

**Background and Implementation
Information for the
Trout Cod *Maccullochella macquariensis*
National Recovery Plan**



Trout Cod Recovery Team



Australian Government

**Department of
Sustainability and
Environment**



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This publication contains detailed background information and implementation detail for the 'National Recovery Plan for the Trout Cod *Maccullochella macquariensis*' (Trout Cod Recovery Team 200a), and should be read in conjunction with that document (available at www.environment.gov.au).

This publication 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.

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Abbreviations

ARI	Arthur Rylah Institute for Environmental Research (DSE, Vic)
CMA	Catchment Management Authority
DSE	Department of Sustainability and Environment (Vic)
DPI	Department of Primary Industries (Vic)
Env ACT	Environment ACT
IUCN	International Union for the Conservation of Nature
MDBC	Murray Darling Basin Commission
PV	Parks Victoria
PIRVic	Primary Industries Research Victoria (DPI, Vic)
TCRT	Trout Cod Recovery Team

Species Information

Description

The Trout Cod *Maccullochella macquariensis* is an elongate, streamlined, moderately large percoid fish with a typically blue-grey colouration on the back and sides, becoming paler, almost white, on the ventral surface of the abdomen. This colouration is overlain by darker spots, blotches and irregular lines on the back and sides, but which are largely absent on the forehead and snout. Fins are blue-grey, with the tail, soft dorsal, anal and pelvic fins frequently with white margins. In profile, the head is straight, the top jaw overhangs the lower jaw, and a dark eye stripe extends from the snout horizontally through the eye to the operculum. Trout Cod grow to a maximum of about 700 mm in length and 16 kg in weight (Lake 1971), but are usually smaller, and can reach sexual maturity at 350-430 mm and 0.75-1.5 kg, which typically corresponds to an age of 3-5 years (G. Gooley PIRVic unpubl. in Koehn & O'Connor 1990; Douglas *et al.* 1994).

The Trout Cod is one of four taxa within the endemic percichthyid genus *Maccullochella*. The other representatives are the Murray Cod *Maccullochella peelii peelii* (Murray-Darling River system in Qld, NSW, Vic, SA), the Mary River Cod *Maccullochella peelii mariensis* (coastal drainages of south-eastern Qld and north-eastern NSW) and the Eastern Freshwater Cod *Maccullochella ikei* (Clarence River, north-eastern NSW) (Harris & Rowland 1996). All species and sub-species of *Maccullochella* are considered threatened; the Trout Cod, Mary River Cod and Eastern Freshwater Cod are Endangered, while the Murray Cod is Vulnerable (EPBC Act).

The Trout Cod is similar to the closely related and more common Murray Cod, which has resulted in some confusion in the identification and taxonomic status of both species, especially as the historical range of both species largely overlapped. Although the Trout Cod was first described in 1829 (Cuvier, in Cuvier & Valenciennes 1829), it was not until 1972 that the species was confirmed as being distinct from the Murray Cod, on the basis of meristic and morphometric analysis, supported by slight differences in immunoelectrophoretic data (Berra & Weatherley 1972). Subsequent electrophoretic analysis of tissue proteins of Murray Cod and Trout Cod (MacDonald 1978; Douglas *et al.* 1995) provided further supportive evidence for differentiation at the species level. However, it is interesting to note that, prior to 1950, professional fisherman in the Murray River could certainly distinguish between Trout Cod and Murray Cod, and, in 1960, J.O. Langtry listed 11 differences between the two species (J.O. Langtry, in Cadwallader 1977).

Trout Cod can be readily distinguished from Murray Cod by the combination of blue-grey colouration overlain with spots and blotches generally not extending onto the head, a straight head profile and the upper jaw longer than the lower jaw. Murray Cod are usually mottled olive greenish tinged with yellow, the mottling extending onto the head, have a concave head profile and jaws of about equal length (the bottom jaw may be slightly longer). Murray Cod also grow substantially larger, to over 1.5 m in length and a maximum weight of 113.5 kg (Harris & Rowland 1996). The eye stripe usually present in Trout Cod (and sometimes used as a diagnostic feature) may also be present in juvenile Murray Cod. Juvenile Murray Cod and Trout Cod (less than 60 mm long) are very similar and require experience to differentiate them. Hybridisation between Murray Cod and Trout Cod has been reported in Cataract Dam (Nepean River New South Wales) (Wajon 1983; Harris & Dixon 1988), in the Murray River downstream of Yarrowonga Weir, and in a fish hatchery (Douglas *et al.* 1995).

Reproduction

Douglas *et al.* (1994) considered that Trout Cod, like captive Murray Cod, formed pairs and spawned annually, usually in spring (September to November) and probably in response to increasing day-length and water temperature. Trout Cod breeding appears to be stimulated by a rise in water temperature to between 15°C and 20°C (G. Gooley PIRVic unpubl., in Koehn & O'Connor 1990). The fertilised eggs of Trout Cod are adhesive, demersal, opaque and 2.5-3.6 mm in diameter. The adhesive properties of the eggs suggest that a hard substrate might be preferred as an egg-laying site and it is speculated that typical egg-laying sites would include on or in logs, amongst rocks, or on hard clay surfaces (Cadwallader 1979; Koehn & O'Connor 1990). The fecundity of Trout Cod is not known, but 1,200-11,300 eggs have been stripped

from individual hatchery broodfish (Ingram & Rimmer 1992). Hatching commences 5-10 days after fertilisation at 20°C, and is mostly completed 2-3 days later. Newly hatched larvae are 6.0-8.8 mm in length and begin feeding about 10 days after hatching.

Trout Cod reach sexual maturity at 3-5 years, between 0.75 and 1.5 kg in weight, and at lengths as small as 35 cm for males and 43 cm for females (G. Gooley PIRVic unpubl., in Koehn & O'Connor 1990), although fish as small as 25.4 cm have been reported in spawning condition (J.O. Langtry, in Cadwallader 1977). Generally male Trout Cod mature younger and smaller than females, although there would be some variation depending on environmental conditions and growth rate.

Movement and territoriality

Information on the movement patterns of Trout Cod is ambiguous. Dakin & Kesteven (1938) suggested that Trout Cod migrate, Cadwallader (1977) suggested that Trout Cod migrate to spawn, and Gooley (in Koehn & O'Connor 1990) suggested that although Trout Cod may move long distances, the pattern of movement is not related to spawning. Certainly some young Trout Cod are capable of undertaking long distance movements. Juveniles and subadults caught in the upper Murrumbidgee River near Cooma and in the ACT almost certainly originated from stockings between 60 km and 100km upstream (Faragher *et al.* 1993; M. Lintermans MDBC pers. comm.). In contrast, Trout Cod released in the upper Murray River near Talmalmo (NSW) and in the Ovens River (Vic) were still caught near the point of release several years after the initial stockings (J. Kershaw, pers. comm., cited in Douglas *et al.* 1994; S. Nicols ARI unpubl. data). Recently, capture of larval Trout Cod in drift nets (Koster *et al.* 2004) indicates that the species may have a short nocturnal drifting phase, similar to that for Murray Cod (Humphries *et al.* 2002), which may assist dispersal away from the breeding site.

More recent data comes from three years of radio-tracking of adult Trout Cod in the Murray River below Yarrawonga. Under the regulated flow conditions that existed at the time, the investigation indicated adult Trout Cod exhibited a high level of site fidelity and had small home ranges. Neither of the two remaining breeding populations shows any evidence of a spawning migration (Brown & Nicol 1998; J. Koehn DSE-ARI unpubl.).

However, data obtained from a preliminary radio-tracking study in 1993 during a period when a 1 in 20 year flood occurred indicated increased movement, including away from the main channel onto the floodplain, around the time when breeding could have been expected (J. Koehn DSE-ARI unpubl.). The biological significance of this movement is unclear, and could simply reflect an avoidance reaction to the elevated water velocities associated with a major flood event. There is also some evidence of movement of adult Trout Cod through the fish lift at Yarrawonga (installed to facilitate fish passage over the weir), apparently in response to an artificially created flow pulse (Thorncraft & Harris 1997).

In aquaria, juvenile Trout Cod establish territories defended against other Trout Cod (Cadwallader 1979), although recreational anglers report sometimes catching several small Trout Cod at the one site over a short period of time. This could suggest that at some stage, Trout Cod may be gregarious, or it could indicate a clustering of juvenile fish around discrete habitat features.

Diet

The Trout Cod is a carnivorous, top-order predator, and its diet includes freshwater crustaceans such as crayfish, yabbies and shrimps, as well as fish and aquatic insects (Cadwallader 1979). Trout Cod fry reared in fertilised earthen ponds feed on a wide range of zooplankton, particularly cladocerans and copepods, and aquatic insects.

Conservation genetics

Bearlin & Tikel (2003) investigated the genetic diversity of Trout Cod populations in the Murray River, Ovens River, Seven Creeks and in captivity at the Snobs Creek and Narrandera hatcheries. The Seven Creeks Trout Cod population, originating from fish translocated from the Goulburn River, has relatively low genetic diversity when compared with the Murray River population, with most haplotypes present in the Murray River population absent from the Seven Creeks population. The Ovens River population, originating from stocked, hatchery-bred fish, has less diversity than the Murray River population but more than the Seven Creeks population. The hatchery populations together cover all haplotypes present in the Murray River.

Conservation status

Currently, only two reproducing populations (of unknown size) of Trout Cod are known: one (natural) in the Murray River (NSW) downstream of the Yarrawonga weir, between Yarrawonga and Barmah (a distance of about 120 km), and a second (introduced by translocation from the Goulburn River) in Seven Creeks (Victoria), south-east of Euroa. Reintroductions from hatchery-bred stock have occurred at several sites in the ACT, NSW and Victoria, but although there are indications of reproduction occurring in at least one of these populations, there is no evidence yet of any sustained recruitment.

National conservation status

The Trout Cod is listed as **Endangered** under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The species has been assessed as **Endangered** on the IUCN Red List of Threatened Species (IUCN 2003) (criteria C2a – version 2.3, 1994). It is considered **Critically Endangered** by the Australian Society for Fish Biology (ASFB 2001), and is considered as **Critical** (=Critically Endangered) by Wager & Jackson (1993).

Conservation status in range states

In New South Wales the Trout Cod is Listed as **Endangered** under the *Fisheries Management Act 1994*. In the Australian Capital Territory it is Listed as **Endangered** under the *Nature Conservation Act 1990*. In Victoria it is Listed as **Threatened** under the *Flora and Fauna Guarantee Act 1988* (FFG Act). and considered **Critically Endangered** (DSE 2003).

The Trout Cod is assessed as **Critically Endangered** under the IUCN Red List categories (2002), on the following criteria: B1a+b(iii)

B1 – Extent of occurrence <100 km²

a – severely fragmented: only two breeding populations known (one natural, one introduced)*

b(iii) – continuing decline in habitat: impact of river regulation, desnagging, thermal pollution, barriers

* reintroductions have been undertaken to establish several new populations, but there is yet no evidence of breeding or recruitment, so the reintroduced populations have not been considered in this conservation status assessment.

Distribution

Past distribution

The Trout Cod is endemic to the Murray-Darling River system in south-eastern Australia, with records from the Murray River (SA & NSW), Murrumbidgee River (NSW & ACT), Macquarie River (NSW) and the Goulburn, Broken, Campaspe, Ovens, King, Buffalo and Mitta Mitta Rivers (Vic) (Berra & Weatherley 1972; Cadwallader 1977; Cadwallader & Gooley 1984; Scott *et al.* 1980). The species was also translocated into several waters outside its recorded range, including Cataract Dam on the Nepean River (NSW) prior to 1910 (Rimmer 1988); Seven Creeks, a tributary of the Goulburn River (Vic) in the early 1920s; and Lake Sambell at Beechworth (Vic) in 1928 (Cadwallader & Gooley 1984). Interestingly, there have been no confirmed records of Trout Cod from either the Darling River (NSW, Qld) or the Lachlan River (NSW).

The mid reaches of the Murray River and its tributaries, particularly in Victoria, and the Murrumbidgee River in NSW seem to have been the centre of its distribution. Up until 1950 at least, Trout Cod were present in the Murray River from Mildura to upstream of Yarrawonga (Cadwallader 1977; Lake 1971), although the species was considered rare downstream from Echuca, but more common upstream (J.O. Langtry, in Cadwallader 1977).

Present distribution

At present only two potentially sustainable, breeding populations of Trout Cod are known: a naturally occurring population in the Murray River (NSW) downstream of the Yarrawonga Weir between Yarrawonga and Barmah (Cadwallader & Gooley 1984; Ingram *et al.* 1990; Douglas *et*

al. 1994), and the translocated population in Seven Creeks below Polly McQuinn's Weir (Vic) (Cadwallader 1979; Morison & Anderson 1987; Richardson & Ingram 1989).

There have been no recent records of wild adult Trout Cod in the Murray River downstream from Echuca (NSW, SA), Macquarie River (NSW), Murrumbidgee River (NSW, ACT), and the Goulburn, Broken, Campaspe, Ovens, King, Buffalo and Mitta Mitta Rivers (Vic). The wild populations formerly occurring in these rivers are now probably extinct. The translocated population in Lake Sambell (Vic) apparently died out in 1970. Trout Cod and Murray Cod translocated into Cataract Dam (Nepean River NSW) have hybridised (Wajon 1983; Harris & Dixon 1988). A population of cod still exists there, but is apparently now composed largely of hybrids, although a photograph in Merrick and Schmida (1984) of a Trout Cod captured in the Nepean River system shows all the features characteristic of the species.

Since the mid 1980s, when techniques to induce spawning in Trout Cod were developed (Rimmer 1987; Ingram & Rimmer 1992), small numbers of juvenile fish have been produced for release into sites within the presumed historical range of the species to establish new populations (Table 2). In several locations, including the Murrumbidgee River (NSW, ACT), the Macquarie River (NSW), the Ovens River and Goulburn Rivers (Vic), stocked fish have survived and are approaching or have reached breeding size. Fish stocked into Ryans Creek (Vic) survived and bred (Douglas & Brown 2000), but the population has since become extinct, possibly due to illegal fishing. In November and December 2003, drifting larvae of Trout Cod and some one year-old juveniles were collected in the Goulburn River downstream from Lake Nagambie (Koster *et al.* 2004), indicating breeding in the stocked population there. However, in January 2004, a fish kill occurred in the Goulburn River for several kilometres downstream of Lake Nagambie, in which many hundreds of native and introduced fish were killed, including at least 20 Trout Cod. Subsequent surveys failed to detect any Trout Cod, and it is unsure if the population still persists there (Koster *et al.* 2004).

Detailed distribution information on the Trout Cod is available from:

New South Wales: Department of Primary Industries (www.dpi.nsw.gov.au)

Victoria: Department of Sustainability and Environment (www.dse.vic.gov.au)

ACT: ACT Parks, Conservation and Lands (www.environment.act.gov.au)

Recovery Information

Existing Conservation Measures

The Trout Cod has been the focus of recovery efforts for almost 20 years, and a considerable effort has gone into recovery over this period. The first national recovery plan was prepared in 1994, and revised in 1998. Many environmental restoration programs are already occurring in places within the range of the Trout Cod, and have the potential to be of substantial benefit to the species. The Murray River is focus for a range of environmental restoration programs, including an increase in environmental flows to the river. Specific and general initiatives that benefit Trout Cod include:

- Listing as a protected species under Australian Government, NSW, ACT and Victorian Government legislation.
- Preparation of two national recovery plans (1994 & 1998), plus supplementary documents (eg. Action Statement) in NSW, ACT and Victoria.
- Formation of a national Recovery Team to coordinate implementation of recovery actions.
- Establishment in captivity and breeding for reintroduction.
- Since 1986, release of over 700,000 hatchery-bred Trout Cod in NSW, ACT and Victoria to establish new wild populations. Evidence of the first sustained wild reproduction occurring in a stocked population was obtained the Goulburn River (Vic), although this recovery was since compromised by an extensive fish kill occurring in the lower Goulburn River in early 2004.
- Prohibition on recreational angling for the species.
- Studies investigating conservation status, biology and ecology (see Bibliography).

- In-stream and riparian habitat rehabilitation in the Murray River (NSW) and Seven Creeks (Vic).
- Information on Trout Cod, 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, signage and on department websites.
- Fishways are being progressively installed in the Murray River and its tributaries in NSW and Victoria. Trout Cod have been recorded passing through the fishway installed on the Yarrowonga weir (Lake Mulwala). The effectiveness of these fishways will be investigated over the course of the plan.
- A proposed increase in environmental flows for the Murray River ('Living Murray' program).
- General river improvements programs, including river health strategies, streamflow management plans and restoration of riparian vegetation for many rivers within the range of the Trout Cod.
- Stocking of trout has been restricted or ceased waters where Trout Cod occur and there could be potential for competition/predation.

Strategy for Recovery

The strategy for recovery of Trout Cod will be to continue to focus on protection and management of locations with natural and reintroduced populations of Trout Cod, continuing stockings, and monitoring stocked populations for establishment and reproduction. Investigation of key biological and ecological attributes, such as spawning cues, movement of stocked fish and distribution of critical habitat is also required to facilitate recovery. Another important issue to address is education and awareness to build community support for conservation efforts. The Trout Cod could benefit from integrated catchment management initiatives, 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 Trout Cod occur. The species is a potential major beneficiary of the 'Living Murray' program. Restoration of fish passage past barriers will also be of benefit to the species. Monitoring the ecological response of Trout Cod 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 implementation. The Trout Cod Recovery Team, a group comprising representatives from DSE, DPI, G-B CMA (Vic), NSW Fisheries, ACT PCL & MDBIC will continue to coordinate implementation of the recovery plan. Any technical, scientific, habitat management or education issue requiring skills not available within the Recovery Team will be referred to specialist organisations and individuals as appropriate. 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 preparing work plans and monitoring progress toward recovery within their own jurisdiction.

Program Evaluation

The Recovery Team will be responsible for informal evaluation annually. Towards the termination of the Recovery Plan, an external reviewer will be appointed to undertake a formal review and evaluation of the recovery program.

Recovery Objectives

The **Long-term Objective** of recovery is to minimise the probability of extinction of the Trout Cod in the wild, and to increase the probability of important populations becoming self-sustaining in the long term, ideally to meet the IUCN Red List criteria for conservation assessment as Least Concern (IUCN 2002).

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

1. Investigate key aspects of biology and ecology.
2. Determine the growth rates and viability of populations.
3. Identify and map habitat critical to survival.
4. Investigate and control threatening processes.
5. Manage Murray River population to ensure its continued sustainability natural and reintroduced populations to achieve self-sustainability.
6. Manage Seven Creeks (Vic) population to ensure its continued sustainability.
7. Manage Ovens River population to ensure its continued sustainability.
8. Manage the Murrumbidgee River and Cotter River populations (ACT) to ensure their continued sustainability.
9. Breed Trout Cod for reintroduction.
10. Undertake reintroductions to establish new populations.
11. Encourage community awareness and support.
12. Trial a stocked recreational fishery for Trout Cod in Victoria.
13. Manage Recovery Plan implementation.

Objective 1. Investigate key aspects of biology and ecology, especially as they relate to conservation management and identification of threatening processes.

Recovery Criterion:

Successfully obtaining biological information for preparation of management strategies to maintain, enhance or restore processes fundamental to survival, reproduction and viability of populations.

Action 1.1 Evaluate current reproductive status, fecundity, recruitment levels and longevity of natural and stocked populations.

Key biological information such as breeding biology and recruitment, age and structure of Trout Cod populations is either rudimentary or based on data from captive populations. Obtaining this information is key to determining population trends and ultimately sustainability of populations, and will be important in determining management responses for the conservation of the species. This biological information will be collected during monitoring of the Murray River and Seven Creeks populations, and from those reintroduced populations showing signs of establishment and wild reproduction.

Action 1.2 Investigate movement and dispersal patterns of Trout Cod.

While Trout Cod have been detected moving through fishways, some radio-tagged Trout Cod have shown little short-term movement, and the requirements for short- or long-term movements of the species are not known. The closely related Murray Cod, and several other Murray-Darling fish species, can undertake substantial short- and long-term movements during their lives. Determining movements and dispersal of Trout Cod, especially tracking the movements of stocked fish, is important for managing reintroductions, and ultimately linkages between reintroduced populations. The project will be based in the Murrumbidgee River in ACT and NSW.

Action 1.3 Determine stimuli for reproduction.

Trout Cod appear to spawn in response to a rise in water temperature, but apparently do not need flooding, unlike some other Murray-Darling fish species. However, the precise requirements for spawning are not known. Determining the spawning requirements is necessary to ensure suitable conditions are available (or can be created) at reintroduction sites,

to maximise chances of successful population establishment and recruitment. This will also assist managing existing populations to maximise successful recruitment. The project should cover the Murray River and Seven Creeks populations, and at least one current reintroduced population where breeding is detected.

Action 1.4 Measure population trends and responses against recovery actions by collecting demographic information including recruitment and mortality, timing of life history stages and morphological data.

Determining the trends and responses of Trout Cod populations to management is important to be able to assess progress towards recovery, and to adjust management actions as required, as populations establish and grow. Of particular importance will be determining the impact of environmental flows, habitat enhancement such as resnagging, and any changes to recreational fishing regulations. The information needs to be collated, analysed and compared with management histories, and reported on in a form that enables rapid integration of the information into management responses. The project should cover the Murray River and Seven Creeks populations, and at least one current reintroduced population where breeding is detected.

Objective 2. Identify and map habitat critical to survival.

Recovery Criterion:

Predictive model for potential habitat developed and tested.

Action 2.1 Survey and map potential habitat, using ecological and bioclimatic information that may indicate habitat preference.

It seems clear that Trout Cod once occurred in a variety of habitat types, from wide, slower-flowing low gradient rivers with abundant fallen timber, to smaller, steeper, swifter-flowing streams with deep pools, shallow riffles and boulder cover. While there is an understanding of what constitutes critical habitat in the Murray River, little is known about the key habitat requirements in rocky streams (eg. Seven Creeks, upper Murrumbidgee River, Cotter River). Determining the key habitat attributes, and their distribution and abundance, is central to current and future reintroductions. It will also assist in gaining an understanding of population establishment, dispersal and fragmentation, and how populations are likely to respond to habitat enhancement.

Objective 3. Investigate and control threatening processes.

Recovery Criterion:

Improved understanding and control of the main threatening processes affecting Trout Cod.

Action 3.1 Investigate the precise impacts of known and potential threats to Trout Cod.

While a range of threatening processes is believed to be affecting Trout Cod, their nature and impact is generally not well known, and reintroductions in particular have proceeded with little understanding of the precise threats or their mitigation. Further research is required to determine and understand the full range of threatening processes, so that more targeted strategies for their subsequent control can be formulated, to increase chances of successful establishment and reproduction, especially of reintroduced populations.

Action 3.2 Investigate the interaction between Trout Cod and introduced freshwater fish.

Several introduced freshwater fish, including carp and trout, occur with Trout Cod, but their impact is still speculative. Further research is required to determine the interaction between Trout Cod and introduced freshwater fish, especially the impact of predation and competition on Trout Cod. This will enable appropriate management strategies to be developed to reduce or eliminate any adverse impact.

Action 3.3 Investigate the impact of incidental angling capture on Trout Cod.

The last remaining natural Trout Cod population, in the Murray River, occurs in an area popular for recreational fishing. As a consequence, Trout Cod are commonly caught by anglers fishing for other species, but must be released unharmed. However, the rate of survival of released fish is not known. Studies of other species of other angling species in Australia and overseas have shown mortality in released fish can vary from quite low to unacceptably high. Determining the impact of incidental angling capture is necessary so that fishing regulations can be adjusted if required to protect Trout Cod populations until they become large enough and to sustain some angling pressure.

Action 3.4 Identify and remove barriers to movement of Trout Cod populations, through the existing fishways programs in Victoria and NSW.

The 'Living Murray' fishways program aims to restore fish passage throughout several thousand kilometres of the Murray River and its major tributaries. Much of this work is currently focused on the lower and mid catchment, largely outside the current range of wild and introduced Trout Cod populations. There is a need to identify where barriers might be a problem for Trout Cod, and either remove or facilitate fish movement past the barrier, through installation of a fishway. This is required to avoid fragmentation, allow for population expansion, and facilitate movement between populations.

Objective 4. Manage Murray River population to ensure its continued sustainability.

Recovery Criterion:

Population parameters such as area of occupancy, presence of a range of size and age classes, spawning and recruitment indicate a stable or increasing population.

Action 4.1 Monitor the range and status of the Trout Cod population in the Murray River, particularly (a) identification of the area and extent of the population; (b) estimates of the size and structure and (c) inference or estimation of population change.

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 Trout Cod and to provide information to enhance management programs where appropriate. The monitoring should be undertaken at a frequency and intensity that can provide sufficient data to detect population structure and changes, and enable status assessments to be made.

Action 4.2 Monitor movement of Trout Cod through the fishway on the Yarrawonga weir.

A fishway, including mechanical lift, has been installed on the Yarrawonga weir (Murray River) to facilitate fish movement upstream into Lake Mulwala and beyond. Some Trout Cod have been detected using the fishway, but the requirement for and importance of upstream movement is not known, nor is the effectiveness of the fishway in facilitating this movement. The fishway outlet is near the intake for the small power station, and movement also needs to be monitored to determine if any fish moving upstream are caught in the power station intake.

Action 4.3 Determine the frequency and impact of population fragmentation along the Murray River using genetic marker analysis and/or other means.

The Trout Cod population in the Murray River occurs over a distance of about 100 km downstream from Yarrawonga, to the Barmah region. However, it is not known if this population is more or less continuous or if it comprises several smaller discrete subpopulations. The level

of fragmentation (if any) needs to be determined (by genetic marker analysis and/or other means), especially if habitat is discontinuous in this area, to formulate appropriate management responses for managing the population and its habitat, especially as fragmentation could lead to localised extinctions.

Action 4.4 Assess the available habitat in the Murray River as a potential limiting factor for population growth.

In the Murray River, Trout Cod appear to require specific habitat attributes that may be patchily distributed along the river. A survey of habitat is required to determine the impact of fragmentation, potential for expansion of the Trout Cod population (a prerequisite for recovery), and whether other recovery options, such as habitat creation or supplementation, and translocation to suitable but isolated habitat, might be required.

Action 4.5 Maintain fisheries compliance activity along the Murray River Trout Cod zone.

The last wild population of Trout Cod occurs in a popular recreational fishing area, and anglers sometimes catch Trout Cod. Despite being fully protected, and information displayed on signs and provided in angling guides, some anglers either inadvertently or deliberately keep Trout Cod they catch. Patrols and inspections by NSW and Victorian fisheries officers will continue to ensure anglers comply with recreational fishing regulations applying to the area, including protection of Trout Cod.

Objective 5. Manage Seven Creeks (Vic) population to ensure its continued sustainability.

Recovery Criterion:

Population parameters such as area of occupancy, presence of a range of size and age classes, spawning and recruitment indicate a stable or increasing population.

Action 5.1 Introduce new stock from the Murray River to Seven Creeks to improve the genetic variability of the Seven Creeks stock, and monitor survival of the introduced fish.

The Seven Creeks population arose through stocking of a small number of individuals taken from the Goulburn River, and as such the population has experienced a genetic 'bottleneck' arising from a small genetic base. Molecular analyses reveal that much of the genetic variability present in the Murray River population is absent from the Seven Creeks population. Increasing the genetic base may well be required to maximise the long-term chances of survival of this small but very important population (one of only two wild breeding populations). This needs to be done carefully to avoid undue competition, ideally through creation or improvement of habitat in Seven Creeks to increase the population size.

Action 5.2 Continue in-stream habitat enhancement in lowland section, and monitor performance and change in stream morphology.

There has been a program of in-stream habitat enhancement in Seven Creeks, undertaken by the Goulburn-Broken Catchment Management Authority. This has involved placing boulders and timber structures in the stream to provide habitat, break up stream flow and cause scour holes to develop, shifting sediment downstream. This is a long-term program aimed at increasing the available habitat for Trout Cod, ultimately increasing population size and distribution within Seven Creeks. The program will continue, with the installation of more in-stream structures, plus an evaluation of their success in improving stream morphology, occupancy and use by Trout Cod.

Action 5.3 Continue fencing and riparian protection and revegetation along Seven Creeks Trout Cod zone.

Some fencing to protect riparian vegetation and the river bank has already occurred along Seven Creeks in the Trout Cod zone. There is a need to identify priority areas and continue fencing and revegetation, to further protect the river bank and improve habitat and water quality.

Action 5.4 Protect the current environmental flows in Seven Creeks.

There is a small weir on Seven Creeks that provides water for domestic supply. While the Trout Cod population has persisted with this diversion, there is a need to ensure that flows continue at current levels, and flows sufficient to cover habitat occur during summer. This may require an investigation of flow levels through the Trout Cod zone in Seven Creeks. Any proposal to draw more water from Seven Creeks should have an impact assessment on Trout Cod and habitat within Seven Creeks.

Action 5.5 Continue to prohibit the stocking of recreational angling species in the Seven Creeks Trout Cod zone.

The current practice of prohibiting stocking of recreational fish species in the Trout Cod zone in Seven Creeks will continue, to protect the Trout Cod population from increased levels of predation or competition.

Action 5.6 Maintain fisheries compliance activity along Seven Creeks Trout Cod zone.

Despite the Trout Cod zone on Seven Creeks being closed to all fishing, some illegal fishing, and illegal take of Trout Cod, still occurs. As Seven Creeks is relatively small, and the total number of Trout Cod in the creek probably low in absolute numbers, the population is very susceptible to factors causing increased levels of mortality such as through angling. Patrols and inspections by fisheries officers will continue to ensure anglers comply with recreational fishing regulations applying to the area.

Objective 6. Manage Ovens River population to ensure its continued sustainability.

Recovery Criterion:

Wild reproduction and recruitment detected in the reintroduced populations.

Action 6.1 Continue the reintroduction to the Ovens River system, Victoria.

Over the past several years, up to 40,000 Trout Cod fingerlings per year have been released in the Ovens River to attempt to establish a new population there. The reintroductions will continue for at least another two years, followed by an intensive survey to assess population establishment, distribution, structure and reproduction, at which time the need for further releases will be assessed.

Action 6.2 Undertake trials to determine the effect of size of fish at release on survival and establishment.

Stocked fish have mostly been 'fingerling' size, about 25 mm long and two-three months of age. Evidence from some other fish stockings indicates an increased survival if fish are stocked at a larger size. A trial has commenced to determine if there is increased survival in stocking of larger fish (1 year old and 70-100 mm). This needs to continue for at least another two years and be monitored for several years after that to determine the optimum size to maximise survival of stocked fish.

Action 6.3 Monitor the survival, growth and recruitment of the reintroduced population in the Ovens River system, and determine needs for additional stockings.

As a key reintroduced population in efforts to recover the species, regular monitoring is required to determine the fate of stocked fish, population trends, and progress towards population establishment and ultimate viability. Monitoring will be carried out at least every two years. When wild reproduction is detected, monitoring will become more frequent to determine survival and recruitments rates to the adult population, as a key indicator of viability.

Action 6.4 Assess the available habitat in the Ovens River as a potential limiting factor for population growth.

Trout Cod appear to dependent upon the right combination of flow and suitable cover such as fallen timber, rock and boulders, to establish at reintroduction sites. Such habitat, especially snags, is of patchy distribution along rivers, and may be a limiting factor to population establishment and expansion at some reintroduction sites. As more becomes known of Trout Cod habitat, its distribution and availability needs to be determined, as an important factor in ultimately establishing viable populations at reintroduction sites. Determination of available habitat will also help formulate management strategies such as habitat supplementation through resnagging, and longer term strategies such as revegetation of streambanks.

Action 6.5 Maintain fisheries compliance activity along Ovens River Trout Cod zone.

Despite Trout Cod being fully protected, and information displayed on signs and provided in angling guides, some anglers either inadvertently or deliberately keep Trout Cod they catch. Patrols and inspections by Victorian fisheries officers will continue to ensure anglers comply with recreational fishing regulations applying to the area, including protection of Trout Cod.

Action 6.6 Manage the stocking of recreational fish species in the Ovens River system (downstream from Bright), including the King River downstream from Lake William Hovell.

Proposals for the stocking of recreational or other fish species in the Ovens/King Rivers 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).

Objective 7. Manage Murrumbidgee River population to ensure its continued sustainability.

Recovery Criterion:

Wild reproduction and recruitment detected in the reintroduced populations.

Action 7.1 Monitor the range and status of the Trout Cod population in the Murrumbidgee River.

As a key reintroduced population in efforts to recover the species, regular monitoring is required to determine the fate of stocked fish, population trends, and progress towards population establishment and ultimate viability. Monitoring will be carried out at least every two years. When wild reproduction is detected, monitoring will become more frequent to determine survival and recruitments rates to the adult population, as a key indicator of viability.

Action 7.2 Assess the available habitat in the Murrumbidgee River as a potential limiting factor for population growth.

Trout Cod appear to dependent upon the right combination of flow and suitable cover such as fallen timber, rock and boulders, to establish at reintroduction sites. Such habitat, especially snags, is of patchy distribution along rivers, and may be a limiting factor to population

establishment and expansion at some reintroduction sites. As more becomes known of Trout Cod habitat, its distribution and availability needs to be determined, as an important factor in ultimately establishing viable populations at reintroduction sites. Determination of available habitat will also help formulate management strategies such as habitat supplementation through resnagging, and longer term strategies such as revegetation of streamsides.

Action 7.3 Maintain fisheries compliance activity along the Murrumbidgee River Trout Cod zone.

Despite Trout Cod being fully protected, and information displayed on signs and provided in angling guides, some anglers either inadvertently or deliberately keep Trout Cod they catch. Patrols and inspections by fisheries officers will continue to ensure anglers comply with recreational fishing regulations applying to the area, including protection of Trout Cod.

Objective 8. Manage the Murrumbidgee River and Cotter River populations (ACT) to ensure their continued sustainability.

Recovery Criterion:

Wild reproduction and recruitment detected in the reintroduced populations.

Action 8.1 Continue the reintroduction to the Murrumbidgee River system, ACT.

Since the early 1990s, many thousands of Trout Cod fingerlings per year have been released into the Murrumbidgee River system to attempt to establish a new population there. The reintroductions will continue for at least two more years, followed by an intensive survey to assess population establishment, distribution, structure and reproduction, at which time the need for further releases will be assessed.

Action 8.2 Monitor the survival, growth and recruitment of the reintroduced population in the Murrumbidgee River and Cotter River, ACT.

As a key reintroduced population in efforts to recover the species, regular monitoring is required to determine the fate of stocked fish, population trends, and progress towards population establishment and ultimate viability. Monitoring will be carried out at least every two years. When wild reproduction is detected, monitoring will become more frequent to determine survival and recruitments rates to the adult population, as a key indicator of viability.

Action 8.3 Prohibit the stocking of recreational fish species in the Trout Cod zones of the Murrumbidgee River and Cotter River.

The current practice of prohibiting stocking of recreational fish species in the Trout Cod zones of the Murrumbidgee River and Cotter River will continue, to protect the Trout Cod population from increased levels of predation or competition.

Action 8.4 Maintain fisheries compliance activity along Murrumbidgee River and Cotter River Trout Cod zones.

Despite Trout Cod being fully protected, and information displayed on signs and provided in angling guides, some anglers either inadvertently or deliberately keep Trout Cod they catch. Patrols and inspections by fisheries officers will continue to ensure anglers comply with recreational fishing regulations applying to the area, including protection of Trout Cod.

Objective 9. Breed Trout Cod for reintroduction to establish new populations.

Recovery Criterion:

Adult fish maintained in captivity, managed to maximise genetic diversity, and breeding every year to provide 40,000+ fish for reintroductions.

Action 9.1 Maintain captive adult breeding populations at Snobs Creek Fisheries Research Station and Narrandera Fisheries Research Station, and breed for reintroduction to the wild.

Captive populations of adult Trout Cod will be maintained at Snobs Creek Fisheries Research Station (Vic) and Narrandera Fisheries Research Station (NSW) to breed Trout Cod for reintroductions programs in NSW, ACT and Victoria.

Objective 10. Undertake reintroductions to establish new populations in the wild.

Recovery Criterion:

Establish new, viable populations to decrease the risk of extinction of the species.

Action 10.1 Monitor the survival, growth and recruitment of the reintroduced populations in the Goulburn, Mitta Mitta and Upper Murray River systems, and determine needs for additional stockings.

Stockings of hatchery-bred Trout Cod have been undertaken for several years now in NSW, ACT and Victoria, and recently there have been encouraging signs of successful reproduction occurring in the Goulburn River for at least the last two breeding seasons. Ongoing monitoring of reintroduced populations is required to assess the outcomes of recent stockings, and the need for further stockings to achieve self-sustainable populations.

Action 10.2 Identify and prioritise new sites for stocking Trout Cod to establish new populations, in consultation with stakeholders.

The Trout Cod is now reduced to two breeding populations – one natural and one reintroduced. So far there is little evidence of sustained recruitment in recent reintroduced populations, and some reintroduced populations have apparently died out. There is a need to continue to find secure suitable locations to establish new Trout Cod populations, to reduce the risk of extinction (based on outcome of Objective 2). This should be undertaken in full consultation with stakeholders to gain support for the reintroductions and ensure other values are not compromised by any releases of Trout Cod.

Objective 11. Encourage community awareness and support for Trout Cod conservation.

Recovery Criterion:

There is support for Trout Cod conservation, participation by community groups in conservation activities, and compliance with fisheries regulations.

Action 11.1 Encourage the reporting of Trout Cod incidental captures by anglers.

Anecdotal reports from fisheries officers indicate recreational anglers are increasingly catching Trout Cod, both in the remaining wild population in the Murray River (as the species' range expands downstream), and in areas where the species has been stocked, especially the Goulburn, Ovens and Murrumbidgee Rivers. This is a potentially valuable source of information that, over time, could give a broad indicator of population trends such as distribution and relative abundance. This action aims to encourage anglers to keep records of any capture of Trout Cod – tag number, date, location, approximate length, and a photograph if possible, and return the fish unharmed to the water.

Action 11.2 Maintain the Fishcare Volunteers program, with emphasis on Trout Cod issues in the Murray, Murrumbidgee and Macquarie River catchments.

The Fishcare Volunteers program operates in NSW and Victoria. Fishcare Volunteers assist sustainable fisheries management by advising anglers on responsible fishing, distribute educational material, collecting research information and data on angler demographics, awareness of fishing rules and regulations, and catch and release practices. Promoting Trout Cod conservation will be an emphasis for Fishcare volunteers working in the Murray, Murrumbidgee and Macquarie River catchments.

Action 11.3 Maintain/enhance education programs to assist anglers to distinguish between Trout Cod and Murray Cod.

There is some confusion about the differences between Trout Cod and Murray Cod, and some anglers still have difficulty distinguishing between the two species. Efforts to increase angler awareness of the two species and their differences will be made through information in recreational fishing guides, provision of extra signage, and emphasis through the Fishcare volunteers program.

Action 11.4 Develop an education kit on Trout Cod conservation and distribute to schools.

Education in schools about Trout Cod is seen as an important initiative to encourage support for its conservation. A kit explaining about the species, its biology, ecology, threats and conservation efforts will be developed and made available to schools especially within the Trout Cod's current range to foster its conservation.

Action 11.5 Encourage the involvement of community groups in the conservation program for Trout Cod.

Community support for Trout Cod conservation is vital to ensuring the successful outcome of conservation efforts. The community group *Native Fish Australia* has previously been involved in breeding Trout Cod and on-growing fingerlings for release. Community group involvement in Trout Cod conservation will be maintained and expanded, where possible. Opportunities include training specific Fishcare volunteers to have a focus on and promote Trout Cod conservation, and involvement of Landcare groups adjacent to rivers containing Trout Cod in habitat protection and rehabilitation.

Action 11.6 Ensure the results of research and management on Trout Cod are publicised through scientific meetings, journal publications and articles for the popular press, including fishing magazines.

Publishing research and other information on Trout Cod and conservation efforts is an important aspect of the recovery program. This information needs to be made available not only in scientific journals, but also in more accessible forms such technical reports for land/water managers to be able to adapt and use the information, and in the popular literature such as magazines and media articles, to keep the community informed and build support for Trout Cod conservation and management.

Objective 12. Trial development of a recreational fishery for stocked Trout Cod in Victoria.

Recovery Criterion:

A recreational fishery for Trout Cod in a specific location that does not conflict with conservation objectives is established, and angler understanding of and support for Trout Cod conservation is improved.

Action 12.1 Liaise with the Victorian Recreational Fishing Peak Body, VRFish, to gauge interest in the development of stocked Trout Cod fisheries in impoundments.

Anecdotal reports from fisheries officers indicates some angler antipathy towards Trout Cod conservation, due to anglers now catching more Trout Cod in stocked populations as fish grow steadily larger, but the species still being protected. There will be an inevitable delay between progress towards recovery (ie. increasing numbers of Trout Cod in rivers) and the time when Trout Cod once again become common enough for anglers to catch without harming recovery prospects. Trout Cod are now readily bred in hatcheries, and can be produced in numbers well in excess of conservation stocking requirements. To build support for Trout Cod conservation among recreational anglers, it is proposed to establish a discrete recreational fishery for the species, at a location that does not compromise existing conservation efforts. The first step in this proposal is to seek the support of VRFish and gauge angler interest in the potential for a specific recreational fishery for Trout Cod. Initially, this action is proposed for Victoria only.

Action 12.2 Identify impounded waters where stocked Trout Cod would be accessible to anglers and where there would be no conflict with conservation stockings.

Any proposal to stock Trout Cod for a recreational fishery would need to be in a discrete location such as a lake or impoundment, with suitable habitat, that does not compromise any other social or environmental values, and be well away from locations where conservation stockings are occurring. Liaison with relevant land/water managers would also be required to gain their support for the proposal.

Action 12.3 Determine fishing regulations for stocked Trout Cod fishery.

If the proposal proceeds, a suite of fishing regulations such as open/closed seasons, minimum size, bag limit, fishing methods etc. will be required for the location where Trout Cod will be stocked before the fishery can open.

Action 12.4 Stock for 4* consecutive years and undertake stock assessment in the 5th year.

Once angler support is gained, regulations determined, a suitable water found, support of the land/water manager obtained, and funding obtained, stockings of hatchery-bred fish will commence.

Action 12.5 Monitor catch rates, angler satisfaction and improved angler awareness of Trout Cod conservation issues.

An important aspect of this action to determine its outcome will be to monitor angler catch rates, attitude to and satisfaction with the project, and also their general awareness of and support for broader conservation initiatives for Trout Cod.

Action 12.6 Provide information to anglers on Trout Cod conservation.

The establishment of a specific recreational fishery for Trout Cod also provides a unique opportunity to provide information to anglers and the broader community on Trout Cod conservation, through the provision of signage at the fishing site, fisheries officer talks to anglers using the site, leaflets and in the fishing guides.

Objective 13. Manage Recovery Plan implementation

Recovery Criterion:

Recovery Team established with representation from key Sate agency stakeholders, to communicate and coordinate recovery actions, facilitate information exchange and prepare funding applications to implement plan.

Action 13.1 Continue with a national Recovery Team to coordinate recovery actions and exchange knowledge with local and interstate agencies to maintain communication, to assist with management and implementation.

While implementation of recovery actions will be the responsibility of individual organisations and state agencies, there is a need for coordination of implementation, especially identification of priorities, and a mechanism for information exchange amongst principal stakeholders. A Recovery Team, formed from key stakeholders involved in conservation efforts, is in place to provide program coordination. The Recovery Team will continue to operate, mainly by phone, emails and video-conferencing where required, with formal meetings held infrequently, perhaps annually.

Action 13.2 Establish and facilitate regional recovery processes where required.

With the distribution of the Trout Cod occurring across two States and the ACT, and differing management arrangements in each State, local management arrangements will be required to facilitate implementation of the Recovery Plan. Establishment of local arrangements will be the responsibility of the key implementation agency in each State.

Action 13.3 Ensure funding submissions are organised through appropriate management agencies each year (or as required).

While a considerable amount of environmental work (eg. 'Living Murray' program, fishways, catchment protection, restoration of environmental flows) is occurring across the range of the Trout Cod, there are still critical gaps in knowledge, especially the fate of reintroduced populations and population responses to environmental improvement programs. External funding (such as NHT) will need to be sought to implement many of the actions contained in this Recovery Plan. Individual agencies will be responsible for seeking funding for actions within their own jurisdiction.

Action 13.4 Undertake a formal review and evaluation at termination of this Recovery Plan.

Review and evaluation of progress towards recovery objectives is an important part of adaptive management for threatened species conservation. The Recovery Team and individual agencies will be responsible for regular (eg. annually) informal review of their progress. A formal, comprehensive review and evaluation of the recovery program needs to occur at the end of the five years of implementation, to determine how effective recovery has been, and to set the process and framework for next phase of recovery. An external evaluator should be used for the termination review, preferably someone familiar with biodiversity conservation issues, but not involved in the recovery program.

Affected interests

Natural and stocked populations of Trout Cod occur in rivers and streams with a variety of managers and management tenures. Consequently, management is the responsibility of a range of agencies and organisations, while several community groups also have an interest in Trout Cod recovery (Table 1).

Table 1. Organisations with an interest in conservation of the Trout Cod including responsibility for management of Trout Cod habitat.

Organisation	Type
National/Regional	
Murray Darling Basin Commission	executive arm of the Murray-Darling Basin Ministerial Council
Victoria	
Department of Sustainability and Environment	State Government
Department of Primary Industries	State Government
Goulburn-Broken Catchment Management Authority	Regional Authority
North East Catchment Management Authority	Regional Authority
Goulburn-Murray Water	Regional Authority
Parks Victoria	State Government
VRFish, angling groups	Community Group
Native Fish Australia	Community Group
Environment Victoria	Community Group
New South Wales	
NSW Department of Primary Industries	State Government
Department of Environment and Climate Change	State Government
NSW Maritime	State Government
NSW Maritime	State Government
Murray Catchment Management Authority	Regional Authority
Murrumbidgee Catchment Management Authority Murray Catchment Management Authority	Regional Authority Regional Authority
Central west Catchment Management Authority Murrumbidgee Catchment Management Authority Murray Catchment Management Authority	Regional Authority Regional Authority Regional Authority
Central west Catchment Management Authority Murrumbidgee Catchment Management Authority	Regional Authority Regional Authority
Central west Catchment Management Authority	Regional Authority
South west Anglers Association	Community group
Institute of Freshwater Anglers South west Anglers Association	Community group Community group
Dept of Commerce (State Water) Institute of Freshwater Anglers South west Anglers Association	State Government Community group Community group
Australian Capital Territory Dept of Commerce (State Water) Institute of Freshwater Anglers	State Government Community group
Environment ACT Australian Capital Territory Dept of Commerce (State Water)	Territory Government State Government
ACTEW Environment ACT Australian Capital Territory	Territory Government Territory Government
UMCCC ACTEW Environment ACT	Regional Authority Territory Government Territory Government

UMCCCCTEW	Regional AuthorityTerritory Government
UMCCC	Regional Authority

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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	Biology & ecology								
1.1	Reproduction, recruitment	1	90%	\$75,000	\$75,000	\$75,000	\$0	\$0	\$225,000
1.2	Movement & dispersal	1	90%	\$100,000	\$100,000	\$100,000	\$0	\$0	\$300,000
1.3	Spawning stimuli	1	90%	\$75,000	\$75,000	\$75,000	\$0	\$0	\$225,000
1.4	Population trends	1	90%	\$0	\$0	\$120,000	\$0	\$120,000	\$240,000
2	Critical habitat								
2.1	Survey & map critical habitat	1	75%	\$0	\$0	\$50,000	\$50,000	\$50,000	\$150,000
3	Threatening processes								
3.1	Investigate threats	1	75%	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
3.2	Introduced fish	1	75%	\$0	\$0	\$50,000	\$50,000	\$50,000	\$150,000
3.3	Incidental capture	1	75%	\$0	\$0	\$0	\$25,000	\$25,000	\$50,000
3.4	Remove barriers	2	75%	\$25,000	\$25,000	\$35,000	\$45,000	\$45,000	\$175,000
4	Manage Murray R population								
4.1	Monitor range, status	1	100%	\$55,000	\$0	\$55,000	\$0	\$55,000	\$165,000
4.2	Monitor fish passage	1	100%	\$25,000	\$0	\$25,000	\$0	\$25,000	\$75,000
4.3	Population fragmentation	1	90%	\$15,000	\$0	\$15,000	\$0	\$15,000	\$45,000
4.4	Habitat assessment	2	90%	\$20,000	\$0	\$20,000	\$0	\$20,000	\$60,000
4.5	Fisheries compliance	1	100%	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000

Action	Description	Priority	Feasibility	Cost estimate					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total
5	Manage Seven Creeks								
5.1	Introduce new stock	1	90%	\$10,000	\$10,000	\$0	\$10,000	\$0	\$30,000
5.2	In-stream habitat enhancement	1	90%	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
5.3	Riparian protection	1	100%	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000
5.4	Environmental flows	1	90%	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
5.5	Prohibit recreational stocking	2	100%	\$0	\$0	\$0	\$0	\$0	\$0
5.6	Fisheries compliance	1	100%	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
6	Ovens River								
6.1	Reintroduction	1	100%	\$20,000	\$20,000	\$20,000	\$0	\$0	\$60,000
6.2	Effect of size at release	2	90%	\$0	\$10,000	\$10,000	\$10,000	\$0	\$30,000
6.3	Monitor survival, growth	1	90%	\$15,000	\$15,000	\$15,000	\$15,000	\$15,000	\$75,000
6.4	Assess available habitat	3	90%	\$0	\$0	\$10,000	\$10,000	\$10,000	\$30,000
6.5	Fisheries compliance	1	100%	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000
6.6	Prohibit recreational stocking	1	100%	\$0	\$0	\$0	\$0	\$0	\$0
7	Murrumbidgee River								
7.1	Monitor range, status	1	100%	\$55,000	\$0	\$55,000	\$0	\$55,000	\$165,000
7.2	Assess available habitat	3	90%	\$0	\$0	\$10,000	\$10,000	\$10,000	\$30,000
7.3	Fisheries compliance	1	100%	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000
8	Murrumbidgee & Cotter River								
8.1	Reintroduction	1	100%	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
8.2	Monitor survival, growth	1	90%	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
8.3	Prohibit recreational stocking	1	100%	\$0	\$0	\$0	\$0	\$0	\$0
8.4	Fisheries compliance	1	100%	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
9	Breed Trout Cod								
9.1	Captive populations	1	100%	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000	\$150,000

Action	Description	Priority	Feasibility	Cost estimate					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total
10	Establish new populations								
10.1	Monitor survival, growth	1	100%	\$10,000	\$10,000	\$10,000	\$0	\$0	\$30,000
10.2	New reintroduction sites	1	100%	\$0	\$0	\$25,000	\$25,000	\$0	\$50,000
11	Education & communication								
11.1	Encourage reporting	2	100%	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
11.2	Fishcare volunteers	2	100%	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
11.3	Cod identification	1	100%	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
11.4	Education kit	3	100%	\$5,000	\$5,000	\$0	\$0	\$0	\$10,000
11.5	Community involvement	3	100%	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
11.6	Publish research	2	100%	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
12	Trial recreational fishery								
12.1	Stakeholder liaison	2	100%	\$2,000	\$0	\$0	\$0	\$0	\$2,000
12.2	Identification of waters	2	90%	\$0	\$3,000	\$0	\$0	\$0	\$3,000
12.3	Fishing regulations	2	100%	\$0	\$0	\$2,000	\$0	\$0	\$2,000
12.4	Stocking Trout Cod	2	100%	\$0	\$0	\$20,000	\$20,000	\$20,000	\$60,000
12.5	Monitor outcomes	2	100%	\$0	\$0	\$0	\$0	\$0	\$0
12.6	Information provision	2	100%	\$0	\$0	\$0	\$0	\$0	\$0
13	Recovery implementation								
13.1	Recovery Team	1	100%	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$100,000
13.2	Establish regional recovery	2	100%	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000
13.3	Funding submissions	1	100%	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
13.4	Program evaluation	1	100%	\$0	\$0	\$0	\$0	\$6,000	\$6,000
Totals				\$739,000	\$580,000	\$1,029,000	\$502,000	\$753,000	\$3,543,000