	1	80%	3	3	3	3	3	**15**
3.1.6	Determine habitat requirements	2	60%	4	4	-	-	-	**8**
3.1.7	Determine genetic structure	2	100%	5	-	-	-	5	**10**
3.2	**Swan galaxias**								
3.2.3	Monitor populations	1	100%	7	6	6	6	6	**31**
3.2.4	Survey for new populations and translocation sites	2	100%	5	5	-	-	-	**10**
3.2.5	Habitat and threat management	1	90%	10	6	6	4	4	**30**
3.2.6	Determine habitat requirements	2	100%	2	2	-	-	-	**4**
3.2.7	Determine genetic structure	2	100%	-	10	-	-	-	**10**
3.3	**Clarence galaxias**								
3.3.3	Monitor populations	1	100%	7	6	6	6	6	**31**
3.3.4	Survey for new	2	100%	10	5	-	-	-	**15**

	populations and translocation sites								
3.3.5	Habitat and threat management	1	60%	18	14	5	5	5	**47**
3.3.6	Determine habitat requirements	3	80%	0	0	0	0	0	**0**
3.3.7	Determine genetic structure	2	100%	-	10	-	-	-	**10**
3.4	**Swamp galaxias**								
3.4.3	Monitor populations	1	100%	6	5	5	5	5	**26**
3.4.4	Survey for new populations and translocation sites	2	100%	5	5	-	-	-	**10**
3.4.5	Habitat and threat management	1	80%	9	6	5	5	5	**30**
3.4.6	Determine habitat requirements	2	80%	0	0	0	0	0	**0**
3.4.7	Determine genetic structure	3	100%	-	10	-	-	-	**10**
3.5	**Saddled galaxias**								
3.5.3	Monitor populations	1	100%	10	7	7	7	7	**38**
3.5.4	Survey for potential translocation sites	2	70%	3	3	-	-	-	**6**
3.5.5	Habitat and threat management	1	90%	17	15	15	14	14	**75**
3.5.6	Determine habitat requirements	1	60%	13	8	-	-	-	**21**
3.5.7	Determine genetic structure	2	100%	-	5	-	-	-	**5**
3.6	**Golden galaxias**								
3.6.3	Monitor populations	1	100%	9	7	7	7	7	**37**
3.6.4	Survey for potential translocation sites	3	100%	-	4	-	-	-	**4**

3.6.5	Habitat and threat management	1	80%	29	27	27	27	27	**137**
3.6.6	Determine habitat requirements	3	80%	-	-	-	-	-	**0**
3.6.7	Determine genetic structure	3	100%	-	5	-	-	-	**5**
3.7	**Arthurs paragalaxias**								
3.7.3	Monitor populations	1	100%	0	0	0	0	0	**0**
3.7.4	Survey for translocation sites	2	70%	0	0	0	0	0	**0**
3.7.5	Habitat and threat management	1	90%	0	0	0	0	0	**0**
3.7.6	Determine habitat requirements	1	60%	13	8	-	-	-	**21**
3.7.7	Determine genetic structure	2	100%	-	5	-	-	-	**5**
3.8	**Shannon paragalaxias**								
3.8.3	Monitor populations	1	100%	9	7	7	7	7	**37**
3.8.4	Survey for potential translocation sites	1	80%	-	5	5	-	-	**10**
3.8.5	Habitat and threat management	1	80%	6	4	3	3	3	**19**
3.8.6	Determine habitat requirements	3	80%	0	0	0	0	0	**0**
3.8.7	Determine genetic structure	2	100%	-	6	-	-	-	**6**
3.9	**Great L. paragalaxias**								
3.9.3	Monitor populations	1	100%	0	0	0	0	0	**0**
3.9.4	Survey for translocation sites	1	80%	0	0	0	0	0	**0**
3.9.5	Habitat and threat management	1	80%	0	0	0	0	0	**0**
3.9.6	Determine habitat	1	80%	-	13	8	-	-	**21**

	requirements								
3.9.7	Determine genetic structure	2	100%	-	6	-	-	-	**6**
3.10	**Western paragalaxias**								
3.10.3	Monitor populations	1	100%	7	6	6	6	6	**31**
3.10.4	Survey for new populations	2	100%	12	-	-	-	-	**12**
3.10.5	Habitat and threat management	1	80%	6	4	4	4	4	**22**
3.10.6	Determine habitat requirements	2	100%	0	0	0	0	0	**0**
3.10.7	Determine genetic structure	3	100%	-	10	-	-	-	**10**
3.11	**Dwarf galaxias**								
3.11.3	Monitor populations	1	100%	13	7	7	7	7	**41**
3.11.4	Survey for new populations	1	100%	7	7	-	-	-	**14**
3.11.5	Habitat and threat management	1	80%	8	6	6	6	6	**32**
3.11.6	Determine habitat requirements	2	80%	0	0	0	0	0	**0**
3.11.7	Determine genetic structure	2	100%	-	10	-	-	-	**10**
Total				**339**	**362**	**213**	**197**	**202**	**1313**

6. Monitoring, Reporting and Review

The existing schedule of monitoring, reporting and review of the recovery plan and progress with actions will continue for the new plan. The recovery team will meet twice-yearly and review a progress update report distributed by the project coordinator before the meeting. Decisions are made by the team on any issues arising. Priorities and directions of actions can be reviewed by the team at any time as required. Outcomes are recorded in minutes and correspondence.

This plan will remain operative until superseded by a revised plan.

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8. Appendix 1

Below are the criteria for which recently listed species have been listed under the EPBC Act 1999:

EXTINCT IN THE WILD

Pedder galaxias (*Galaxias pedderensis*)

The EPBC Act provides for the listing of native species in the category 'Extinct in the Wild'. Section 179 (2) states that:

'A native species is eligible to be included in the **extinct in the wild** category at a particular time if, at that time:

a. it is known only to survive in cultivation, in captivity, or as a naturalised population well outside its past range; or
b. it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.'

The Pedder Galaxias meets both criteria for listing in the extinct in the wild category.

ENDANGERED

Golden galaxias (*Galaxias auratus*)

Criterion 2 - Geographic distribution

The Golden Galaxias has a naturally very restricted range. The two naturally occurring populations of the species are estimated to have an extent of occurrence of approximately 76km^2. There is no evidence to suggest the species has previously occurred in any other locations.

In 2001, carp-proof screens were placed in the canal that connected Lake Sorell and Lake Crescent. This has effectively prevented upstream movement of the species, as well as downstream movement of all but larval Golden Galaxias. Each lake is considered to be a single location due to the presence of the carp screens, even though prior to 2001, the lakes were connected. Therefore, Golden Galaxias populations are known to exist at only two natural locations, and the two natural populations are fragmented.

In addition, the species' habitat quality has declined and is expected to continue to decline. Shallow waters at the edges of both lakes provide egg laying, shelter and feeding sites for the Golden Galaxias. Erosion of this habitat has been exacerbated by evaporation, low rainfall and water extraction for irrigation. Low water levels in the lakes also leave sediments vulnerable to wind disturbance and increased turbidity, which has been linked to mortality of Golden Galaxias in the past. If water levels in Lake Sorell and Lake Crescent are not managed adequately, further habitat loss and degradation is likely.

The Golden Galaxias has a very restricted extent of occurrence (less than 100km^2). The species is only known to exist at two locations, its habitat is fragmented, degraded and likely to continue to decline without appropriate management. In combination, these factors mean that the species' geographic distribution is precarious for its survival.

Therefore it is **eligible** for listing as endangered under this criterion

Arthurs paragalaxias (*Paragalaxias mesotes*)

Criterion 1 - Decline in numbers

The Arthurs Paragalaxias was previously known to occur in two locations, Woods Lake and Arthurs Lake in central Tasmania. However, surveys conducted twice-yearly and quarterly for the species in both lakes have failed to locate it in Woods Lake since 1989. The species still occurs in Arthurs Lake.

When the Arthurs Paragalaxias was found in both Woods and Arthurs Lakes, its area of occupancy was estimated to have been approximately 75 km^2. Based on the likelihood that the species no longer occurs in Woods Lake, its area of occupancy has declined to approximately 62 km^2. Additionally, the species' extent of occurrence was previously estimated to be approximately 180km^2, but following its apparent disappearance from Woods Lake, the extent of occurrence for the Arthurs Paragalaxias is estimated to have declined to approximately 87 km^2.

Habitat quality and availability for the Arthurs Paragalaxias fluctuates in both Woods and Arthurs lakes as water levels change due to extraction for irrigation and hydroelectricity. Although the exact spawning habitat of Arthurs Paragalaxias is not known, other galaxiid species deposit eggs under rocks in shallow waters. These shallow areas are often subject to drying, and given that rocky areas occur around the shore in Woods Lake, it is possible that a slight drop in water level may expose a large width of shoreline, potentially displacing fish from important breeding habitat. Low water levels are also linked to high turbidity as a result of wind-driven sediment disturbance. Over the past decade, Woods Lake has experienced two events of extremely high turbidity, one in 1995 and one in mid 2000. High turbidity is considered to increase the risk of harmful algal blooms and fish gill erosion, which has the capacity to cause high mortality among fish populations.

It is likely that Brown Trout (*Salmo trutta*) have been present in Woods Lake for over a century. Whilst they are likely to prey on Arthurs Paragalaxias, the degree of predation is not known. Given that the species remain common in Arthurs Lake, which also contains Brown Trout, it is unlikely that predation pressure alone is the cause of the species decline in Woods Lake.
Based on very severe decline in area of occupancy, and a severe decline in extent of occurrence, the Arthurs Paragalaxias is suspected to have undergone a severe decline in numbers. The quality of the habitat in which the remaining population of Arthurs Paragalaxias occurs has also declined. Therefore, the species is **eligible** for listing as **endangered** under this criterion.

Criterion 2 - Geographic distribution
It is believed that Arthurs Paragalaxias now only occurs in Arthurs Lake. The species appears to have disappeared from, or is in extremely low in numbers in Woods Lake, where it has not been documented since 1989. The species' extent of occurrence is estimated to be less than $100km^2$, and its area of occupancy is estimated to be less than $500km^2$.
The cause of the species' disappearance from Woods Lake is unclear, but it is likely that it has occurred due to habitat change and degradation as a result of damming for hydroelectricity, possibly in combination with increased predation by Brown Trout. In addition to having apparently disappeared from Woods Lake, habitat quality and availability continue to fluctuate in Arthurs Lake as water levels change due to extraction for irrigation and hydroelectricity. If water levels are not managed appropriately at Arthurs Lake, it is likely that the quality and availability of the species' habitat, and numbers of the species will continue to decline.
The species geographic distribution is restricted and is precarious for its survival. Therefore, the species is **eligible** for listing as **endangered** under this criterion.