Background and Implementation Information for the Australian Grayling *Prototroctes maraena* National Recovery Plan

Australian Government

Department of Sustainability and Environment

Inland Fisheries Service

Victoria The Place To Be

Prepared by Gary Backhouse, Justin O'Connor (Department of Sustainability and Environment, Victoria) and Dr Jean Jackson (Department of Primary Industries, Water and Environment, Tasmania).

Published by the Victorian Government Department of Sustainability and Environment (DSE) Melbourne, 2008.

Authorised by the Victorian Government, 8 Nicholson Street, East Melbourne.

ISBN 1 74152 434 2

This publication contains detailed background information and implementation detail for the 'National Recovery Plan for the Australian Grayling *Prototroctes maraena*' (Backhouse *et al.* 2008a), and should be read in conjunction with that document (available at www.environment.gov.au).

This document has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

Disclaimer

This publication may be of assistance to you but the State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence that may arise from you relying on any information in this publication.

An electronic version of this document is available on the Department of Environment, Water, Heritage and the Arts website www.environment.gov.au

For more information contact the DSE Customer Service Centre 136 186

Citation: Backhouse, G., Jackson, J. and O'Connor, J. 2008b. Background and Implementation Information for the Australian Grayling *Prototroctes maraena* National Recovery Plan. Department of Sustainability and Environment, Melbourne.

Cover photograph: Australian Grayling *Prototroctes maraena* by Gary Backhouse.

Table of Contents

Abbreviations

ARI Arthur Rylah Institute for Environmental Research (DSE, Victoria)

CMA Catchment Management Authority

DPIWE Department of Primary Industries, Water and Environment

DPI Department of Primary Industries

DSE Department of Sustainability and Environment (Victoria)

IFS Inland Fisheries Service (Tasmania)

IUCN International Union for the Conservation of Nature

MDBC Murray Darling Basin Commission

PV Parks Victoria

Species Information

Species description

The Australian Grayling *Prototroctes maraena* Günther, 1864 is a small to medium-sized, slender, laterally compressed fish, with soft-rayed fins lacking any spines. The short-based dorsal fin (9–13 rays) is situated well back on the body, just in front of a tiny adipose fin. The caudal fin is forked. The anal fin (16–20 rays) is short-based, ending below the adipose fin. The pelvic fins (6 rays) are abdominal and inserted in front of the origin of the dorsal fin. The small pectoral fins (12–14 rays) are inserted just behind the gill plates. The head is small and conical, the snout somewhat rounded and blunt. The mouth is small and slightly oblique, the gape extending back to beneath the eye. The lower jaw is shorter than upper jaw, and tapers to a fine, soft point. Teeth in the upper jaw are rather blunt and form a uniform comb-like row, that bites on a narrow, tough shelf in the lower jaw. The body is covered with small, thin, cycloid, easily dislodged scales (the head is scale-less), scale count 68–84 along the body; there is no lateral line. There is a low, horny, abdominal keel present in front of the vent. When freshly caught, this species has distinct cucumber-like odour, giving rise to an old common name of 'cucumber herring'.

Colour is generally greyish-bronze, slightly darker on the dorsal surface, fading to silvery white below; each scale has a darker outline, and the operculum is silvery. Occasionally there is a steely blue sheen along the body and operculum. Fins are translucent to yellowish-grey, the adipose fin matching the dorsal surface. The body may sometimes bear a wedge-shaped black mark at the base of the caudal fin, and three or more wide, chevron-shaped bands along the sides between the operculum and dorsal fin; these may appear bolder when the fish is agitated.

The Australian Grayling reaches a maximum size of about 330 mm and 0.5 kg, but is usually smaller, more commonly to 170–190 mm. The species is sexually dimorphic. During the breeding season, mature males develop numerous small nuptial tubercles on each scale and on rays of the pectoral, pelvic, dorsal and anal fins.

The Australian Grayling belongs to the family Retropinnidae (smelts and graylings), subfamily Prototroctinae (southern graylings), which contains only two species: *P. maraena* and the New Zealand Grayling *Prototroctes oxyrhynchus*, a species endemic to New Zealand, not seen since the mid-1920s and now believed extinct (McDowall 1978, 1996b).

Aspects of the biology and ecology of the Australian Grayling have been described in several publications (Bacher & O'Brien 1989; Berra 1982, 1987; Berra *et al.* 1987; Bishop and Bell 1978 a & b; Crook *et al.* in prep; Hall and Harrington 1989; Jackson 1976; Jackson and Koehn 1988; McDowall 1974, 1976, 1996a; O'Connor and Mahoney 2004). The Australian Grayling is a diadromous species that migrates between fresh and marine waters. Most of its life is spent in freshwater, but at least part of the larval and/or juvenile stages are spent in coastal seas. Spawning occurs in fresh water, from late summer to winter, the timing varying with location and between years. In eastern Victoria (Tambo River) spawning occurs in autumn (April-May), but in other localities it may occur earlier, during late summer (February). Fecundity varies from 25,000 to 68,000 eggs per female. The eggs are small, less than 1 mm in diameter, pale yellow, demersal and non-adhesive. Spawning appears to be initiated by an increase in river flows from seasonal rains, possibly coupled with a decrease in water temperatures. Spawning sites and behaviour are unknown, but the eggs sink and settle in the interstices of the substrate. The eggs hatch after 10-20 days; larvae are about 6.5 mm long, slender, buoyant and swim actively to the water surface. They have a small yolk sac that is soon absorbed. The larvae are swept downstream to estuaries and move into marine waters, where it is believed they remain for about six months before returning to fresh water, where they probably spend the rest of their lives. In the Tambo River (Victoria), young-of-the-year fish return to fresh water in about November; they attain 73–142 mm in length at one year, 113–200 mm in length after two years and 183–234 mm in length after three years. However, most fish die after their second year, probably soon after spawning, although a small proportion may reach four or five years of age. Some males may spawn in their first year, but most males and females do not spawn until their second year. This means that most individuals probably spawn only once before dying.

The Australian Grayling is omnivorous, feeding on a wide variety of small aquatic organisms, including crustaceans such as cladocerans, insects and their larvae, and algae. They also take terrestrial insects that fall on to the water surface. Grayling can form large schools (possibly spawning aggregations), and are fast swimmers, darting away from danger very quickly.

Conservation status

Australian Grayling were once reported as common to abundant throughout much of their range, but in recent decades the species was thought to be extremely rare and perhaps in danger of extinction (Lake 1971), especially since the closely related New Zealand Grayling had become extinct. Surveys in Victoria and New South Wales since then indicate that, while the species appears to have declined throughout much of its range, it is still widely but patchily distributed, and can be locally common in some areas (Bell *et al.* 1980; Berra 1982; Jackson & Koehn 1988; McDowall 1996a).

National conservation status

The Australian Grayling is listed as **Vulnerable** under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The species has been assessed as **Vulnerable** on the IUCN Red List of Threatened Species (IUCN 2003) (criteria A1c – version 2.3, 1994), and it is considered **Vulnerable** by the Australian Society for Fish Biology (ASFB 2001).

Conservation status in range States

New South Wales: Listed as a **Protected Species** under the *Fisheries Management Act* 1994.
Victoria: Listed as **Threatened** under the *Flora and Fauna Guarantee Act* 1988; considered **Vulnerable** (DSE 2003).
Tasmania: Listed as **Vulnerable** under the *Threatened Species Protection Act* 1995, and is Listed as a **Protected Fish** under Section 131 of the *Inland Fisheries Act* 1995.

Distribution

The Australian Grayling occurs in south-eastern Australia, in coastal rivers and streams in New South Wales, Victoria and Tasmania (Cadwallader & Backhouse 1983; Fulton 1990; McDowall 1996a). In New South Wales it occurs from the Shoalhaven River south. In Victoria it occurs widely across the State, from the Genoa River system in the east to the Hopkins River system in the west. The Australia Grayling occurs around much of Tasmania, although it has not been recorded from the south-west. However, no targeted distribution surveys have been conducted, and the apparent absence from the south-west is probably due to lack of surveys. The species has also been recorded from King Island in Bass Strait. There is a single record from Ewens Ponds near Port MacDonnell in the far south-east of the South Australia (Kuiter 1983), where it is considered either extremely rare or locally extinct (Hammer 2001). As the species has a marine larval/juvenile stage that facilitates dispersal beyond the spawning catchment, the record is most likely of a vagrant fish.

Recovery Information

Existing Conservation Measures

Many environmental restoration programs are already occurring in places within the range of the Australian Grayling, and have the potential to be of substantial benefit to the species. Specific and general initiatives that benefit Australian Grayling include:

- A number of studies looking at conservation status, biology and ecology (eg. Berra 1982, 1987; Berra *et al.* 1987; Bishop & Bell 1978 a & b; Crook *et al.* in prep; Hall & Harrington 1989; Jackson 1976; Jackson & Koehn 1988; Bacher & O'Brien 1989; McDowall 1974, 1976, 1996a; O'Connor & Mahoney 2004).
- Listing as a protected species under Australian, NSW, Victorian and Tasmanian Government legislation.

- A review of conservation status, threats and recovery actions for Australian Grayling included in *The Action Plan for Australian Freshwater Fishes* (Wager & Jackson 1993).
- Information on the Australian Grayling, including threats, protected status and management actions required for conservation of the species, is available in a range of publications such as listing statements, brochures, recreational fishing guides and on department websites (eg. Bryant & Jackson 1999).
- Programs to facilitate fish passage past barriers in New South Wales, Victoria and Tasmania. In Victoria, fishways have been installed in 14 coastal rivers and stream within the grayling's range, facilitating access to over 3,000 km of rivers previously blocked (DSE-ARI unpubl. data), and Australian Grayling have been recorded in the Yarra River well upstream of Dights Falls since installation of a fishway there in 1999. In Tasmania, an NHT-funded project removed or modified 12 weirs on coastal rivers to allow fish passage; Australian Grayling have been recorded from five of these rivers but are likely to occur in all (IFS 2003a, b). New South Wales has completed a barrier survey and is developing a prioritisation process to restore fish passage past barriers.
- An increase in environmental flows to the Snowy River, the catchment of which contains some of the most important populations of Australian Grayling in Victoria.
- General river improvement programs, including river health strategies, streamflow management plans and restoration of riparian vegetation for many rivers within the range of the Australian Grayling.
- Stocking of trout has ceased in the Barwon River, because of the presence of several threatened fish species including Australian Grayling.
- A major catchment management program for improved water quality in the Gippsland lakes (Vic).

Strategy for Recovery

The Australian Grayling is ideally placed to benefit from integrated catchment management, including maintaining or restoring environmental flows, and protection and revegetation of riparian zones to increase streamside cover and reduce erosion and sediment input into waterways. Many such programs are already occurring in catchments where Australian Grayling occur. The species is a potential major beneficiary of the Snowy River restoration program, through increased flows and habitat, and improved water quality. Programs to restore fish passage past barriers will also be of major benefit to the Australian Grayling. Monitoring the ecological response of Australian Grayling to these measures will be a key factor in managing the recovery of this species.

Program Implementation

The Recovery Plan will run for five years from the time of adoption of a Final Plan and will be managed largely by the Department of Sustainability and Environment (Victoria), the Department of Primary Industries, Water and Environment (Tasmania) and the Department of Primary Industries (NSW). Implementation of individual actions will remain the responsibility of the relevant agencies and organisations identified in the Recovery Plan (subject to available resources), who will be responsible for sourcing resources (eg. NHT funds), preparing work plans and monitoring progress toward recovery within their own jurisdiction. A Recovery Team will be formed consisting of staff with relevant technical, scientific and habitat management skills, to coordinate recovery actions, circulate information and facilitate a review and evaluation of this Recovery Plan at its termination.

Program Evaluation

The Recovery Team will be responsible for annual assessments of progress towards recovery. Towards the end of the Recovery Plan, an external evaluator will be appointed to undertake a formal review and evaluation of the recovery program.

Recovery Objectives

The **overall objective** of recovery is to minimise the probability of extinction of the Australian Grayling in the wild, and to increase the probability of important populations becoming self-sustaining in the long term.

Within the life span of this Recovery Plan, the **Specific Objectives** of recovery of the Australian Grayling are to:

1. Identify important populations of Australian Grayling.
2. Protect and restore habitat for Australian Grayling.
3. Investigate important life history attributes to acquire targeted information for management.
4. Investigate and manage threats to populations and habitats.
5. Increase awareness of Australian Grayling with resource managers and the public.
6. Manage Recovery Plan implementation.

Objective 1. Identify important populations of Australian Grayling.

Recovery Criterion:
Important populations across the range, and threats to their survival, are identified and documented.

Action 1.1 Collate existing data on distribution, abundance and population parameters.

Some data on Australian Grayling collected over several decades has been published, while other unpublished data is held in files and databases in a number of locations. Available data needs to be collected and collated for assessment prior to determination of gaps for surveys and further research.

Action 1.2 Determine gaps in distribution data and undertake surveys to determine presence and significance of grayling populations in areas poorly surveyed.

Once distribution and population data have been collated, apparent gaps in distribution (eg. south-west Tasmania, some rivers in Otway ranges and South Gippsland) can be identified and targeted for surveys to gain a current assessment of distribution and abundance of Australian Grayling.

Action 1.3 Undertake a genetic assessment of population structure throughout range.

A genetic assessment is required to determine if there is any population structuring in Australian Grayling, which will in turn identify conservation units for management. As the species has a marine larval/juvenile stage, there is an assumption that it possibly comprises a single genetic stock. However, any genetic structuring in the population, especially between Tasmania and mainland Australia, needs to be determined as part of the process in identifying important populations of the species.

Action 1.4 Identify populations and locations for long-term monitoring, especially to determine population trends and responses in locations where recovery actions are occurring (eg. fishway installation, catchment protection).

While there are a number of environmental initiatives (eg. installation of fishways, Snowy River flow restoration, revegetation in catchments) occurring throughout the grayling's range, the response of populations to these initiatives is generally not known. This action aims to identify important populations and locations across the species' range to commence long-term monitoring to determine population and species trends, especially where catchment protection, habitat restoration or other management actions are occurring.

Action 1.5 Acquire baseline data on selected populations by conducting surveys including (a) identification of the area and extent of populations; (b) estimates of the size and structure of populations; (c) inference or estimation of population change and (d) habitat quality.

Once populations and locations for long-term monitoring are identified, ongoing monitoring needs to be undertaken to obtain data to gain an understanding of population distribution and changes. The results will be used to gain an indication of the impact of environmental management programs on Australian Grayling and to provide information to enhance programs where appropriate.

Objective 2. Protect and restore habitat for Australian Grayling.

Recovery Criterion:
Revegetation of riparian zones in important catchments continues, and there is an increase in length of rivers available for Australian Grayling through facilitation of fish passage past barriers.

Action 2.1 Identify and map important habitat (rivers/locations), particularly for recruitment and as potential drought refuge habitat.

While the Australian Grayling is still reasonably widespread in south-eastern Australia, the size of populations varies greatly, both among locations and between years. This action aims to identify those areas that could provide important habitat, especially good breeding habitat and locations that could serve as important drought refuges in periods of low flow. This information is important for subsequent use in environmental restoration programs such as riparian revegetation, installation of fishways and restoration of environmental flows for streams.

Action 2.2 Identify rivers where flow regulation or water abstraction potentially impacts on important populations and habitats of Australian Grayling, and ensure conservation requirements are included in river management processes.

Once important populations and locations for Australian Grayling have been identified, the next step is to identify if these occur in any rivers affected by flow regulation or excessive water abstraction. With winter flows apparently important for initiating spawning in Australian Grayling, where important habitats or populations occur, winter flows need to be maintained to ensure reproductive viability in these rivers. Where important populations and locations for Australian Grayling occur in any rivers affected by flow regulation or excessive water abstraction, grayling conservation requirements will need to be included in planning and management processes such as determination of environmental flow requirements for rivers, so that winter flows are sufficient to maintain spawning habitat and requirements.

Action 2.3 Ensure Australian Grayling conservation requirements are included in fishway programs.

Fishways have been installed on several rivers and streams where Australian Grayling occur, and are planned for other locations within the range of the species. There is evidence that the species will use fishways, with their occurrence recorded in mid sections of the Yarra River (Vic) in recent years. Where fishways are proposed, the needs of Australian Grayling need to be incorporated into design and location. Where important populations or habitats occur, the need for fishways should be assessed to maximise access to habitat and facilitate upstream and downstream migration.

Action 2.4 Protect and restore riparian vegetation in catchments supporting Australian Grayling populations, with priority to those catchments supporting important habitats or populations.

Intact riparian vegetation is one important requirement for maintaining or improving river health, as well as providing shelter and a food source for stream fauna, and is an important aspect of maintaining habitat conditions for Australian Grayling. Many revegetation programs in

catchments where Australian Grayling occur are already in place. Information on important locations and habitats for the species will be provided to land managers (eg. CMAs) to help assist with determining revegetation priorities.

Objective 3. Investigate important life history attributes to acquire targeted information for management.

Recovery Criterion:
Key life history attributes are identified and information supplied to management for population and habitat protection.

Action 3.1 Investigate spawning cues, particularly the influence of river flows.

There is evidence that high winter stream flows are an important stimulant for initiating spawning in Australian Grayling. If flows are insufficient, spawning may be substantially reduced or not occur. For a short-lived species such as the Australian Grayling, several reduced or missed spawning opportunities in quick succession (such as could occur in regulated rivers) could have important consequences, leading to decline or local extinction, especially of small populations. This Actions aims to investigate the factors that initiate spawning in Australian Grayling and use the information to provide input into river management processes such as determining environmental flows.

Action 3.2 Investigate larval and juvenile distribution, habitat and movements.

While it is known that the Australian Grayling is diadromous, involving a larval/juvenile marine phase, just how larval and juvenile fish use and move in estuaries and coastal seas is not known. This Action aims to fill in major gaps in the life history of the species, and will be critical in identifying important locations for protection or special management attention.

Action 3.3 Investigate adult distribution, habitat and movements.

While adult grayling live in freshwater, it is not known if populations are reasonably stationary or there is movement within catchments or even between catchments. Little is known of how the species uses specific habitats, especially what the requirements are for spawning habitat. This is a research project aimed at determining the distribution, habitat use and movement of adults, to better target protection for the species and its habitat, and inform catchment management programs aimed at environmental improvement.

Objective 4. Investigate and manage threats to populations and habitats.

Recovery Criterion:
Important populations are secure from controllable threats.

Action 4.1 Investigate the potential for predation on larvae/juveniles in estuarine environments.

Larval and juvenile Australian Grayling have an estuarine/marine phase, and may be susceptible to predation, especially if aggregations of small fish gather prior to movement upstream to the adult habitat. This Action aims to determine if aggregations gather, how movement into freshwater occurs, if the species might be susceptible to excessive predation levels at this stage, and what strategies might be available to reduce excessive predation pressure.

Action 4.2 Investigate the impact of trout on Australian Grayling.

Trout are known to consume small Australian Grayling, and migrating grayling are probably especially vulnerable as they are small and may have to pass through multiple areas occupied by trout. However, the precise impact is not known, and this action will aim to investigate the

impact and recommend strategies for mitigation. Initial investigation will involve correlation between presence/absence of trout and grayling, and perhaps later include experimental studies.

Action 4.3 Ensure important populations and locations are protected from stocking of trout.

Current restrictions on trout stocking in Victoria and New South Wales in areas where important populations of Australian Grayling occur will be maintained. Any new information on the location of important grayling populations, especially those acting as 'source' populations, will need to be considered with trout stocking proposals. Proposals for the stocking of recreational or other fish species in Victorian waters where the Australian Grayling occurs will be managed in accordance with the *Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria* (DPI 2003) and the *Protocols for the Translocation of Fish in Victorian Inland Public Waters* (DPI 2005).

Action 4.4 Investigate the impact of increased sedimentation on Australian Grayling and habitats in catchments affected by wildfires in 2003.

The extensive wildfires in south-eastern Australia in early 2003 burnt through the upper catchments of several rivers including the Tambo River and Snowy River, holding important populations of Australian Grayling. Sections of these rivers subsequently suffered extensive siltation due to heavy rainfall following the fire, that smothered large stretches of potential grayling habitat. This action will investigate the impact on the species and its habitat, and to determine if remedial actions are required in these catchments to ameliorate the impact of any degradation of habitat.

Objective 5. Increase awareness of Australian Grayling conservation with resource managers and the public.

Recovery Criterion:
Awareness of Australian Grayling increases with managers and the public, and conservation requirements are included in NRM plans and projects.

Action 5.1 Ensure research findings are publicised and incorporated into catchment management and river health programs where appropriate.

Publishing research findings in journals or as technical reports is important in making information more widely available. It is also important that published research information is available in a form that is easily included in other planning and management instruments, such as river health strategies, fishway programs, catchment management plans and environmental flow determinations. This enables management implications of the research to be conveyed to resource managers in a useful and timely fashion.

Action 5.2 Promote angler awareness of conservation of Australian Grayling where incidental capture is likely to be an issue.

Historical records indicate Australian Grayling were once common enough and of a large enough size to be caught by anglers. Nowadays, the species is not often caught by anglers, being much less common and usually too small, although there is some take of juveniles in the Tasmanian whitebait fishery. However, as grayling numbers increase in response to recovery actions, especially with fish moving into locations past barriers where they were previously absent, anglers might once again start to catch grayling. It is a sensitive species susceptible to rough handling, and, as a protected species, it needs to be returned to the water alive and unharmed. In locations where anglers are likely to come into contact with Australian Grayling, the need for caution and careful handling will be publicised.

Affected interests

The Australian Grayling occurs across a variety of water/land tenures and management, including public waters, parks, reserves, state forest, heritage rivers and private land/water. Consequently, management is the responsibility of a range of agencies, organisations and individuals (Table 1). This Recovery Plan has the support of State government agencies and land/water managers in the range States.

Table 1. Organisations with an interest in conservation of the Australian Grayling including responsibility for management of Australian Grayling habitat'

Organisation	Type
Victoria	
Department of Sustainability and Environment	State Government
Parks Victoria	State Government
East Gippsland Catchment Management Authority	Regional Authority
West Gippsland Catchment Management Authority	Regional Authority
Port Phillip & Western Port Catchment Management Authority	Regional Authority
Corangamite Catchment Management Authority	Regional Authority
Glenelg Hopkins Catchment Management Authority	Regional Authority
Melbourne Water	Regional Authority
Tasmania	
Inland Fisheries Service	State Government
Parks and Wildlife Service (Dept of Tourism, Parks, Heritage and the Arts)	State Government
Resource Management and Conservation Division (Dept of Primary Industries, Water & Environment)	State Government
Water Resources Division (DPIWE)	State Government
Forestry Tasmania	State Government
Forest Practices Board	State Government
Hydro Tasmania	Govt Business Enterprise
New South Wales	
Department of Primary Industries	State Government

References

ASFB 2001. Conservation Status of Australian Fishes – 2001. Australian Society for Fish Biology, website www.asfb.org.au.

Bacher, G.J. and O'Brien, T.A. 1989. Salinity tolerance of the eggs and larvae of the Australian grayling, *Prototroctes maraena* Günther (Salmoniformes: Prototroctidae). *Australian Journal of Marine and Freshwater Research* 40: 227-230.

Bell, J.D., Berra, T.M., Jackson, P.D., Last, P.R. and Sloane, R.D 1980. Recent records of the Australian grayling *Prototroctes maraena* Günther (Pisces: Prototroctidae) with notes on its distribution. *The Australian Zoologist* 20: 419-431.

Berra, T.M. 1982. Life history of the Australian grayling, *Prototroctes maraena* (Salmoniformes: Prototroctidae) in the Tambo River, Victoria. *Copeia* 1982: 795-805.

Berra, T.M. 1987. Speculations on the evolution of life history tactics of the Australian grayling. *American Fisheries Society Symposium* 1: 519-530.

Berra, T.M., Campbell, A and Jackson, P.D. 1987. Diet of the Australian grayling, *Prototroctes maraena* Günther (Salmoniformes: Prototroctidae), with notes on the occurrence of a trematode parasite and black peritoneum. *Australian Journal of Marine and Freshwater Research* 38: 661-669.

Bishop, K.A. and Bell, J.D. 1978a. Observations on the fish fauna below Tallowa Dam (Shoalhaven River, New South Wales) during river flow stoppages. *Australian Journal of Marine and Freshwater Research* 29: 543-549.

Bishop, K.A. and Bell, J.D. 1978b. Aspects of the biology of the Australian grayling *Prototroctes maraena* Günther (Pisces: Prototroctidae). *Australian Journal of Marine and Freshwater Research* 29: 743-761.

Bryant, S.L. and Jackson, J.E. 1999. *Tasmania's Threatened Fauna Handbook: what, where, and how to protect Tasmania's threatened animals.* Threatened Species Unit, Parks and Wildlife Service, Hobart. Available on www.dpiwe.tas.gov.au under Parks and Wildlife> Nature of Tasmania> Threatened Species.

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

Crook, D.A., Macdonald, J.I., O'Connor, J. and Barry, B. In prep. Use of otolith chemical analysis to examine patterns of diadromy in Australian Grayling (*Prototroctes maraena*).

D'Emden, A. 2002. Draft Swan-Apsley Catchment Management Plan. Department of Primary Industries, Water and Environment, Hobart.

DPI 2003. *Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria*. Department of Primary Industries, Melbourne.

DPI 2005. *Protocols for the Translocation of Fish in Victorian Inland Public Waters*. Fisheries Management paper No. 24. Department of Primary Industries, Melbourne.

DSE 2003. Advisory List of Threatened Fauna in Victoria. Department of Sustainability and Environment, Melbourne.

Fulton, W. 1990. *Tasmanian Freshwater Fishes*. Fauna of Tasmania Handbook No. 7, University of Tasmania, Hobart.

Hall, D.N. and Harrington, D.J. 1989. Studies on the spawning and early life history of Australian grayling *Prototroctes maraena* Günther in the Barwon River, Victoria. Arthur Rylah Institute for Environmental Research Technical Report Series No. 84. Department of Conservation, Forests and Lands, Melbourne.

Hammer, M. 2001. Freshwater Fishes of south-eastern South Australia – Data sheet. Native Fish Australia (SA) Inc.

IFS 2003a. A survey of fish barriers in coastal Tasmanain rivers. Unpublished report, Inland Fisheries Service, Hobart.

IFS 2003b. The identification and removal or modification of redundant weirs to improve fish passage in Tasmanian rivers. Unpublished report, Inland Fisheries Service, Hobart.

IUCN 2001. *IUCN Red List Categories and Criteria: Version 3.1.* IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN 2003. *2003 IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland.

Jackson, P.D. 1976. A note on the food of the Australian grayling, *Prototroctes maraena* Günther (Galaxoidei: Prototroctidae). *Australian Journal of Marine and Freshwater Research* 27(3): 525-528.

Jackson, P.D. and Koehn, J.D. 1988. A review of biological information, distribution and status of the Australian grayling (*Prototroctes maraena*) Günther in Victoria. Arthur Rylah Institute for Environmental Research Technical Report Series No. 52. Conservation Forests and Lands, Melbourne.

Kuiter, R. 1983. Mount Gambier Fishes. *The SCUBA Diver* 2 (4): 3-8.

Lake, J.S. 1971. *Freshwater Fishes and Rivers of Australia*. Nelson, Melbourne.

McDowall, R.M. 1974. Specialisation in the dentition of the southern graylings – Genus Prototroctes (Galaxiodei: Prototroctidae). *Journal of Fish Biology* 6(2): 209-213.

McDowall, R.M. 1976. Fishes of the Family Prototroctidae. *Australian Journal of Marine and Freshwater Research* 27(4): 641-659.

McDowall, R.M. 1978. *New Zealand Freshwater Fishes: a Guide and Natural History*. Heinemann (NZ), Auckland.

McDowall, R.M. 1996a. Family Prototroctidae Southern graylings. Pp 96–98 in McDowall, R.M. (ed.). *Freshwater Fishes of South-eastern Australia*. Reed Books, Chatswood.

McDowall, R.M. 1996b. Threatened Fishes of the World: *Prototroctes oxyrhynchus*. *Environmental Biology of Fishes* 46: 60.

O'Connor, J. and Mahoney, J. 2004. Observations of ovarian involution in the Australian grayling (*Prototroctes mareana*). *Ecology of Freshwater Fish* 13: 70-73.

Wager, R. and Jackson, P. 1993. *The Action Plan for Australian Freshwater Fishes*. Australian Nature Conservation Agency Endangered Species Program Project no. 147.

Priority, Feasibility and Estimated Costs of Recovery Actions

Action	*Description*	*Priority*	*Feasibility*	*Cost estimate*					
				Year 1	Year 2	Year 3	Year 4	Year 5	**Total**
1	**Identify imp. populations**								
1.1	Collate existing data	1	100%	**$8,000**	**$0**	**$0**	**$0**	**$0**	**$8,000**
1.2	Distribution gaps and surveys	1	100%	**$0**	**$20,000**	**$20,000**	**$0**	**$0**	**$40,000**
1.3	Genetic assessment	2	100%	**$15,000**	**$15,000**	**$0**	**$0**	**$0**	**$30,000**
1.4	Determine monitoring sites	1	100%	**$0**	**$15,000**	**$15,000**	**$0**	**$0**	**$30,000**
1.5	Acquire population data	2	100%	**$0**	**$0**	**$0**	**$60,000**	**$60,000**	**$120,000**
2	**Protect, restore habitat**								
2.1	Habitat identification, mapping	1	75%	**$0**	**$0**	**$0**	**$50,000**	**$50,000**	**$100,000**
2.2	Flow regulation issues	1	50%	**$6,000**	**$0**	**$0**	**$0**	**$0**	**$6,000**
2.3	Fish passage	1	75%	**$0**	**$6,000**	**$6,000**	**$0**	**$0**	**$12,000**
2.4	Riparian habitat	2	60%	**$0**	**$0**	**$6,000**	**$6,000**	**$6,000**	**$18,000**
3	**Investigate life history**								
3.1	Spawning cues	1	90%	**$40,000**	**$40,000**	**$40,000**	**$0**	**$0**	**$120,000**
3.2	Larval, juvenile habitat use	1	90%	**$50,000**	**$50,000**	**$50,000**	**$0**	**$0**	**$150,000**
3.3	Adult movement, habitat use	2	90%	**$50,000**	**$50,000**	**$50,000**	**$0**	**$0**	**$150,000**
4	**Investigate, manage threats**								
4.1	Larval predation	2	50%	**$0**	**$0**	**$50,000**	**$50,000**	**$50,000**	**$150,000**
4.2	Impact of trout	1	50%	**$0**	**$0**	**$75,000**	**$75,000**	**$75,000**	**$225,000**
4.3	Trout stocking management	1	50%	**$6,000**	**$6,000**	**$6,000**	**$6,000**	**$6,000**	**$30,000**
4.4	Habitat sedimentation	2	50%	**$50,000**	**$50,000**	**$0**	**$50,000**	**$0**	**$150,000**
5	**Public awareness**								
5.1	Research publication	3	100%	**$6,000**	**$6,000**	**$6,000**	**$6,000**	**$6,000**	**$30,000**
5.2	Angler awareness	3	100%	**$6,000**	**$6,000**	**$6,000**	**$6,000**	**$6,000**	**$30,000**
	Totals			**$237,000**	**$264,000**	**$330,000**	**$309,000**	**$259,000**	**$1,399,000**