Threatened and Potentially Threatened Freshwater Fishes of Coastal New South Wales and the Murray-Darling Basin

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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Those authorities and individuals who provided comments and attended the specialist workshop held to assess technical details of the species synopses are listed in Appendices 1 and 2.

Special thanks are extended to Jack Hannan for his skillful preparation of the fish illustrations, John Matthews for his help in creating maps of the study area and to Peter Unmack for his help in relation to the species distribution maps.

EXECUTIVE SUMMARY

This report, which has been prepared by the NSW Fisheries Office of Conservation for the Commonwealth Government's Fisheries Action Program and the World Wide Fund for Nature, reviews the biological and ecological characteristics and conservation status of thirty species of threatened and potentially threatened freshwater fishes inhabiting the rivers and streams of coastal New South Wales and the Murray-Darling Basin.

Work on this project commenced in April 2000 and was completed in January 2001. A specialist workshop was held in conjunction with the Annual Conference of the Australian Society for Fish Biology in Albury during August 2000, which brought together around a dozen experts from government and non-government organisations, private industry and academic institutions from Queensland, Victoria, South Australia and New South Wales with particular expertise in this area. The aims of this workshop were to discuss the proposed conservation status of as many of the identified species as possible, and to attempt to reach a consensus on a conservation status for each species. Information from the workshop discussions was incorporated into the individual synopses for each species wherever appropriate. Comments and advice were also sought from a wide range of other individuals and organisations with expertise in freshwater fishes and aquatic conservation ecology and management throughout the duration of this project.

Thirty species of the approximately 80 freshwater fish species found in this area of south-eastern Australia are analysed in this report. Using IUCN conservation categories and criteria, we have recommended listing these fishes as follows: 0 taxa as Extinct (EX), 2 taxa as Critically Endangered (CR), 8 taxa as Endangered (EN), 4 taxa as Vulnerable (VU), 0 taxa as Lower Risk conservation dependent (LR cd), 3 taxa as Lower Risk near threatened (LR nt), 11 taxa as Data Deficient (DD), and 2 taxa as Lower Risk least concern (LR lc).

The report highlights the conservation concerns for many of these threatened and potentially threatened freshwater fish species occurring in this area of south-eastern Australia. The main causes of declines in freshwater fishes in the area were identified as habitat degradation (due to various forms of water pollution, catchment development and agriculture-related activities), changes to water flow regimes, barriers to fish passage, the introduction of alien fish species, and fishing pressure.

This report recommends a number of actions to abate these threats in areas where significant aggregations of threatened and potentially threatened freshwater fish species have been confirmed to exist. These actions include the management of pest species, protection of instream cover and riparian vegetation, preservation of the genetic integrity of native fish stocks, removal of barriers to fish passage, and restoration of natural flow and temperature regimes in the coastal and inland rivers and streams of New South Wales and the Murray-Darling Basin.

It is hoped that this report, through the species conservation synopses and general discussion presented, will hopefully provide the impetus for more research, community action and funding in relation to the protection and conservation of threatened freshwater fishes and their known habitats in the freshwaters of coastal New South Wales and the Murray-Darling Basin.

NON-TECHNICAL SUMMARY

Title: Threatened and potentially threatened freshwater fishes of coastal New South Wales and the Murray-Darling Basin

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OBJECTIVES:

1. To determine the distribution and abundance status of threatened and potentially threatened freshwater fish species in the waters of coastal New South Wales and the Murray-Darling Basin.

2. To identify the 'hotspots' of freshwater fish diversity in coastal New South Wales and Murray-Darling Basin waters.

3. To identify the critical habitats for and key threatening processes affecting these threatened and potentially threatened freshwater fish species, and the opportunities available to address those conservation problems identified through threatened species legislation, community action and environmental engineering solutions.

SUMMARY:

1. This report reviews the basic biology, distribution and conservation status of 30 threatened and potentially threatened freshwater fish species from the waters of the Murray-Darling Basin and coastal New South Wales, and the threatening processes affecting them.

2. Confirmed recordings of these species from 1990 to the present have been collated in order to identify threatened fish diversity 'hotspots' within Murray-Darling Basin and coastal New South Wales waters.

3. Recommendations made to mitigate identified threatening processes in relation to threatened fishes found in these areas include changes to current threatened species listings, environmental engineering solutions and community actions.

1. INTRODUCTION

River ecosystems support much of Australia's aquatic biodiversity, as well as important recreational and commercial fisheries resources. The scarcity of rivers in this dry continent makes them all the more precious, and therefore requiring carefully executed conservation measures. In coastal New South Wales and the Murray-Darling Basin, as in other parts of Australia, troubling problems are emerging in relation to our river systems. There are conflicts over the use of water, frequent signs of environmental degradation, damaged catchments, declining natural resources, barriers to fish passage, and threatened aquatic biodiversity. Concern also arises from the increasing occurrence of various forms of pollution, declining fish stocks with ever more disjunct distributions, increasing distributions and abundances of alien fish species, and the lack of adequate tools for assessing and monitoring river health. Despite the level of interest, there is little factual information available on the nature and status of riverine biological resources in coastal New South Wales and Murray-Darling Basin waters. Responding to these problems, the Fisheries Action Program (FAP) and the World Wide Fund for Nature (WWF) contracted NSW Fisheries to compile a report on threatened and potentially threatened freshwater fish species present within the waters of coastal New South Wales and the Murray-Darling Basin, and from this to formulate a subset of non-technical advice highlighting freshwater fish diversity 'hotspots' and to suggest community projects and environmental engineering solutions in relation to the conservation and protection of priority species and locations. This project thus aims to educate as wide an audience as possible in outlining the currently known distributions of threatened fishes in coastal New South Wales and Murray-Darling Basin waters, illustrating the environmental problems facing these threatened species, and where possible suggesting solutions to reduce the impacts of threatening processes operating in their habitats.

1.1. Background to the Study

A total of around 80 species of freshwater fishes, including native, alien and some primarily upper estuarine species, have been recorded from New South Wales freshwater rivers and streams. The NSW Rivers Survey (Harris & Gehrke, 1997) collected 53 of these species, plus a further six primarily estuarine/marine species. Freshwater fishes in New South Wales waters form five distinct bioregional groupings (Gehrke & Harris, 2000). The montane fish community, which occurs in rivers above 700m elevation on both sides of the Great Dividing Range, is dominated by mountain galaxias and the alien species rainbow trout and brown trout, with long-finned and short-finned eels also present in the coastal montane areas. Below 700m, the eastern slopes and lowland rivers in the North Coast region are dominated by the long-finned eel, freshwater catfish, Australian smelt, Australian bass, freshwater mullet, and empire and striped gudgeons. The equivalent South Coast fish community is dominated by the long-finned eel, Australian smelt, Australian bass and empire and striped gudgeons. In the inland rivers, the fish community that inhabits the Darling River and its tributaries is dominated by carp, an alien species, with western carp gudgeon, bony herring and golden perch being the most dominant native species and gambusia another common alien species. Finally, the fish community of the Murray River system (including the Murray, Murrumbidgee and Lachlan Rivers and their tributaries) is also dominated by the introduced carp, with Macquarie perch, golden perch and Australian smelt being the most common native species, and rainbow trout and redfin perch present as additional common alien species. Because these communities are usually distributed over large areas through which many different fish species may migrate, those species encountered may vary among sites over time (Harris & Gehrke, 1997).

Freshwater fish communities in coastal New South Wales and Murray-Darling Basin waters are generally relatively simple, with relatively few species being present at any one trophic level. This means that if the population of any one species becomes depleted, then there is unlikely to be another similar species to take on the ecological role of the first species. Progressive loss of ecosystem functions is both a cause and a symptom of environmental degradation. Consequently, fish play a vital role in maintaining the ecological integrity of aquatic ecosystems (Harris & Silveira, 1999). Fish conservation is therefore a much bigger issue than simply ensuring the survival of species for their direct future exploitation by humans: it is an essential component to the rehabilitation of entire river systems on which humans depend.

Fish perform a number of important ecological functions in freshwater ecosystems (Gehrke, 2000). They occupy trophic levels from herbivores and detritivores through to carnivores at the top of the food chain. Fish prey on other animals and plants, and in turn may provide prey for other larger animal species. Fish have a role in maintaining water quality through top-down control, as planktivorous fish may graze zooplankton to low levels, which in turn may allow phytoplankton populations to grow rapidly and cause algal blooms. If carnivorous fish are present and feed on smaller planktivorous fish, they are able to control their numbers, maintaining zooplankton at sufficient densities to prevent algal blooms from developing. The interactions that determine food chain processes can be quite complex and are strongly influenced by nutrient availability and other environmental conditions (Gehrke & Harris, 1994). Migratory fish also play a role in transporting carbon and energy upstream in rivers, which partially counteracts the movement of other organisms, nutrients and materials washed downstream.

New South Wales' degraded riverine ecosystems are rapidly losing their biodiversity (Harris & Gehrke, 1997). Evidence of degradation is especially clear in the Murray River region, in rivers regulated for water supply, in inland lowland rivers, and in montane areas of coastal drainages. As indicators of river ecosystem condition, freshwater fishes appear to be in severe decline, with the NSW Rivers Survey collecting only 40 of the 53 native freshwater species expected to occur in New South Wales rivers. This means that 13 (25%) of the species which were expected to occur were not found during this extensive survey. To add to the concern, eight of these missing species (including at least three endangered and two vulnerable species) were previously recorded in a survey of these river systems carried out in the early 1980s (Llewellyn, 1983).

The Murray River system in particular appears to have become more depauperate in comparison with other rivers in inland regions, with only 5.5% of the total native fish catch coming from this region during the above NSW Rivers Survey. The failure to capture Murray cod from sites known to previously contain this species provides further evidence that the Murray cod population in the Murray River region has become more fragmented and patchy.

Many species that were once reasonably common across some of the regions surveyed, including the olive perchlet, freshwater catfish, short-finned eel and river blackfish, are now much more restricted in their distributions. In contrast, other species such as spangled perch and short-headed lamprey have recently been found outside their predicted ranges.

High levels of visible abnormalities were also found to occur in many species, with up to 25% of the fish caught during the NSW Rivers Survey showing evidence of parasites and other diseases (Harris & Gehrke, 1997).

Some conclusions based on the findings of the more recent of these river surveys carried out by NSW Fisheries are summarised below.

1.1.1. Threatened species

Recent surveys have confirmed the conservation status of the eleven freshwater fish species in New South Wales listed as threatened by the World Conservation Union (IUCN, 1994 Red List), and suggest that the conservation status of other, previously abundant, fishes also needs to be carefully reviewed (Harris & Gehrke, 1997).

1.1.2. Alien species

Eleven alien species introduced to Australia from other countries have been recorded from New South Wales rivers. Of these, only six (carp, goldfish, redfin perch, brown trout, rainbow trout and gambusia (which is also known as mosquitofish or plague minnow) were captured during recent surveys, constituting 18% of the total fish catch. Rivers in the Darling region had the highest numbers of alien species, but the Murray region had the highest proportion of individuals belonging to alien species (58%), compared to 25% in the Darling region and less than 10% in each of the two coastal regions (Faragher & Lintermans, 1997). Higher carp densities were found to be associated with habitats affected by human activities, in particular the effects of dams and agriculture (Driver *et al*., 1997). Carp were not found in any of the montane sites (above 700m altitude), but were present at all inland sites below 500m. In the coastal regions, carp were only found near major population centres.

1.1.3. Indicators of change

The Index of Biotic Integrity (IBI) is a measure of the condition of fish communities and, by extension, indicates the health of a particular river reach based on fish species richness, abundance, community structure, trophic complexity, and the health of individual fish. Values of the IBI calculated for New South Wales rivers show that fish communities present in the Murray region, and those in a large proportion of coastal montane rivers, are seriously degraded (Harris & Silveira, 1999). The IBI can be applied to repeated fish survey results to assess trends over time in fish communities and river health, and to guide management decisions for freshwater fish and their habitats.

1.1.4. Commercial and recreational fishing

The freshwater commercial fishery in New South Wales has been a low production fishery, providing only ~1% of the total commercial fish catches from New South Wales waters during 1995-96 (Reid *et al.*, 1997). Native species of commercial significance included Murray cod, golden perch, silver perch and freshwater catfish. These species have all suffered notable declines, both in recent years and for more than 50 years in the past, which can be partly attributed to commercial fishing. Declining catches of native species have been replaced to some extent by increasing catches of carp.

The fisheries resources of NSW support a large and growing recreational sector. A recent survey of angling in NSW suggests that approximately 30% of the state’s population fishes at least once a year. This indicates that there are about two million recreational anglers in the State, many of whom fish for Murray cod, golden perch, silver perch, freshwater catfish and Australian bass, as well as rainbow trout and brown trout, in the State’s fresh waters. Accurate figures on recreational catches are not available for freshwater species, but the pressure on some populations from anglers is strong.

1.1.5. Recent trends

The depressed abundance of native species and the dominance of inland fish communities by carp seem likely to continue unless a marked improvement in the condition of the Murray-Darling Basin’s rivers occurs on a wide scale (Harris & Gehrke, 1997). Variability in environmental conditions from year to year makes it difficult to identify consistent trends from short-term data sets. Recently, however, widespread rainfall in late 1998 in both coastal and inland catchments has led to strong recruitment of native fish species.

1.1.6. Current management

Management of freshwater fish in New South Wales currently focuses on species targeted by commercial and recreational fisheries, the development and implementation of recovery plans for threatened species, and habitat protection and rehabilitation. There is a role for greater focus on managing fish communities in line with the ecosystem focus provided by large-scale catchment management programs (Gehrke & Harris, 2000).

The commercial fishery for native fish in New South Wales has recently been phased out to reduce pressure on declining fish populations, with incentives to transfer as much fishing effort as possible to carp. Recent policy initiatives such as the NSW Water Reforms, State Weirs Policy, State Fishways Program and the State Wetlands Policy address in part the need for habitat rehabilitation to reduce the impacts of carp and to restore native fish habitats.

A freshwater angling license was recently introduced in New South Wales, funds from which are contributing towards the costs of management and research on freshwater fish species. Fishing restrictions, including closures and gear, bag and size limits, are imposed for selected fisheries and reviewed periodically. The NSW Angling Catch Database is a tool for stock assessment based on angler catches, and provides feedback on the effectiveness of changes in fishing regulations.

NSW Fisheries has also produced a booklet outlining fish conservation and aquatic habitat policies and guidelines to protect both aquatic species and their habitats, the latter in recognition of the role of habitat degradation in the decline of native species (Smith & Pollard, 2000). Habitat protection plans have also been developed to provide added protection for key habitats and to conserve biodiversity.

Pest species such as carp have serious implications for the conservation of native fish species. Impacts of carp, and opportunities for carp management, are outlined in detail by Koehn *et al.* (2000).

The NSW Water Reforms represent a major initiative to rehabilitate this State's rivers. River flow and water quality objectives have been established for major river systems, while the remaining rivers have been listed according to their conservation value and the level of stress to which they are subjected.

The Fisheries Management Act 1994 integrates the conservation of threatened species into development control processes under the Environmental Planning and Assessment Act 1979. The effect of a development or activity on threatened species must be considered by a consent and/or determining authority (e.g. a State government agency or local council). Where there is likely to be a significant effect on a threatened species, a detailed Species Impact Statement (SIS) must be prepared. The Fisheries Management Act also imposes strict penalties (up to $220,000 and 2 years imprisonment) for harming a threatened species, population or community or their habitat without appropriate authority. There are also penalties for buying, selling or possessing threatened species. Recovery plans must be prepared for all threatened species listed under this act. Recovery plans are designed to promote the recovery of a threatened species to a position of viability in nature. Part 7a of the NSW Fisheries Management Act 1994 (1997 amendments) contains provisions for the conservation of threatened species, populations and ecological communities of fish and marine vegetation, and also recognises critical fish habitats and key threatening processes. Four freshwater fish species have been listed as endangered and three as vulnerable to date in New South wales waters, with procedures in place for further nominations. Recovery plans are currently being developed for most of these listed species.

1.1.7. Recent NSW Fisheries research

The NSW Rivers Survey has been the largest, most comprehensive assessment of freshwater fish communities ever undertaken in Australia. This survey began in winter 1994, and the last assessment was completed early in 1999. The survey studied the distribution, abundance and diversity of both native and introduced freshwater fishes (e.g. carp), investigated the ecological effects of river regulation, developed a method for monitoring river health based on fish community assessments, and provided a standardised survey structure for use in other studies (Harris & Gehrke, 1997).

A comprehensive analysis of freshwater commercial fisheries catches was also recently completed, examining historical fisheries data to identify trends in catch and effort, and the species composition and geographic distribution of the catch in the New South Wales inland fishery (Reid *et al*., 1997). Several studies have also been completed or are currently investigating aspects of fish migration and fishway development. Current projects are also investigating the effects of thermal pollution from dams, the benefits of environmental flows, methods for the control of carp and managing their impacts, recruitment ecology of native fish, and threatened species assessments.

1.1.8. Future research needs

With the increasing focus at national and state levels on water reforms, there is a pressing need to develop methods for predicting the benefits of environmental flows, and to demonstrate the changes that occur in fish communities and river ecosystems following the implementation of enhanced stream flows.

The NSW Rivers Survey also identified trends in the incidence of diseased fish, but to date there have not been any detailed assessments of diseases in wild fish populations. In view of the multiple programs being implemented to improve river health, a detailed study of the distribution and severity of fish diseases would be valuable.

There is alarming evidence from overseas countries that fish stocking has had serious detrimental genetic and ecological impacts on wild fish populations. Better knowledge of the actual and potential impacts of this activity is required to develop appropriate strategies to manage both authorised and unauthorised stockings.

It is particularly pertinent to this report that rare and threatened species are often not collected in more general fish surveys. This is thought to be because sound survey design often requires sites to be selected without bias; however, to maximise the likelihood of collecting rare or threatened species, sampling bias is often required to select specific habitats where these species are known or thought to live. Consequently, information needed to manage rare and threatened species often needs to be collected by highly focused sampling directly targeted at the species concerned. This approach can make threatened species surveys relatively expensive compared to more general surveys, but the cost of not collecting appropriate information may include the extinction of species as a result of mismanagement. For this reason, it is critically important to fund and conduct research on the distribution and abundance of rare and threatened species so that their declines can be detected, monitored and reversed.

The distinction between rare species and threatened species also needs to be clarified. Even a casual observer will recognise that not all species are equally abundant. Large predators at the top of the food chain will almost always be less numerous than their prey. Species with apparently similar diets may have different environmental tolerances, or different habitat requirements, resulting in each species having different distributions and or natural levels of abundance. It is to be expected then, that under natural conditions even specialist researchers may rarely encounter some species. A species' behaviour can also influence human perceptions of rarity, with, for instance, nocturnal species appearing quite rare during the daytime. Secretive or cryptic species may in fact be relatively abundant, but their behaviour means that most collectors might not be aware of their presence. Under these conditions, rare species may be in no immediate threat of extinction simply because they are caught or observed only infrequently.

In contrast, some extremely abundant species may be undergoing serious declines without their peril being detected, simply because they are still relatively abundant. The ability to distinguish between rare species and threatened species requires information to be collected over time to detect trends in populations. However, in the case of many species discussed in this report, there is insufficient information available to determine with confidence whether a species is rare, threatened, or neither. For practical purposes, therefore, we have only classified species as "threatened" where they can be formally recognised as such (i.e. as critically endangered, endangered or vulnerable), and used an appropriate multi-level classification for those regarded as potentially threatened. It is likely that some of the species considered may only be rare, not threatened, but further study is required to determine their true status.

1.2. Aims and Objectives of the Study

Threatened and potentially threatened fish species in coastal New South Wales and Murray-Darling Basin waters have until recently received little detailed attention. Together, NSW Fisheries, with financial support from the World Wide Fund for Nature and the Commonwealth Government's Fisheries Action Program, have therefore aimed to investigate:

- the distribution and abundance status of threatened and potentially threatened freshwater fish species in this area;
- the 'hotspots' of freshwater fish diversity in this area;
- the habitats of and key threatening processes affecting these threatened and potentially threatened fish species; and
- the opportunities available to address those conservation problems identified through both community action and environmental engineering solutions and changes to current conservation status listings.

This project focuses primarily upon riverine environments, rather than major impoundments, particularly with regard to recommendations in relation to current conservation listings and the cessation of stocking of alien species in areas supporting listed threatened species or endangered ecological communities.

2. METHODS

2.1. Selection of Taxa for Inclusion

The bases for the consideration and inclusion of individual fish species in this report are outlined in Table 1, and these species include those listed in:

- the IUCN's 2000 Red List of Threatened Animals,
- the ASFB's conservation status listings of Australian fishes,
- the Australian Commonwealth Government's Threatened Species List,
- Australian State & Territory Threatened and Protected Species Lists, and
- other Australian freshwater fishes nominated as being threatened or potentially threatened by the various Australian ichthyological experts who were consulted during the study.

Table 1: Reasons for inclusion of individual species in this report.

Species Name	Common Name	Reasons for Inclusion
Mordacia praecox	Non-parasitic lamprey	Very restricted distribution in NSW south coast streams. Threatened by barriers to migration and habitat degradation.
Anguilla australis	Short-finned eel	Reduced distribution and abundance throughout the northern part of its range.
Potamalosa richmondia	Freshwater herring	Now not common in many rivers where it was previously thought to commonly occur. Numbers seem to fluctuate widely.
Galaxias brevipinnis	Climbing galaxias	In NSW, fragmented populations remain in only a few suitable habitats.
Galaxias fuscus	Barred galaxias	Disjunct distribution, restricted to the Goulburn River system in Victoria. Taxonomic confusion with other galaxiids.
Galaxias maculatus	Common galaxias	Not found recently in locations where it was previously known to be common in NSW.
Galaxias olidus	Mountain galaxias	Highly fragmented distribution, often occurring in only small isolated populations.
Galaxias rostratus	Murray jollytail	Distribution is now restricted and intermittent in the Murray region.
Prototroctes maraena	Australian grayling	Only surviving species in this family, now found only on the southern coastline in NSW.
Tandanus tandanus	Freshwater catfish	Reduced distribution and abundance throughout the southern reaches of its known range.

Craterocephalus amniculus	Darling hardyhead	Reduced abundance and distribution. Taxonomic confusion with other hardyhead species.
Craterocephalus fluviatilis	Murray hardyhead	Greatly reduced abundance and distribution, now limited to only a few sites in the Murray region. Taxonomic confusion with other hardyhead species.
Craterocephalus stercusmuscarum var. *fulvus*	Non-speckled hardyhead	Now considered to be rare in the southern parts of its known range. Taxonomic confusion with other hardyhead species.
Melanotaenia fluviatilis	Crimson-spotted rainbowfish	Reduced abundance and scattered distribution.
Rhadinocentrus ornatus	Ornate rainbowfish	Patchy, localised distribution in NSW north coast wallum stream habitats.
Ambassis agassizii	Olive perchlet	Reduced abundance and distribution within its southern range in the Murray-Darling Basin.
Maccullochella ikei	Eastern cod	Populations restricted to isolated tributaries of the Clarence River. Now considered extinct in the Richmond River except for stocked fish.
Maccullochella macquariensis	Trout cod	Only known surviving wild population is in the Murray River below Yarrawonga.
Maccullochella peelii	Murray cod	Has declined dramatically in range and abundance, now relatively uncommon in many areas.
Macquaria ambigua	Golden perch	Although relatively common throughout the Murray-Darling system, possibly between 3 and 5 different sub-species may exist in different areas.
Macquaria australasica	Macquarie perch	Populations of the western drainage fish are now restricted, fragmented, and absent from much of the former known range.
Bidyanus bidyanus	Silver perch	Only one remaining abundant, self-sustaining inland population known south of the Queensland border – between Torrumbarry and Euston Weirs on the Murray River.
Bidyanus welchi	Welch's grunter	Not recently recorded in NSW waters despite being previously known from the Bulloo and Bancannia internal drainages. Taxonomic uncertainty over the species' validity.

Leiopotherapon unicolor	Spangled perch	Restricted to the warmer reaches of the Murray-Darling River systems. Southern extent of coastal range is limited to the Clarence River system.
Nannoperca australis	Southern pygmy perch	Large scale reductions in range since European settlement, probably due to habitat loss and predation. Absent from much of the Murrumbidgee and Murray Rivers systems.
Nannoperca oxleyana	Oxleyan pygmy perch	Within NSW it is now only known to be present at a few disjunct locations on the far north coast.
Gadopsis bispinosus	Two-spined blackfish	Reduced distribution and abundance in south-eastern NSW.
Gadopsis marmoratus	River blackfish	Restricted to altitudes above 150m in the Murray-Darling river system in NSW. Seems susceptible to increased sediment loads. Rare in many areas where it was previously known to be common.
Pseudaphritis urvillii	Congolli	Barriers to migration have probably led to reduced upstream abundance in NSW south coast rivers.
Mogurnda adspersa	Southern purple-spotted gudgeon	Reduced abundance and distribution, especially throughout the southern portion of the Murray-Darling Basin. Coastal distribution in NSW is limited to far north coast streams.

2.2. Synthesis of Available Information

Details pertaining to individual species, as well as information relating to broader areas of concern, have been synthesised into species conservation synopses. These are used to summarise details concerning the most important aspects of the biology, ecology, distribution and abundance, conservation status, reasons for decline, and management actions required for each species. Current species locality data were obtained predominantly from the results of the recent NSW Rivers Survey (Harris & Gehrke, 1997) and recent Australian Museum records. However, the results of smaller surveys, mainly from other projects carried out by NSW Fisheries and independent consulting services, were also used to provide further details of recent fish distribution localities. Only the results from surveys conducted since 1990 have been used to illustrate current distributional data. Historical distributional data are based on maps presented in McDowall (1996). Environment Australia also provided distribution maps for some threatened species in the Murray-Darling Basin. Commercial catch records from NSW Fisheries have also assisted in determining the relative abundances of targeted fish species in the inland commercial fishery and broad indications of their distributions.

2.3. Specialist Workshop and Consultation

Additional technical advice and comments were sought from members of the Australian Society for Fish Biology (ASFB) at a specialist workshop held in conjunction with the annual meeting of the Society's Threatened Fishes Committee, on which the Project Leader (D. Pollard) is the New South Wales representative. Technical advice relating to the conservation or biology of freshwater fishes in coastal New South Wales and Murray-Darling Basin waters was also sought from numerous other scientists involved in freshwater fish biology and habitat research projects within NSW Fisheries and other specialists working on particular species from various other research organisations throughout Australia.

2.4. Collaboration with Stakeholders

The Inland Rivers Network, NSW Nature Conservation Council and World Wide Fund for Nature comprise a partnership representing the main conservation stakeholders with interests in our rivers and their fauna. Organisations represented through the Inland Rivers Network include not only the NSW Nature Conservation Council, but also the Australian Conservation Foundation, National Parks Association of NSW, Coast and Wetlands Society, Friends of the Earth and Total Environment Centre.

3. CONSERVATION CATEGORIES AND CRITERIA

3.1. History of Conservation Categories and Criteria

Significant discussion at the ASFB's 1985 Threatened Fishes Workshop (Harris, 1987) centred on the categories of threat and the criteria that defined them. Although the classification scheme adopted and used by the ASFB was similar to that of the International Union for the Conservation of Nature (IUCN) at that time, it was not identical. It was considered that some fish conservation issues in Australia required more specific definition. A seven-stage scheme of classification (Table 2 and Appendices 7 & 8) was adopted, with four categories of threatened species requiring action. These included Endangered, Vulnerable, Potentially Threatened and Indeterminate, with the last category covering species having insufficient data available to place them specifically in one of the first three categories, but which were likely to fall into one of them.

One of the first organisations to develop conservation categories and criteria was the IUCN, now known as the World Conservation Union. The various editions of the IUCN's Red Lists of Threatened Species through the 1994 edition utilised a set of categories and criteria that was considered by some to be too subjective. There were international concerns that these categories and criteria may have been generally unsuitable for most invertebrates and fishes, although suitable for larger terrestrial vertebrates such as elephants and kangaroos. As a result, a new set of categories that utilised primarily numerical criteria involving population sizes, percentage declines, and/or distribution areas was proposed in 1994 and utilised for the 1996 Red List. The IUCN held a workshop specifically on marine fish in 1996 that identified problems in considering the conservation status of many marine species (Hudson & Mace, 1996). From the results of this workshop, the IUCN decided to re-consider the applicability of its criteria in general. In this regard a series of workshops was subsequently held to discuss the practical use of the IUCN criteria. The applicability of these numerical criteria, especially for fishes that are targets of managed fisheries, continues to be discussed.

An analysis of both the ASFB's and IUCN's threatened conservation categories indicated that the two were roughly one step out of phase, with the ASFB's highest (Endangered) conservation category roughly corresponding to the IUCN's highest (Critically Endangered) category (Table 2).

Table 2: Extinction Risk Categories used by the IUCN and the ASFB.

CATEGORY TYPE	ASFB	IUCN
Threatened	Extinct	Extinct
	Endangered	Critically Endangered
	Vulnerable	Endangered
	Potentially Threatened	Vulnerable
	Indeterminate	
Lower Risk	Restricted	
		Near Threatened
		Conservation Dependent
	Uncertain Status	Data Deficient
		Least Concern

4. SPECIES CONSERVATION SYNOPSES

4.1. Species Conservation Synopses Arranged in Phylogenetic Order

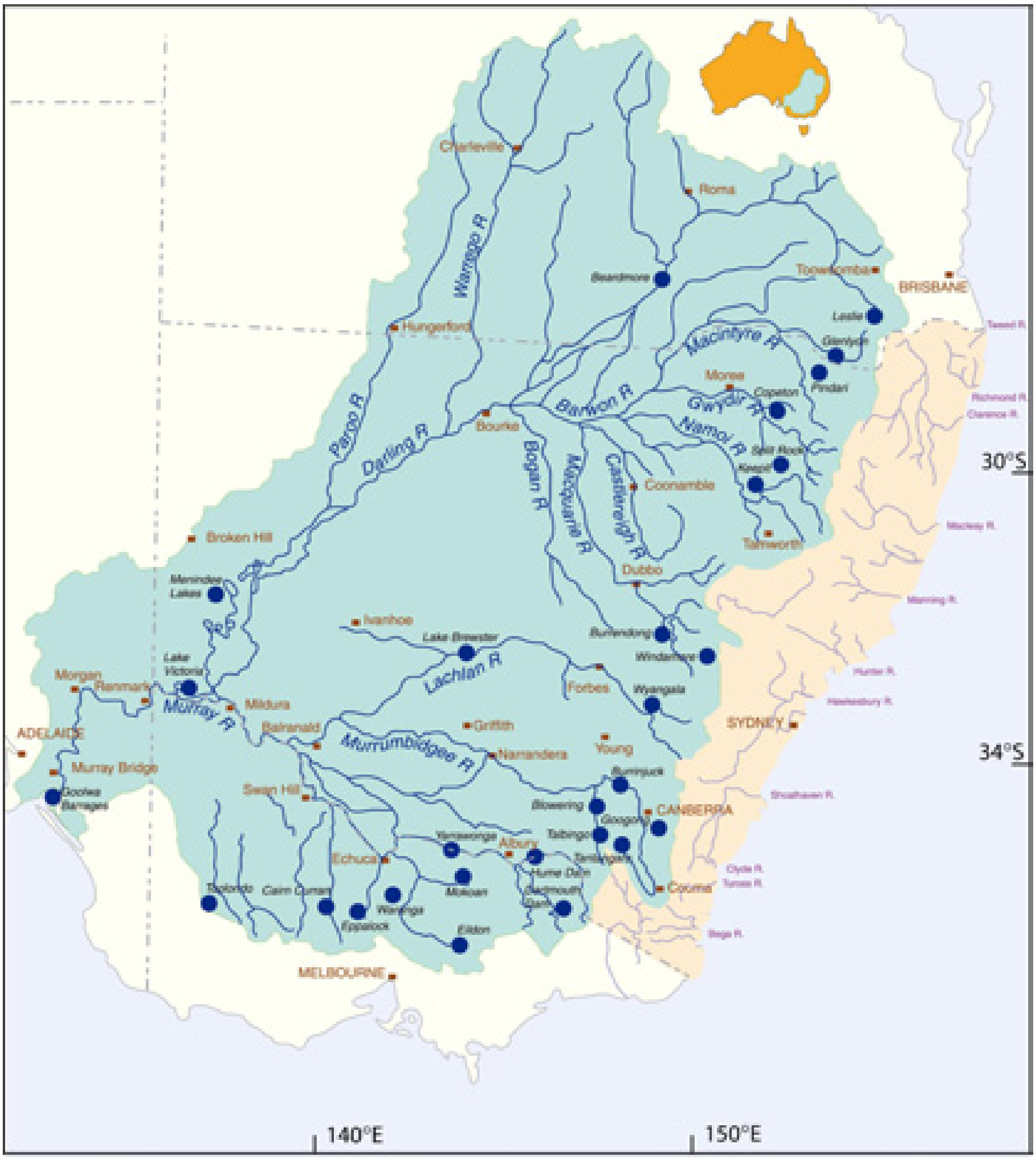
Individual conservation synopses have been prepared for each species considered using both published scientific literature and other available information. These synopses cover aspects of the species' biology, ecology, distribution and current conservation status, and consider management options available to address any identified threatening processes. Some changes and additions to the current conservation status listings of the species studied have also been suggested based on this information.

Illustrations of fish species have been composed using detailed descriptions of the species as well as colour photographs, and can thus be used as an identification tool.

Distribution maps have been prepared for all of the species covered in this report. Historical distributions are based on the maps presented in "Freshwater Fishes of South-eastern Australia" (McDowall, 1996), and are indicated by blue shading. Corrections to these known historical distributions were based on "Biogeography of Australian Freshwater Fishes" (Unmack, 2000) and are indicated by black cross-hatching for deletions and blue dashes around extensions of the previously known natural or historical distributions. Unconfirmed or questionable extensions to the natural or historical distributions are indicated on the maps by question marks. Confirmed locality records for these species since 1990 are indicated by red dots (records that have been confirmed as stocked populations, however, have not been included).

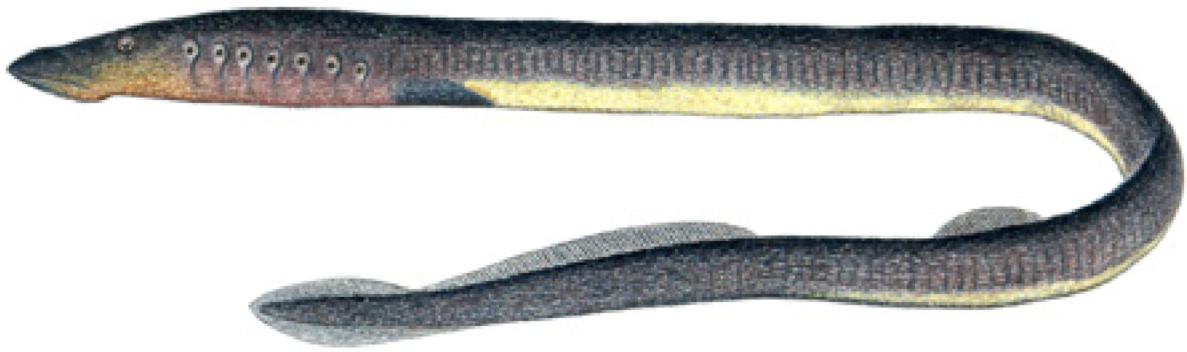
The geographical area covered in this report is shown in Figure1.

Figure 1. The geographical area covered in this report, including the entire Murray Darling Basin system and coastal rivers of New South Wales, together with some of the main localities and major rivers discussed in the text (● indicates localities of major dams and weirs).



Non-parasitic lamprey

Family Name:	Scientific Name:	Other Common Name(s):
Mordaciidae	*Mordacia praecox* Potter, 1968	N/A



Drawing by Jack Hannan

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC
Vulnerable (D2)	Vulnerable	Not Listed	Not Listed	Not Listed

Reasons for Concern:
The non-parasitic lamprey has a very restricted distribution in New South Wales south coast streams. This species is threatened by barriers to migration and habitat degradation (Harris & Gehrke, 1997) and uncertain taxonomy can make positive identification of ammocoete larvae of this species difficult.

Distribution:
Mordacia praecox is known from the Moruya River, Tuross River (Wager & Jackson, 1993), Bega River and Wallagaraugh River in southern coastal New South Wales (Harris & Gehrke, 1997). Locations in Victoria remain to be substantiated due to confusion of ammocoetes (i.e. larvae) with those of the parasitic sister species *Mordacia mordax* (Potter, 1996). Surveys during 1994-96 found only a few specimens in the Moruya, Tuross and Bega River basins (Harris & Gehrke, 1997). Larger numbers were found in the Wallagaraugh River near Eden, New South Wales, which was outside this species' predicted distribution range (see Potter 1996) (Harris & Gehrke, 1997).

Australian Museum Records – 12 specimens (85-152mm SL), ranging in distribution from the Moruya River (35° 54' S, 150° 02' E) southwards to the Wallagaraugh River (37° 21' S, 149° 42' E) near Eden in New South Wales; collected between circa 1965 and 1996.

Habitat:
Mordacia praecox is restricted to flowing freshwater and estuarine habitats, including coastal rivers and streams.

Biology & Behaviour:
The non-parasitic lamprey has an extended larval stage (Potter, 1996), and unlike the closely related *Mordacia mordax* lacks a parasitic stage (Michaelis, 1985). The ammocoete (larval) stage lasts for three years (Allen, 1989), with metamorphosis commencing in October or early November (Hughes & Potter, 1969). In the Moruya River, ammocoetes typically metamorphose at 130-160mm in length (Potter, 1996). After the beginning of metamorphosis, *M. praecox* spends at least 9 months in the river system before reaching sexual maturity (Hughes & Potter, 1968), the macrophthalmia (i.e. early adult) life-history stage presumably migrating upstream in April (Allen, 1989). From about July, nearly mature oocytes can be observed through the body wall. Spawning occurs between August and October, with fecundity being comparatively lower than in *M. mordax*, comprising between 326-675 eggs. This is attributable to the smaller size of mature adult *M. praecox* compared to *M. mordax* (Hughes & Potter, 1968).

Diet:
Non-parasitic lamprey larvae feed on microorganisms filtered out of the soft bottom mud which they inhabit (Allen, 1989). Although the food of the adult form has not been described, the adults are considered to be non-parasitic (Llewellyn, 1983).

Size:
Adult non-parasitic lampreys generally range in length from 100-170mm (Hubbs & Potter, 1971). Ammocoetes and adults have been measured to 172mm, with males being distinctly larger than females (Potter, 1996).

Reasons for Decline:
Habitat destruction and barriers to migration have been the key causes of the decline of *Mordacia praecox* (Harris & Gehrke, 1997). This species may also be under threat from local agricultural land-use practices.

Protected Areas in which the Species Occurs:
Deua National Park (NSW)
Wadbilliga National Park (NSW)

Recovery Objectives / Management Actions Required:
It is necessary to determine the extent of this species' current distribution and abundance in southern New South Wales and possibly northern Victorian waters. Monitoring programs focused on these separate populations need to be initiated to accurately assess population numbers. Further information on biological and environmental requirements is needed to help identify any threatening processes (Wager & Jackson, 1993).

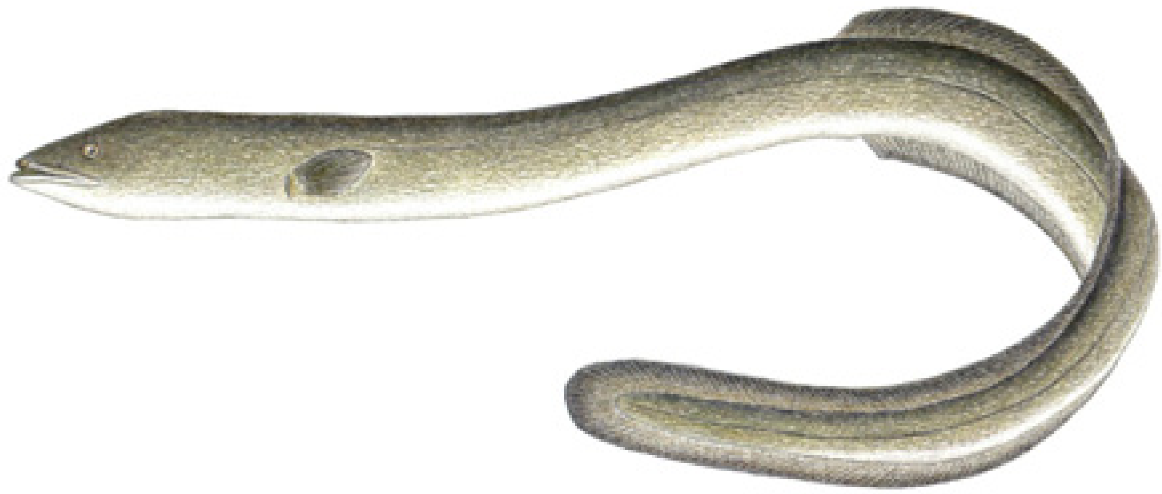
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC
No Change	No Change	Vulnerable	Vulnerable	Further studies are required

References:
Allen, 1989; Harris & Gehrke, 1997; Hubbs & Potter, 1971; Hughes & Potter, 1968; Hughes & Potter, 1969; Llewellyn, 1983; Michaelis, 1985; Potter, 1996; Wager & Jackson, 1993.

Short-finned eel

Family Name:	Scientific Name:	Other Common Name(s):
Anguillidae	*Anguilla australis* Richardson, 1841	N/A



Drawing by Jack Hannan

Synonyms:
Anguilla australis australis Richardson, 1841.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Anguilla australis has reduced distribution and abundance throughout its northern range. Surveys conducted from 1960 to 1976 in northern New South Wales collected this species at only six sites (Llewellyn, 1983). Extensive surveys carried out from 1994 to 1996 collected only a single specimen from the north coast rivers of New South Wales (Harris & Gehrke, 1997).

Distribution:
Adult *Anguilla australis* occur in temperate south-eastern Australian (from eastern South Australia to southern Queensland) and Tasmanian coastal drainages (Pollard *et al.,* 1980). Large quantities of glass eels of this species, however, have been collected from central and southern Queensland (B.Pease, pers. comm. 2000). It also occurs in streams on Flinders and Vansittart Islands in Bass Strait and is widespread in coastal and lowland rivers in Tasmania. It is also widespread on Norfolk Island, Lord Howe Island and the Chatham Islands, as well as in New Zealand (Beumer, 1996) and New Caledonia.

Australian Museum Records – 123 records (7-840mm SL), ranging in distribution from McCulloch Reef (17^o 18' S) in Queensland (leptocephalus larvae) southwards to Coffee Creek (43^o 03' S) in Tasmania; collected between circa 1884 and 1999.

Habitat:
Anguilla australis occurs during different stages of its growth cycle in a variety of habitats ranging from coastal rivers and streams, lakes and swamps, to estuaries and the open sea (Cadwallader & Backhouse, 1983).

Biology & Behaviour:
The life cycle of the Australian short-finned eel is strictly catadromous, the adults living in coastal freshwaters and migrating to the sea as 'silver eels' to spawn in deep water in the Coral Sea (Pollard *et al.*, 1980). The adult spawning migration probably occurs around March and April (Llewellyn, 1983). Females from 520 to 930mm long have been found to contain between 0.46 and 3.06 million eggs (Cadwallader & Backhouse, 1983). Adults presumably die after spawning, and after hatching the leptocephalus (transparent leaf-shaped') larvae are swept southwards via the East Australia Current, where they are deposited along the coastlines of eastern Australia, New Zealand, New Caledonia, Lord Howe Island and Norfolk Island. Attracted to freshwater outflows from coastal rivers, short-finned eels metamorphose into their typical cylindrical adult body shape (Pollard *et al.,* 1980), which is accompanied by a reduction in width and length, loss of the teeth, and cessation of feeding for a short time (Cadwallader & Backhouse, 1983). Entering estuarine waters as glass eels (in New South Wales, from April through to September) (B.Pease, pers. comm. 2000), short-finned eels are at least 200 to 300 days old and 50-70mm long. They migrate to the upper reaches of estuaries by selectively using flood tides, seeking shelter in mud and amongst vegetation when not travelling. During this time they rapidly develop into fully pigmented elvers, grow new teeth, and acclimatise to lower salinity levels. Further migrations into the upper freshwater reaches of streams and associated lakes and swamps are usually made soon after their primary migration from the sea (Cadwallader & Backhouse, 1983), or when conditions are suitable. Growth rates are apparently faster in still or slow-flowing waters (Pollard *et al.,* 1980).

Diet:
Short-finned eels are nocturnal, opportunistic carnivores, feeding on a wide range of aquatic organisms such as crustaceans, molluscs and fishes (Cadwallader & Backhouse, 1983).

Size:
Angullia australis grows to over 1m in length and 3kg in weight (Cadwallader & Backhouse, 1983).

Reasons for Decline:
Bishop and Bell (1978) suggested that the construction of dams and weirs on coastal streams has prevented or limited the upstream movements of elvers. Most eels have some ability to climb over or around weirs and dams, but structures that slow their upstream migrations increase the risk of predation and reduce the number of eels able to reach upstream habitats. High barriers would invariably lead to significant effects on eel stocks in the upstream reaches (Pollard *et al.*, 1980; Gehrke *et al.,* 2001). Obstructed migration also leads to large congregations of glass eels and elvers trapped at the bases of the obstructions, allowing heavy predation upon them by birds (Cadwallader & Backhouse, 1983) and other fishes (including long-finned eels). This species forms a component of the commercial fisheries along the coastlines of Victoria and southern New South Wales, and may be under pressure from increasing demand for imported eels in overseas markets. Small, but increasing, quantities of glass eels of this species are being harvested from estuaries in New South Wales as seed stock for the Australian eel aquaculture industry (B.Pease, pers. comm. 2000).

Protected Areas in which the Species Occurs:
Watagon State Forest (NSW)
Heaton State Forest (NSW)
Ourimbah State Forest (NSW)
McPherson State Forest (NSW)
Putty State Forest (NSW)
Pokolbin State Forest (NSW)
Olney State Forest (NSW)
Kosciusko National Park (NSW)

Recovery Objectives / Management Actions Required:
Management actions associated with improvements to fish passage, especially at sites which have barriers restricting movement of elvers and glass eels directly from marine to freshwater habitats, should have a positive effect on the recruitment levels of this species.

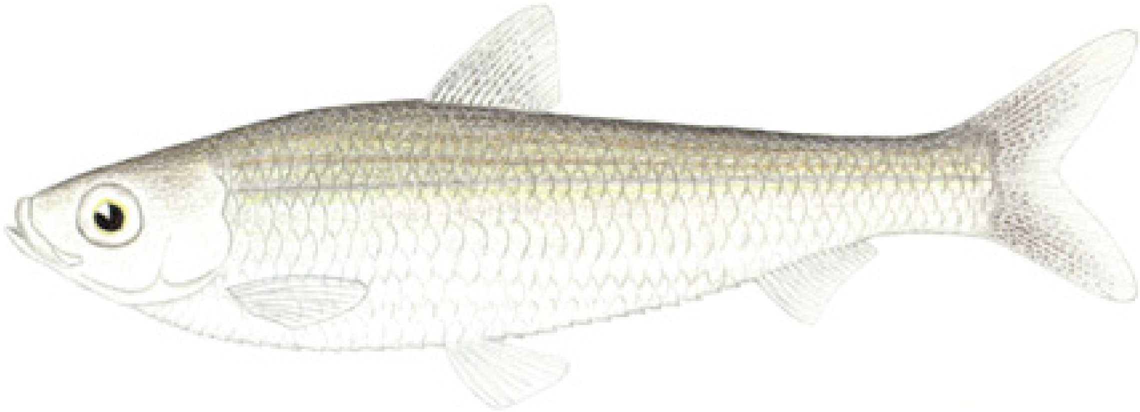
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD
Lower Risk (Least Concern)	No Change	No Change	No Change	No Change	No Change

References:
Beumer, 1996; Cadwallader & Backhouse, 1983; Gehrke *et al.*, 2001; Harris & Gehrke, 1997; Llewellyn, 1983; B.Pease, pers. comm. 2000; Pollard *et al.*, 1980.

Freshwater herring

Family Name:	Scientific Name:	Other Common Name(s):
Clupeidae	*Potamalosa richmondia* (Macleay, 1879)	Nepean herring



Drawing by Jack Hannan

Synonyms:
Clupea richmondia Macleay, 1879; *Potamalosa antiqua* Ogilby, 1897.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD
Not Listed	Not Listed	Not Listed	Not Listed	Data Deficient	Not Listed

Reasons for Concern:
The freshwater herring is now not common in many rivers where it was previously thought to commonly occur. Numbers of freshwater herring seem to fluctuate widely (Harris & Gehrke, 1997; Gehrke *et al.*, 2001).

Distribution:
The range of the freshwater herring is restricted to the South-East Coast Drainage Division, particularly in rivers to the north of Sydney (Merrick & Schmida, 1984). The New South Wales Rivers Survey located a single specimen on the south coast, but most specimens were located along the north coast of New South Wales (Harris & Gehrke, 1997). More recently, however this species has been recorded in relatively large numbers in the Shoalhaven River downstream of Tallowa Dam (Gehrke *et al.*, 2001) and a single specimen has been recorded from eastern Victoria.

Australian Museum Records – 43 records (24-267mm SL), ranging in distribution from Leycester Creek (28^{o} 48' S) near Lismore southwards to the Clarence River (35^{o} 36' S) in northern New South

Wales; collected between circa 1885 and 1997. This species has been recorded from only a single drainage (in East-Gippsland) south of the Clyde River (Unmack, 2000).

Habitat:
Briggs (1980) described freshwater herring populations as inhabiting a wide variety of aquatic habitats, though they seem to prefer slightly turbid (Llewellyn, 1983) to clear streams with a moderate flow (Merrick & Schmida, 1984).

Biology & Behaviour:
Ripe adults of both sexes are reported to move to estuarine areas in winter for spawning and it is presumed that the young subsequently migrate upstream (Merrick & Schmida, 1984). Local populations quickly become extinct upstream of barriers to fish passage. Eggs and exact breeding areas are not known (Llewellyn, 1983).

Diet:
Potamalosa richmondia is a carnivore, feeding on insects, shrimps and worms (Briggs & McDowall, 1996).

Size:
Potamalosa richmondia is known to grow to 320mm, but most specimens caught are generally only around half this size (Briggs & McDowall, 1996).

Reasons for Decline:
Although it is not common in many rivers, and its numbers often seem to fluctuate, this species is not considered to be under any serious threat (Briggs & McDowall, 1996). *Potamalosa richmondia* may be under threat from predation and competition with alien fish species. Agriculture and grazing on north coast streams may have contributed to the decline of this species by reducing the water quality and introducing pesticides, which reduce the abundance of this species' invertebrate prey. The species' upstream distribution is, however, seriously reduced by dams and weirs blocking migrations. Weirs or barrages near the salt water limit in estuaries may result in the total disappearance of freshwater herring upstream.

Protected Areas in which the Species Occurs:
This species occurs in various national parks and nature reserves situated along the coastline of New South Wales.

Recovery Objectives / Management Actions Required:
Further study needs to be conducted in order to establish the extent of its current distribution and the key causes of any declines. The small size of this species enables heavy predation by both native and alien fish species, and therefore the eradication and/or control of alien species should significantly improve its chances of survival. Restoration of fish passage is critical to maintain its distribution in impounded river systems.

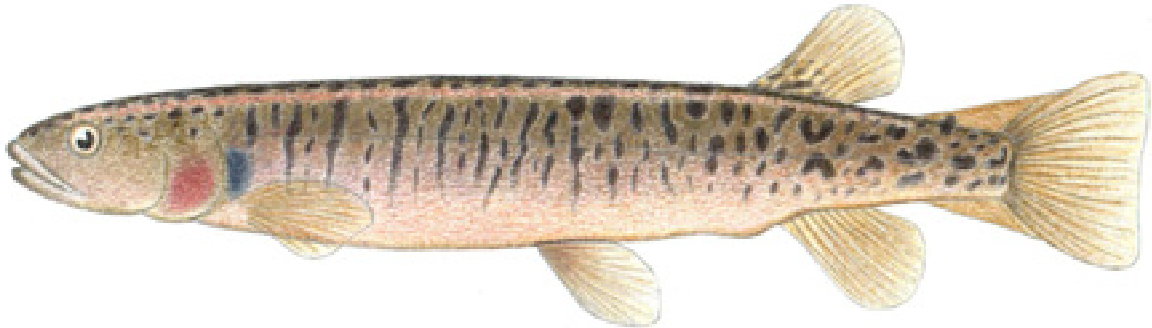
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD
Lower Risk (Least Concern)	No Change	No Change	No Change	No Change	No Change

References:
Briggs & McDowall, 1996; Gehrke *et al.*, 2001; Harris & Gehrke, 1997; Llewellyn, 1983; Merrick & Schmida, 1984; Unmack, 2000.

Climbing galaxias

Family Name:	Scientific Name:	Other Common Name(s):
Galaxiidae	*Galaxias brevipinnis* Günther, 1866	Cox's mountain galaxias, pieman galaxias, broad-finned galaxias



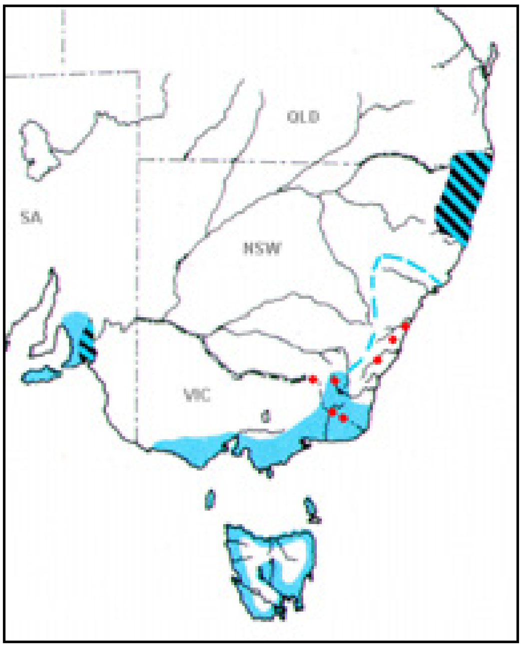
Drawing by Jack Hannan

Synonyms:
Galaxias coxii Macleay, 1883; *Galaxias weedoni* Johnston, 1883; *Galaxias atkinsoni* Johnston, 1883; *Galaxias nigothoruk* Lucas, 1892; *Galaxias affinis* Regan, 1906; *Galaxias (Galaxias) parkeri* Scott, 1936.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
In New South Wales, fragmented populations of this species remain in only a few suitable habitats (McDowall & Fulton, 1996).



Distribution:
Found in coastal drainages from Sydney, south and westwards to Adelaide, where fragmented populations still remain in suitable habitats (McDowall & Fulton, 1996). Possibly the northern extent of its current range is a small landlocked (McDowall, 1999) population in Curl Curl Creek in the Manly Dam catchment just north of Sydney (Lo, 1998). Other landlocked populations exist in isolated tributaries upstream of the upper Nepean River water storages to the south-west of Sydney (Gehrke *et al.*, 1999). The discovery of populations in the Murray River during the 1996 NSW Rivers Survey most likely reflects the transfer of water from lakes in the Snowy River hydroelectric power scheme to the upper reaches of the Murray River system (McDowall & Fulton, 1996).

Australian Museum Records – 116 records (32-175mm SL), ranging in distribution from Lawsons Creek (32° 37' S, 149° 42' E) in New South Wales to Great Lake (41° 52' S, 146° 44' E) in Tasmania; collected between circa 1880 and 1999.

Habitat:
The climbing galaxias is usually found in rocky, fast-flowing upland streams in forested catchments (Cadwallader & Backhouse, 1983); however, a preferred habitat of slower-flowing headwater streams is exhibited in the absence of other species, such as trout (O'Connor & Koehn, 1998, citing Koehn & O'Connor, 1990). It is particularly abundant in streams surrounded by an adequate cover of native vegetation (O'Connor, 1994). Large adults can often be seen cruising near the surface of rocky pools in densely forested catchments (Gehrke & Harris, 1996). Juveniles can be found in estuarine and marine habitats, free-swimming at the surface (Gomon *et al.*, 1994).

Biology & Behaviour:
Galaxias brevipinnis spawns during high flows in mid-autumn. Spawning takes place over riparian areas inundated with water, where the eggs are shed over the substratum, mainly in the gaps between cobbles and pebbles. Between high flows, eggs remain out of the water (mostly ~1m but sometimes up to 7m from the water's edge) for days or weeks, during which time both the eggs and the substrate are kept moist via shade from surrounding forests and riparian cover along the stream banks (O'Connor & Koehn, 1998). Once the embryo has fully developed, about two weeks after spawning, the eggs will hatch only after inundation and agitation by subsequent high flow, which also serves to carry the newly hatched larvae to the sea where they commence feeding. Juveniles return from the sea the following spring, when water temperatures are increasing and there is an abundance of food. Landlocked populations exist in Curl Curl Creek near Sydney and upstream of Sydney's major water supply dams, an apparent adjustment to loss of opportunities for seasonal migration. Using their large pectoral and pelvic fins as suction cups, juveniles have the unusual ability to climb vertical, damp surfaces such as waterfalls. Once in their preferred habitat, *Galaxias brevipinnis* generally dwell amongst stones or woody debris (O'Connor, 1994).

Diet:
Galaxias brevipinnis is a generalised invertebrate carnivore, feeding on a variety of insects, such as mayfly and caddisfly larvae, and amphipods, both at the water's surface and near the bottom (McDowall & Fulton, 1996).

Size:
In Australia *Galaxias brevipinnis* grows to a known maximum length of 214mm (McDowall & Frankenberg, 1981), but it is more commonly found at sizes of up to around 150-170mm (McDowall & Fulton, 1996).

Reasons for Decline:
The loss of bankside and instream vegetation cover, caused by logging, sedimentation, erosion, and the introduction of regulated flows and barriers, has inhibited the success of spawning, larval dispersal and recruitment, and the establishment of juveniles upstream, while also reducing the quantity of available food resources for this species (O'Connor, 1994). Populations in New Zealand are sparse in streams that do not have a good canopy of forest cover (McDowall, 1980).

The alien brown trout *Salmo trutta* has been implicated in the displacement of *Galaxias brevipinnis* (Koehn & O'Connor, 1992) via predation and competition during most life history stages (O'Connor, 1994). It is becoming increasingly evident that *Galaxias brevipinnis* only occurs in areas inaccessible to trout (McDowall & Frankenberg, 1981). The alien fish species *Gambusia holbrooki* may also be a threat to climbing galaxias where the distributions of these two species overlap.

The Curl Curl Creek population in New South Wales is reported to be particularly susceptible to the effects of local urban development and runoff from a surrounding golf course, which has been implicated in the decline of the species in this area (Lo, 1998). As this species undergoes downstream spawning movements to the sea, water storages above spawning sites may impede larval passage upstream, and hence decrease recruitment of juveniles (Koehn & O'Connor, 1990).

Protected Areas in which the Species Occurs:
Kosciusko National Park (NSW) (translocated population)
Morton National Park (NSW)

Recovery Objectives / Management Actions Required:
Galaxias brevipinnis is abundant in areas that have never been stocked with trout or have physical barriers that block upstream invasion (McDowall & Frankenberg, 1981, citing Andrews, 1976). The small size of this species enables heavy predation by both native and alien fish species, therefore the eradication and/or control of alien species should significantly improve its chances of survival.

Bankside vegetation is crucial to the conservation of this species as it provides shading for eggs deposited along the bank, thus preventing their desiccation. Bankside vegetation also prevents erosion and sedimentation of the surrounding environment, while also ensuring a healthy invertebrate fauna (O'Connor, 1994). Barriers such as weirs and dams need to allow for altered flow rates in conjunction with this species' seasonal requirements for spawning, dispersal and recruitment of larvae and juveniles.

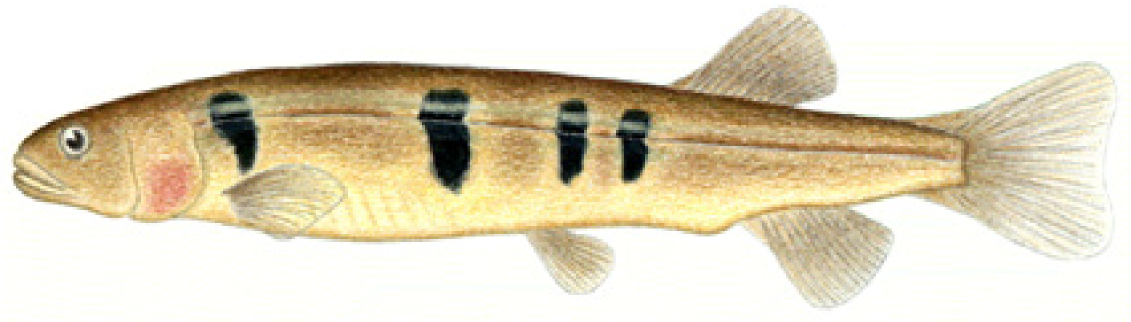
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	SA
Data Deficient	No Change	No Change	No Change	No Change	Protected

References:
Cadwallader & Backhouse, 1983; Gehrke & Harris, 1996; Gehrke *et al.*, 1999; Gomon *et al.*, 1994; Koehn & O'Connor, 1990; Koehn & O'Connor, 1992; Lo, 1998; McDowall, 1980; McDowall, 1999; McDowall & Frankenberg, 1981; McDowall & Fulton, 1996; O'Connor, 1994; O'Connor & Koehn, 1998.

Barred galaxias

Family Name:	Scientific Name:	Other Common Name(s):
Galaxiidae	*Galaxias fuscus* (Mack, 1936)	Brown galaxias



Drawing by Jack Hannan

Synonyms:
Galaxias olidus var. *fuscus*.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	VIC
Critically Endangered (A1c +2c, B)	Endangered	Critically Endangered	Critically Endangered

Reasons for Concern:
McDowall (1996) does not recognise *G. fuscus* as distinct from *G. olidus*. However, Victorian workers recognise *G. fuscus* as a separate species with a disjunct distribution, restricted to the Goulburn River system in Victoria (Raadik, 1995).

Distribution:
The barred galaxias is restricted to small tributaries of the upper Goulburn, Big and Acheron Rivers, north of the Great Dividing Range in Victoria. Its distribution has contracted eastward from the Yea River system (Barnham, 1998). This species has been collected from a total of 16 streams since it was first described in 1936. Currently, breeding populations occur in only 11 small streams located in three areas in the upper reaches of the Goulburn River system, Victoria (Raadik *et al.*, 1996). Waters that are now known to still contain this species include the upper Rubicon River and the upper Torbreck River near Lake Mountain; Godfrey, Raspberry, Perkins and Pheasants Creeks and Brewery Gully near Woods Point; and Stanley, Bindaree and Falls Creeks near Mount Stirling. It appears that the present distribution of this species represents the fragmentation of a previously much wider range. Barred galaxias have disappeared from Mountain Creek near Kinglake, Whitehouse Creek near Lake Mountain, Quartz Creek and the lower Rubicon River (type locality) near Rubicon, and Gaffneys Creek near Woods Point (Raadik, 1995).

Australian Museum Records – No records listed.

Habitat:
The barred galaxias prefers small (1-4m wide), flowing, clear (Raadik *et al.,* 1996), shallow upland streams (500-1200m) that are cool and well oxygenated (Raadik, 1995). These streams usually have boulder, pebble, gravel and sand substrates (Raadik *et al.,* 1996).

Biology & Behaviour:
Gonadal development appears to begin as early as January, and spawning appears to be triggered by an increase in day length and water temperature during late winter and early spring. The eggs are large (unshed ova are 2.2mm in diameter), demersal and adhesive, with the mean fecundity being approximately 500 eggs.

Diet:
The barred galaxias feeds on aquatic invertebrates, mainly insects (Barnham, 1998).

Size:
This species can reach up to 150mm in length, though fish around 80-100mm are usually more common (Barnham, 1998).

Reasons for Decline:
The main threat to this species appears to be the negative interaction between it and brown and rainbow trout. The effects of introducing trout into areas inhabited by the barred galaxias have been documented (Raadik, 1993), with strong evidence of predation, particularly amongst younger age classes (Raadik, 1995). There is also evidence of competition between these species, as well as between adults and juveniles of the barred galaxias (T.Raadik, pers.comm. 2001) for both habitat and food resources (Shirley, 1991). This species lays demersal eggs and therefore sedimentation is also a threat to the conservation of this species (T.Raadik, pers.comm. 2001).

Other threats to populations of this species may include the effects of timber harvesting operations on water quality and instream habitat (Barnham, 1998).

Protected Areas in which the Species Occurs:
Alpine National Park (Vic)

Recovery Objectives / Management Actions Required:
Intended management actions, as stated in the action statement prepared by Koehn & Raadik, (1995), include the establishment of a recovery team, predator/competitor control, future monitoring and surveys, and taxonomic, genetic and ecological research.

A species protection program has been undertaken in very small headwaters of the Acheron and Goulburn Rivers, where barriers have been erected to prevent the upstream movement of trout, and the latter have been actively removed above these barriers (Barnham, 1998).

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	VIC
No Change	No Change	No Change	No Change

References:
Barnham, 1998; Raadik, 1995; Raadik *et al.,* 1996; Shirley, 1991.

Common galaxias

Family Name:	Scientific Name:	Other Common Name(s):
Galaxiidae	*Galaxias maculatus* (Jenyns, 1842)	Spotted minnow, common jollytail

Drawing by Jack Hannan

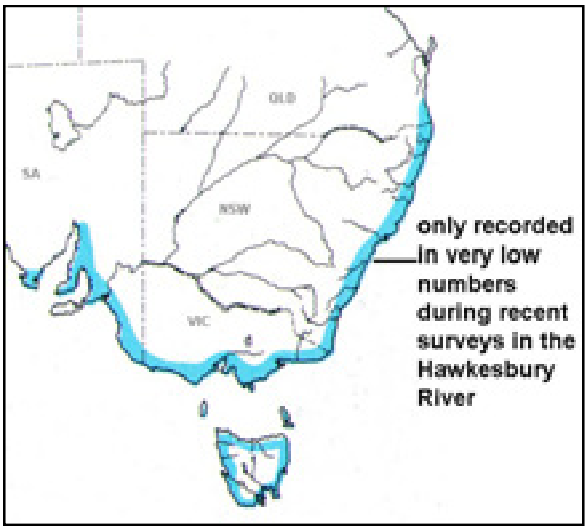
Synonyms:
Mesites maculatus Jenyns, 1842; *Mesites attenuatus* Jenyns, 1842; *Galaxias scriba* Valenciennes, 1846; *Galaxias punctatus* Günther, 1866; *Galaxias krefftii* Günther, 1867; *Galaxias pseudoscriba* McCoy, 1867; *Galaxias waterhousi* Krefft, 1868; *Galaxias delicatulus* Castelnau, 1872; *Galaxias versicolor* Castelnau, 1872; *Galaxias amaenus* Castelnau, 1872; *Galaxias cylindricus* Castelnau, 1872; *Galaxias obtusus* Castelnau, 1872; *Galaxias nebulosa* Macleay, 1881; *Galaxias parrishi* Stokell, 1964; *Galaxias maculatus ignotus* Stokell, 1966.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Galaxias maculatus is now not found to be common in some coastal rivers in New South Wales (e.g. the Hawkesbury River, as indicated on map below) where it was previously known to occur in high numbers (Gehrke & Harris, 1996).

Distribution:
Galaxias maculatus is the most widely distributed galaxiid species, with a range in the Southern Hemisphere extending from south-eastern Australia, New Zealand and the Chatham Islands, to Chile, Tierra del Fuego, Argentina and the Falkland Islands (Merrick & Schmida, 1984). Within Australia it is found in streams at low elevations which drain to the coast in far southern Queensland, New South Wales, Victoria, Tasmania and westwards to around Adelaide and Port Lincoln in South Australia (McDowall & Fulton, 1996). It has recently been collected on Moreton Island, southern Queensland (Unmack, 2000).



Australian Museum Records – 185 records (12-147mm SL), ranging in distribution from Lake Hiawatha (29° 42' S, 153° 14' E) in New South Wales southwards to Fortesque Bay (43° 42' S, 148° 01' E) in Tasmania, to St Vincent's Gulf (35° 12' S, 138° 28' E) in South Australia; collected between circa 1881 and 1999.

Habitat:
Galaxias maculatus is found in a wide variety of aquatic habitats but is most abundant in still or gently-flowing lowland streams and rivers (McDowall & Frankenberg, 1981), and around lake and lagoon margins (Pollard, 1971). Larvae and juveniles of the migratory form are pelagic during their marine phase (McDowall & Fulton, 1996).

Biology & Behaviour:
Galaxias maculatus exist as both a migratory and a landlocked form. The migratory stream-dwelling form spawns during autumn when environmental conditions are optimal (i.e. when water flows in intermittent creeks), migrating over considerable distances into the brackish tidal reaches of rivers. Spawning is dependent upon tidal influence; fish enter riparian breeding areas on spring tides and spawn amongst flooded shoreline vegetation where the eggs are stranded until the next high tides occur, around two weeks later. Landlocked lake dwelling *Galaxias maculatus* spawn during spring when water temperatures rise, water levels increase, and there is an abundance of planktonic food organisms present. These landlocked forms migrate short distances from lakes into intermittent inflowing creeks where the eggs are deposited in slow-flowing water over shallow, flat, flooded areas amongst vegetation along the stream bank, where they remain stranded after the water level subsides. There is a high incidence of adult mortality after spawning amongst landlocked fish (Pollard, 1971).

In both the landlocked and migratory forms, adhesive eggs develop in around 14 days (or longer if they are not inundated during the next water level increase) in the moist environment amongst the roots and leaves of vegetation occurring along the shoreline. Larvae of the migratory stream-dwelling form are washed downstream and spend their first winter at sea, migrating upstream around six months later (Pollard *et al.,* 1980) at lengths of about 50mm (Lake, 1978). Larvae of the landlocked lake form are washed downstream after hatching and spend their first few months sheltering amongst vegetation in the shallower shoreline areas of their lake habitat (Pollard, 1971). Chessman & Williams (1975) identified *Galaxias maculatus* as being able to endure a wide range of salinity levels from 1 to 49 ppt (Merrick & Schmida, 1984). This physiological trait, known as euryhalinity (i.e. wide salinity tolerance) enables *Galaxias maculatus* to occupy estuarine and marine habitats (as larvae) and saline lakes as well as freshwater riverine habitats (McDowall & Frankenberg, 1981). Other aspects of the biology of this species are discussed by Pollard (1971-74).

Diet:
Adults of this species have been found to be opportunistic carnivores, preying on a variety of aquatic and terrestrial insects such as midge larvae, ants and small crustaceans. Marine larvae and small juveniles consume amphipods, ostracods, mysids and polychaetes (Merrick & Schmida, 1984). The preferred diet of landlocked lake populations includes crustaceans, while migratory stream dwelling populations prefer various types of aquatic and terrestrial insects (Pollard, 1971).

Size:
Juvenile *Galaxias maculatus* can reach lengths of about 55mm while in the sea, and adults grow to around 190mm while in freshwater. Adults are more commonly found at lengths of around 100-120mm (Gomon *et al*., 1994).

Reasons for Decline:
The decline of *Galaxias maculatus* and other small freshwater schooling fishes in coastal rivers such as the Hawkesbury-Nepean River system may be part of a broader decline in small native fish species in general (Gehrke & Harris, 1996). It is likely that weirs and other barriers may impede both downstream spawning migrations and the upstream migrations of juveniles. Habitat changes,

such as the decline of macrophytes in the upper estuary and bank slumping, may also be involved in the decline of *Galaxias maculatus* in the Hawkesbury-Nepean River system (Gehrke & Harris, 1996). This species relies on natural flows, riparian vegetation and seasonal water temperature changes for successful spawning, larval development and recruitment (Pollard *et al.,* 1980), which may have restricted population abundances in systems affected by cold water pollution, modified flows or degraded habitats. Modified flows and low water temperatures due to river regulation can affect riverine habitats downstream for great distances, inhibiting spawning cues as well as reducing the availability of preferred habitat.

Protected Areas in which the Species Occurs:
This species occurs in various national parks and nature reserves situated along the coastlines of New South Wales and other parts of south-eastern Australia.

Recovery Objectives / Management Actions Required:
Further studies need to be conducted in order to establish the extent of this species' current distribution and abundance and the key causes of any observed declines. The small size of this species enables heavy predation by both native and alien fish species, therefore the eradication and/or control of alien species should significantly improve its chances of survival.

Improving flow regimes at critical times of the year (e.g. during spawning migrations) and rectifying any impediments to fish passage to allow better dispersal and recruitment may be important management actions necessary for the recovery of this species. Ensuring flow regimes that protect riverine habitats is an integral step in ensuring the perpetuation of remaining populations. Further ecological work is required to determine environmental tolerances and any interactions with alien species.

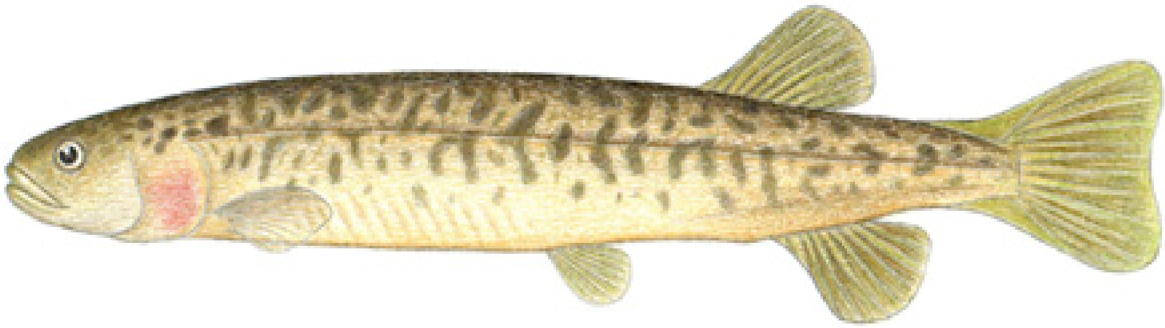
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Lower Risk (Least Concern)	No Change	No Change	No Change	No Change	No Change	No Change

References:
Gehrke & Harris, 1996; Gomon *et al*., 1994; Lake, 1978; McDowall & Frankenberg, 1981; McDowall & Fulton, 1996; Merrick & Schmida, 1984; Pollard, 1971-74; Pollard *et al.,* 1980; Unmack, 2000.

Mountain galaxias

Family Name:	Scientific Name:	Other Common Name(s):
Galaxiidae	*Galaxias olidus* (Günther, 1866)	N/A



Drawing by Jack Hannan

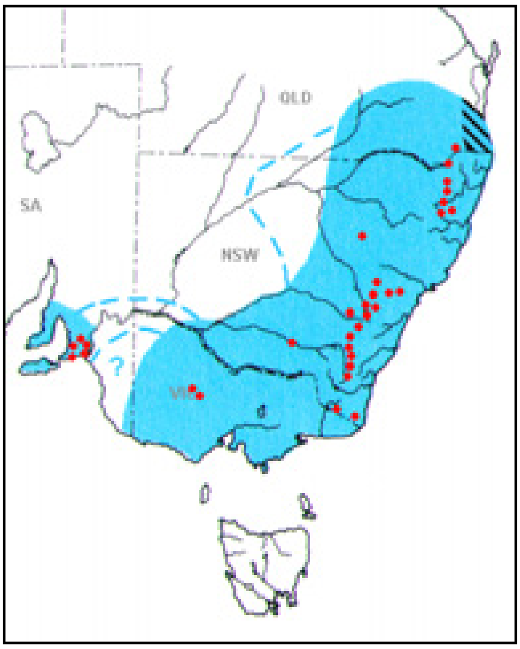
Synonyms:
Galaxias schomburgkii Peters, 1869; *Galaxias ornatus* Castelnau, 1873; *Galaxias bongbong* Macleay, 1881; *Galaxias findlayi* Macleay, 1882; *Galaxias kayi* Ramsey, 1886; *Galaxias oconnori* Mack, 1936.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
This species has been identified as having a highly fragmented distribution, often occurring in only small isolated populations (Tilzey, 1976; Cadwallader, 1979; Jackson & Davies, 1983).

Distribution:
Galaxias olidus occurs from southern Queensland (in tributaries of the upper Darling River system) to eastern South Australia. It can be found at moderate to high elevations in rivers draining the Great Dividing Range and associated mountains, in both coastal drainages and inland Murray-Darling system drainages (McDowall & Fulton, 1996). Recent surveys have also found *Galaxias olidus* upstream of Narrandera in the Murrumbidgee River (I.Wooden, pers. comm. 2000).



Australian Museum Records – 248 records (10 - 165mm Standard Length), ranging in distribution from the Condamine River (28° 20’ S, 152° 16’ E) in Queensland southwards to the Buchan River (37° 22’ S, 148° 54’ E) in Victoria, and from the Richmond River (29° 04’ S, 153° 21’ E) in New South Wales westwards to the Myponga River (35° 30’ S, 138° 30’ E) in South Australia; collected between circa 1881 and 1999.

Habitat:
Galaxias olidus is generally found in small headwater streams at altitudes up to 1800m above sea level (McDowall & Frankenburg, 1981). These areas are usually devoid of brown trout and rainbow trout (McDowall & Fulton, 1996).

Biology & Behaviour:
The eggs of *Galaxias olidus* may be found drifting, lodged in the substrate or attached to instream debris. Each of these situations involves a different degree of disturbance to the egg itself, possibly leading to variations in hatching times (O'Connor & Koehn, 1991). Surveys in Bruces Creek, Victoria, found that spawning commences from August to about late October when water temperatures ranged between 8 ^{o}C and 10 ^{o}C. Mean fecundity was found to be 198 eggs per female and the average diameter of the eggs was found to be 2.3mm. Eggs were estimated to hatch in 47 days at about 9 ^{o}C and 32 days at about 13 ^{o}C. Newly hatched larvae emerged at 9.4mm TL with relatively small yolk sacs which were fully absorbed after about 5 days, with feeding commencing after a further 3 days (O'Connor & Koehn, 1991). There is no seagoing migration and the young may be found with or near the adults, forming loose shoals in pools (McDowall & Fulton, 1996). This species has been collected from icy ponds in the Mount Kosciusko area as well as amongst moist leaves under rocks in Queensland (Koehn & O'Connor, 1990).

Diet:
Galaxias olidus feeds on a variety of aquatic insects, crustaceans, molluscs and worms. This species is also known to feed on terrestrial insects and spiders (McDowall & Fulton, 1996).

Size:
Galaxias olidus can attain lengths of around 135mm, but it is more commonly found at lengths of between 60-70mm (McDowall & Fulton, 1996).

Reasons for Decline:
This species is most likely to be under significant pressure from competition and predation by alien fish species such as brown trout and rainbow trout (Koehn & O'Connor, 1990; Tilzey, 1976). This, combined with the effects of barriers to fish passage, has probably led to populations being distributed more randomly. The loss of riparian vegetation may also be responsible for the decline of this species, as the vegetation cover prevents erosion, provides instream habitat and shading, as well as supporting an abundance of the terrestrial invertebrates which form an important element of its diet. The loss of interstitial spaces in the substrate due to sedimentation and increasing siltation may have led to spawning failures and loss of essential spawning habitat (O'Connor & Koehn, 1991).

Protected Areas in which the Species Occurs:
This species occurs in various national parks and nature reserves situated along the inland and coastal rivers and streams of New South Wales and other parts of south-eastern Australia.

Recovery Objectives / Management Actions Required:
Further studies need to be conducted in order to establish the extent of this species' current distribution and abundance and the key causes of any observed declines. Due to its small size, this species is heavily preyed upon by both native and alien fish, and the control and/or eradication of alien species should significantly benefit its survival. Relocation and recolonisation of mountain galaxias to trout free waters may also be a viable management option (Crook & Sanger, 1997; Lintermans, 2000).

Improving flow regimes at critical times of the year (e.g. when spawning) and rectifying any impediments to fish passage to allow better dispersal and recruitment may be important management actions necessary for the recovery of this species. Ensuring flow regimes that protect riverine habitats is an integral step in ensuring the perpetuation of remaining populations. Further ecological work is required to determine environmental tolerances and any interactions with alien species.

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Lower Risk (Least Concern)	No Change	No Change	No Change	No Change	No Change	No Change	No Change

References:

Cadwallader, 1979; Crook & Sanger, 1997; Fletcher, 1979; Jackson & Davies, 1983; Koehn & O'Connor, 1990; Lintermans, 2000; McDowall & Frankenburg, 1981; McDowall & Fulton, 1996; O'Connor & Koehn, 1991; Tilzey, 1976.

Murray jollytail

Family Name:	Scientific Name:	Other Common Name(s):
Galaxiidae	*Galaxias rostratus* Klunzinger, 1872	Flathead galaxias, flathead jollytail

Drawing by Jack Hannan

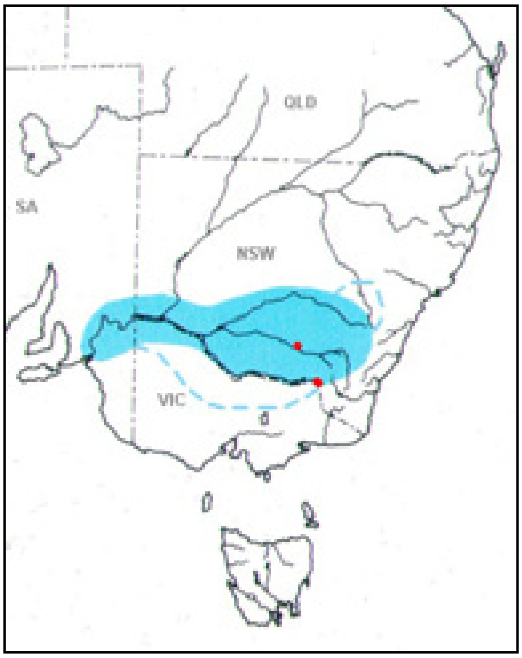
Synonyms:
Galaxias planiceps Macleay, 1881; *Galaxias waitii* Regan, 1906; *Galaxias (Galaxias) rostratus* Scott, 1936; *Galaxias planiceps waitii* Whitley, 1964.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	SA
Vulnerable	Vulnerable	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
The distribution of *Galaxias rostratus* is restricted and intermittent in the Murray region. This species was not collected in recent surveys of its known habitats in New South Wales (Harris & Gehrke, 1997).

Distribution:
Galaxias rostratus is known from the southern portion of the Murray River system, and the upper Macquarie River (Unmack, 2000). The distribution of *Galaxias rostratus* is now restricted and intermittent in the Murray region (Harris & Gehrke, 1997). *Galaxias rostratus* was reported to be present in large numbers in Lake Hiawatha south of Grafton in northern coastal New South Wales (McDowall & Fulton, 1996; Lo, 2000). However these specimens have since been re-identified as *Galaxias maculatus*.



Australian Museum Records – 23 records (36 -110 mm SL), ranging in distribution from Rankins Lagoon near Bathurst (33^{o} 25’ S, 149^{o} 35’ E) in New South Wales southwards to Seven Creeks (36^{o} 43’ S, 149^{o} 33’ E) in Victoria, and from Rankins Lagoon near Bathurst (33^{o} 25’ S, 149^{o} 35’ E) in New South Wales westwards to the Murrumbidgee River (34^{o} S, 142^{o} E) in New South Wales; collected between circa 1868 and 1992.

Habitat:
Galaxias rostratus inhabits still or gently flowing waters such as lakes, lagoons, billabongs and backwaters (McDowall & Frankenburg, 1981).

Biology & Behaviour:
Galaxias rostratus is a shoaling fish that congregates in midwater. Spawning occurs in small ponds when water temperatures are between 9 and 14°C (McDowall & Frankenberg, 1981) during the months of August and September (Llewellyn, 1983). The eggs are small (1.3-1.6mm in diameter), with a fecundity of several thousand eggs per female (McDowall & Frankenberg, 1981). The demersal eggs are deposited randomly by the female in mid-water and settle on the substrate (Merrick & Schmida, 1984). The eggs develop in about 9 days and the larvae are 6-7mm in length after hatching. Llewellyn (1971) observed breeding continuing for up to a month, with only small numbers of eggs being shed by any one fish at a time (McDowall & Frankenberg, 1981).

Diet:
Galaxias rostratus probably consumes mainly small crustaceans and aquatic insects (Llewellyn, 1983).

Size:
Llewellyn (1971) identified *Galaxias rostratus* as growing to about 130mm, though individuals are more commonly found at lengths of around 100mm (McDowell & Frankenberg, 1981).

Reasons for Decline:
The causes of the decline of this species are unknown but may include habitat changes due to agricultural practices, spawning failures due to cold water releases from dams, and predation by and competition with alien species such as redfin perch, brown trout, rainbow trout and gambusia.

Protected Areas in which the Species Occurs:
None known.

Recovery Objectives / Management Actions Required:
The ecology of the Murray jollytail requires further study before an accurate conservation status can be assigned (Wager & Jackson, 1993). The conservation and protection of known populations of this species needs to be initiated immediately.

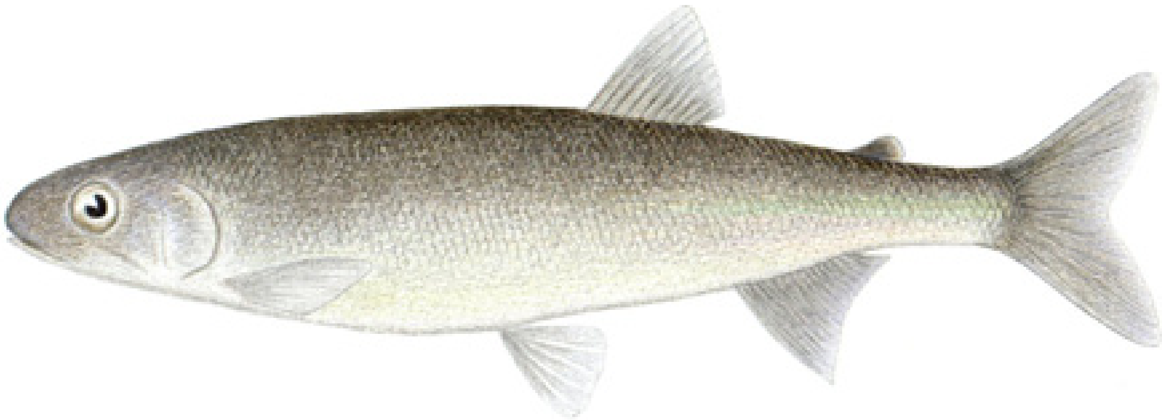
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	SA
No Change	No Change	Vulnerable	Vulnerable	Data Deficient	Protected

References:
Harris & Gehrke, 1997; Llewellyn, 1971; Llewellyn, 1983; McDowall & Frankenberg, 1981; Unmack 1999; Wager & Jackson, 1993.

Australian grayling

Family Name:	Scientific Name:	Other Common Name(s):
Prototroctidae	*Prototroctes maraena* Günther, 1864	Cucumber mullet, cucumber herring



Drawing by Jack Hannan

Current Conservation Status:

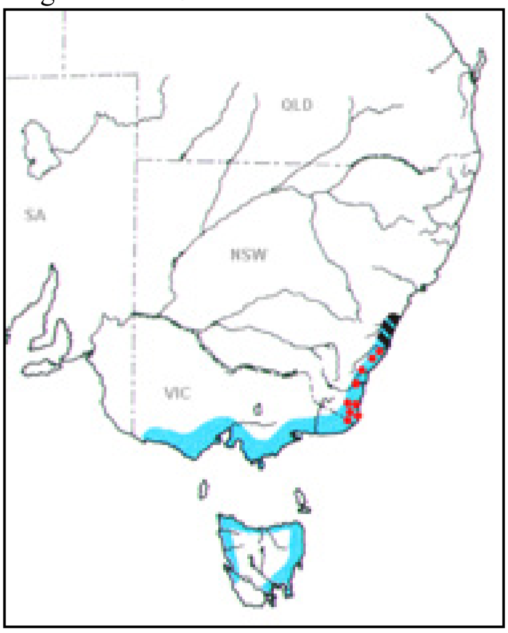
IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC
Vulnerable (A1c)	Potentially Threatened	Vulnerable	Not Listed	Vulnerable

Reasons for Concern:

The Australian grayling is the only surviving species in this family, and is now found on the mainland only in coastal rivers in Tasmania, Victoria and southern New South Wales (McDowall, 1996).

Distribution:

The Australian grayling was formerly widespread, occurring from the Grose River to the north and west of Sydney (Stead, 1903) and southwards throughout the coastal streams of New South Wales, Victoria, Tasmania and eastern South Australia. Currently it has a discontinuous distribution throughout its former range, but large populations still exist in the Tambo River in Victoria (Wager & Jackson, 1993). The NSW Rivers Survey recorded 64 specimens from 6 different southern New South Wales coastal rivers (Harris & Gehrke, 1997), and it is known to be present in relatively large numbers in several coastal rivers from the Clyde River south to the New South Wales-Victorian border. Since the completion of Tallowa Dam in 1976, only one specimen has been collected in the Shoalhaven River system (R.Faragher, pers. comm. 2000). It has not been recorded from the Grose River (part of the Hawkesbury-Nepean River system) since the 1950s (Gehrke & Harris, 1996).



Australian Museum Records – 39 records (30-250mm SL), ranging in distribution from Macquarie Rivulet (34^o 34' S, 150^o 37' E) in New South Wales southwards to the northern rivers (43^o S, 147^o E) of Tasmania; collected between circa 1884 and 1994.

Habitat:
The freshwater habitat of this species includes large and small coastal rivers and streams (Wager & Jackson, 1993), generally with gravel substrates and moderate flows (McDowall, 1996). It has also been found in some degraded streams, and (as larvae and juveniles) in inshore marine and estuarine habitats.

Biology & Behaviour:
The Australian grayling is a shoaling (Gomon *et al.,* 1994), amphidromous species, the young of which migrate upstream from the sea to complete its life-cycle. Spawning occurs in the same general area as the adult freshwater habitat (Cadwallader & Backhouse, 1983) during late summer to early autumn, when water temperatures begin to drop (Koehn & O'Connor, 1990). Fecundity varies from between 25,000 to 68,000 eggs per female (Cadwallader & Backhouse, 1983). The eggs, 1.1mm in diameter after fertilisation, settle amongst gravel on the streambed. Twelve days after fertilisation, when water temperatures are around 16^{o}C, the eggs hatch, though they may take a few more days at lower temperatures. The larvae are 4-5mm long and are positively phototactic, swimming to the surface where they are swept downstream to the estuary or the sea (McDowall, 1996). Juvenile fish approximately 55-75mm in length return to freshwater habitats around six months later (Faragher, 1999). Fish reach maturity at two years of age for females and at 1 year of age for males, and there are increasingly large mortality rates amongst spawning adults after 2 years (Koehn & O'Connor, 1990).

Diet:
In freshwater, *Prototroctes maraena* is a microphagic omnivore, usually feeding on cladocerans, algae (Michaelis, 1985), and small aquatic and terrestrial insects (McDowall, 1996). Adaptation to the consumption of algae is facilitated by a double loop in the intestine, an unusual feature in salmoniform fishes (McDowall, 1996).

Size:
Marine juveniles of the Australian grayling reach a length of at least 50mm, while adults are known to reach 330mm, but more commonly occur at around 170-190mm in length (Gomon *et al.,* 1994). Fish reach about 80mm at 1 year of age, 150mm at 2 years of age, and 190mm at 3 years of age (McDowall, 1996).

Reasons for Decline:
In the latter half of the twentieth century, however, the Australian grayling was believed to have suffered a severe decline throughout most of its range (Ingram *et al.,* 1990). Dams, weirs and culverts prevent dispersal, and also its diadromous migrations and the re-colonisation of the previous generations' upstream habitats. Populations have been found immediately downstream of barriers in the Barwon and Yarra Rivers in Victoria (Wager & Jackson, 1993), and also in recent surveys conducted around Bega and northwards to the Shoalhaven River system in New South Wales (Faragher, 1999). It has been suggested that the construction of impoundments (Bell *et al.*, 1980) and river regulation (T.Raadik, pers. comm. 2001) have been the main contributors to the decline of the Australian grayling in New South Wales and Victorian coastal streams. Agriculture, forestry and sand and gravel extraction have damaged the Australian grayling's habitat through erosion (Wager & Jackson, 1993) and increased siltation (Gomon *et al.,* 1994). The loss of riparian vegetation, to which *Prototroctes maraena* is considered sensitive (Ingram *et al.,* 1990), has, along with erosion and siltation, had a negative effect on the abundance of its major food source, macro-invertebrate communities (Wager & Jackson, 1993). As there is a large mortality rate amongst adults after spawning, several years of heavy losses in succession can eliminate populations from a stream system (Koehn & O'Connor, 1990). Predation by and competition with brown trout and

rainbow trout (Koehn & O'Connor, 1990), especially during the earlier juvenile stages, are also probable causes of population decline (McDowall, 1996).

Protected Areas in which the Species Occurs:
Moreton National Park (NSW)
Snowy River National Park (Vic)
Wilsons Promontory National Park (Vic)
Otway National Park (Vic)
Croajingalong National Park (Vic)
The Aire River (Vic) has recently been listed as a Heritage River

Recovery Objectives / Management Actions Required:
The distribution and abundance of Australian grayling seem to be relatively stable at this time, especially in places where populations enjoy a high degree of catchment protection in national parks and native forest reserves. Unobstructed migration corridors within rivers are essential to this species' survival, making improved fish passage an integral component of any recovery program. Conservation of Australian grayling requires further study of the species' population genetics, and especially the question of whether populations in individual rivers are discrete or part of single, larger homogeneous population that should be managed as a single unit. The stocking of brown trout and rainbow trout should be restricted in catchments identified as sustaining populations of *Prototroctes maraena* (Wager & Jackson, 1993). Increased siltation from various sources is a threat to spawning habitats. Improved land use practices and the re-establishment of riparian vegetation could be achieved via further education of landholders, and would result in further improvement of water quality. Habitat restoration at localities where Australian grayling populations are known to occur may also significantly benefit this species.

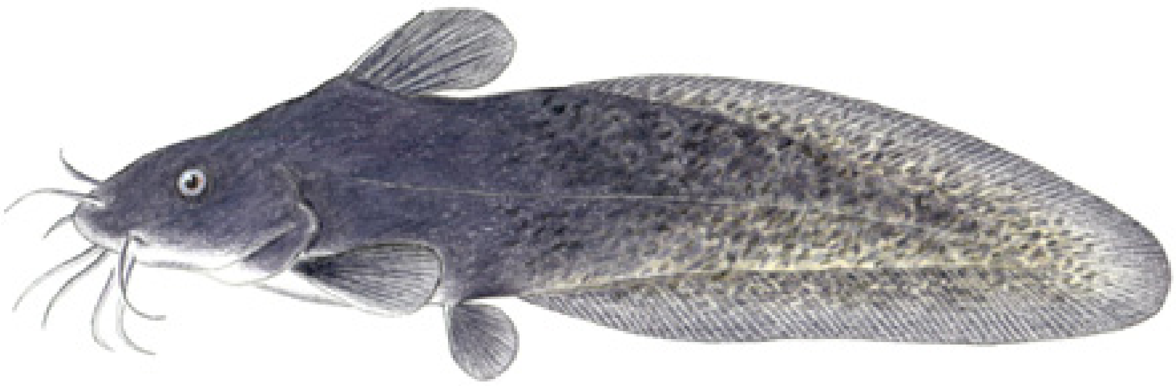
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC
No Change	Vulnerable	No Change	No Change	No Change

References:
Bell *et al.*, 1980; Cadwallader & Backhouse, 1983; Faragher, 1999; R.Faragher, pers. comm. 2000; Gehrke & Harris, 1996; Gomon *et al.,* 1994; Harris & Gehrke 1997; Ingram *et al.,* 1990; Koehn & O'Connor, 1990; Lo, 1999; McDowall, 1996; Michaelis, 1985; Pollard *et al.*, 1980; Wager & Jackson, 1993.

Freshwater catfish

Family Name:	Scientific Name:	Other Common Name(s):
Plotosidae	*Tandanus tandanus* (Mitchell, 1838)	Eel-tailed catfish, freshwater jewfish, dewfish, keranu, tandanus



Drawing by Jack Hannan

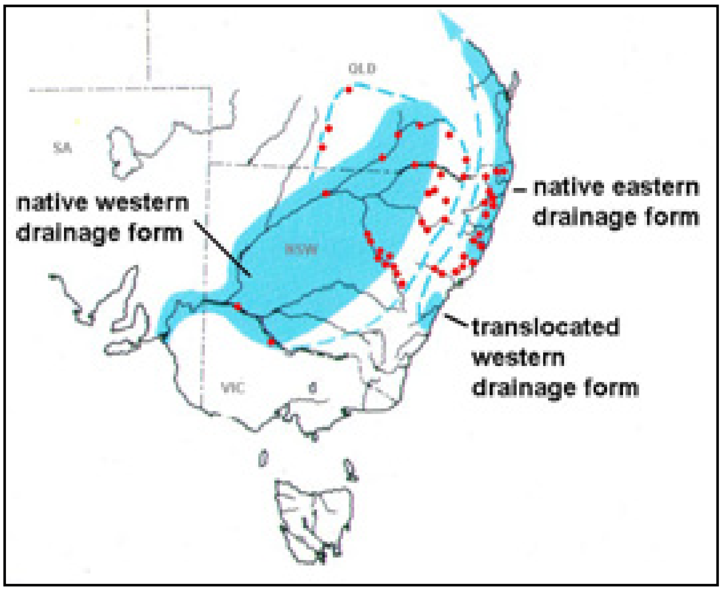
Synonyms:
Plotosus (Tandanus) tandanus Mitchell, 1838.

Current Conservation Status: Inland Population / Coastal Population

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Not Listed/ Not Listed	Not Listed/ Not Listed	Not Listed/ Not Listed	Not Listed/ Not Listed	Vulnerable/ N/A	Not Listed/ Not Listed	Protected/ N/A

Reasons for Concern:
The distribution and abundance of freshwater catfish has been significantly reduced throughout the southern parts of its known range (Harris & Gehrke, 1997).

Distribution:
This species was previously widely distributed in the Murray-Darling River system, only being rare or absent upstream from Wagga Wagga in the Murrumbidgee River and upstream from Mulwala in the Murray River (Lake, 1971). This species has since disappeared from naturally flowing streams in Victoria, and is now found only in regulated systems and impoundments (T.Raadik, pers. comm. 2000). Strong populations of freshwater catfish, however, still apparently exist in the Queensland portion of the Murray Darling-Basin



(Moffatt *et al.,* 1997). Recently, only a few specimens were found in the Darling River (Harris *et al.*, 1992), at Murtho on the Murray River (Mallen-Cooper & Brand, 1992), and in the Bell River (Thorncraft & Harris, 1996). The NSW Rivers Survey found no specimens in the Murray River, and only fragmented populations in the Darling River catchment, with considerably larger numbers being found in streams along the New South Wales north coast and south to the Shoalhaven River (Harris & Gehrke, 1997). Specimens from the Murray-Darling River system were released in the past into the Hawkesbury-Nepean and Shoalhaven River systems, although it is uncertain whether natural populations existed in these rivers previously (Gehrke & Harris, 1996). Some evidence suggests that one or more separate species exist in the coastal drainages in New South Wales and Queensland (Musyl & Keenan, 1996).

Relatively abundant and naturally breeding populations have recently been recorded in the Queensland portion of the Murray-Darling Basin and many large impoundments in New South Wales, as well as in Ewenmar Creek (Macquarie River), Duck Creek (Bogan River) and Lake Victoria (Murray River) in New South Wales. In Victoria, populations remain in the Little Murray River, Cardross Lakes and the Wimmera River (Clunie & Koehn, 2000). A translocated population in the Wimmera River is considered to be the largest in Victoria (A.Baxter, pers. comm. 2000). This species is still present in the Murray River near Mildura (T.Raadik, pers. comm. 2000).

In general, more recent records have tended to extend the accepted distribution of this species further upstream into the headwater streams along both sides of the Great Dividing Range.

Australian Museum Records – 90 records (19-550mm SL), ranging in distribution from the Edwards River (14^o 40' S, 142^o 45' E) in Queensland southwards to the Murrumbidgee River (36^o S, 149^o E) in New South Wales, and from Crystal Creek (28^o 19' S, 153^o 20' E) in New South Wales westwards to the Darling River (34^o S, 141^o E) in New South Wales; collected between circa 1881 and 1998.

Habitat:
This species is found in a wide variety of habitats, including rivers, creeks, lakes and billabongs. It generally prefers sluggish or still waters (Cadwallader & Backhouse, 1983).

Biology & Behaviour:
Spawning may take place from late spring until mid-summer, usually in nests up to 200cm in diameter built of pebbles or gravel (Lake, 1971). Water temperatures of around 24^oC may induce spawning, which occurs several times, preceded each time by an elaborate courtship display (Cadwallader & Backhouse, 1983). Females can lay up to ~14,000 eggs per kg of body weight. The demersal and non-adhesive eggs are guarded and fanned by the male. The eggs generally develop at water temperatures of between 21 and 25^oC. After 7 days at 19-25^oC they hatch into larvae 7mm long, and in a further 7 days their barbels are well formed. At 3 weeks after fertilisation a length of 15mm is attained, at which stage the larvae have developed into juveniles (Lake, 1971). Sexual maturity is reached at about the same size in both sexes, in the third to fifth year of life, at lengths of between 350-400mm (Cadwallader & Backhouse, 1983). The freshwater catfish is a hardy fish, able to tolerate gradual fluctuations in water temperature from 1^oC up to 38^oC (but only for very short periods of time) (Lake, 1971).

Diet:
Adult fish are essentially carnivores and bottom feeders, taking molluscs, crustaceans (Lake, 1971), insect larvae and small fishes (Cadwallader & Backhouse, 1983), especially gudgeons of the genus *Hypseleotris* (Pollard *et al.*, 1980).

Size:
This species has been known to grow to a length of about 900mm and a weight of 6.8kg (Pollard *et al.*, 1980). Fish of less than 2kg, however, are more common (Lake, 1971).

Reasons for Decline:
River regulation is likely to have played a key role in the decline of freshwater catfish in a variety of different ways, and especially due to a reduced frequency of flooding and a decline in the number of suitable habitats such as billabongs, floodplains, wetlands and backwaters. Cold-water pollution is also likely to have played a role in the decline of this species in some river reaches within the Murray-Darling system which are affected by bottom offtakes on dams. Reduced water temperatures may affect general metabolic functioning, feeding, maturation and growth rates. Areas affected by cold water pollution which have experienced declines in freshwater catfish populations include those downstream of Hume Dam on the Murray River, Burrinjuck Dam on the Murrumbidgee River, Wyangala Dam on the Lachlan River, Burrendong Dam on the Macquarie River, Lake Eildon on the Goulburn River (Clunie & Koehn, 2000), Copeton Dam on the Gwydir River, and Keepit Dam on the Namoi River. According to Davis (1977), spawning may take place when water temperatures reach 24°C. The apparent absence of this species from the upper reaches of the Murray and Murrumbidgee Rivers may thus be attributed to such cold water discharges from large dams (Pollard *et al.*, 1980). The absence of this species from the Murray River near Albury-Wodonga has been linked to environmental changes due to the impoundment of Lake Hume, the establishment of alien species, and variations in river water levels due to irrigation management (Walker, 1980). Short term fluctuations in water levels during the spawning months of this species can cause the abandonment of nests as they become exposed above the water level (Lake, 1971). Davis (1975) observed changes in diet, migration and distribution patterns of freshwater catfish resulting from the impoundment of the Gwydir River (i.e. Copeton Dam). He also found that a large proportion of mature fish failed to breed after impoundment due to low oxygen levels in the backwaters (Harris, 1985).

Predation by and competition for food and habitat resources with alien species may also have contributed to the general decline of this species, especially in areas with well established alien fish populations, although there is at present no clear evidence of this (Clunie & Koehn, 2000).

The loss of riparian vegetation, mainly through forestry and agricultural activities, may adversely affect instream habitat and decrease habitat diversity, but whether these changes have affected freshwater catfish populations is difficult to determine and yet to be documented (Clunie & Koehn, 2000). Freshwater catfish in general seem relatively tolerant to many common water quality problems and it seems unlikely that the latter have played a key role in this species' decline. However particular water quality problems, such as the inflow of pesticides, may have caused local declines in certain areas (Clunie & Koehn, 2000).

Although this has not been clearly documented, woody debris may provide refuge for the freshwater catfish (Clunie & Koehn, 2000); whether it also provides a habitat for part of its diet is also not known. Recreational and commercial fishing are not considered to have been a key reason for the decline of freshwater catfish; however, once a species such as this has experienced a significant decline in its abundance and distribution due to other factors, it may become more vulnerable to fishing pressure (Clunie & Koehn, 2000).

Protected Areas in which the Species Occurs:
Hattah Kulkyne National Park (Vic)

Objectives/ Management Actions Required:
In order to address the previously underestimated issue of cold water pollution, the Freshwater Catfish Recovery Plan supports the establishment of a Cold Water Pollution Reduction Program as identified by Lugg (1999a & 1999b). It also encourages the development of a strategy for the Murray-Darling River system to address the need for variable level offtakes or alternative options for large dams where thermal pollution is a problem. The construction of new dams should not be undertaken without the ability to provide natural water temperatures downstream, while research

should also be conducted on the effects of cold water on the biology and movement patterns of larval, juvenile and adult freshwater catfish (Clunie & Koehn, 2000).

A management process is already in place to address the improvement of fish passage in the Murray-Darling Basin, which is likely to include benefits to freshwater catfish. Modifications to facilitate movement over barriers in areas where healthy populations of freshwater catfish exist may enable an expansion of these populations (given that all other problems in surrounding areas are addressed) and reduce the potential for their isolation. Considerations of the removal of weirs where there are significant populations of freshwater catfish should, however, first weigh up the implications for this species and the surrounding aquatic habitat and wildlife, as there may be particular cases where freshwater catfish have actually benefited from modified flow regimes. Further research is required to understand the swimming ability of freshwater catfish and the migratory patterns of various populations during different life-history stages in the Murray-Darling Basin (Clunie & Koehn, 2000).

The control of carp in areas still inhabited by substantial populations of freshwater catfish would be beneficial to this species. Further research into the interactions between carp and freshwater catfish is also recommended. Additional research should also be carried out to investigate interactions between redfin perch and freshwater catfish and to determine whether redfin perch prey upon or compete with any of the life-history stages of freshwater catfish. Such information could assist stocking programs for freshwater catfish in areas where redfin perch occur (e.g. in the possible selection of larger catfish specimens for stocking release).

Experiments should be conducted to determine what diseases freshwater catfish are susceptible to, and whether these fish may experience lethal or sub-lethal effects. Further research is also needed to clarify the significance of water quality problems such as sedimentation, increasing salinity, algal blooms and pollution on freshwater catfish biology and behaviour (Clunie & Koehn, 2000).

Determination of the structural habitat requirements and how different habitats influence food availability and diversity for this species at different life-history stages is also required, as is encouragement of the protection and rehabilitation of riparian zones in areas where significant populations of freshwater catfish occur – the latter through state agency and community group action and education (Clunie & Koehn, 2000).

The decline of this species throughout most of its range means that retaining its surviving genetic diversity is important for the future. It is essential that the genetic composition of different stocks is well understood and appropriate translocation principles are implemented. Further research should trial stockings in a range of suitable habitats with varying sizes of fingerlings and yearlings to determine which sizes are most successful and appropriate. Genetic testing of populations in coastal areas within New South Wales and Queensland should be undertaken to determine the distributions of any possible new species and subspecies (Clunie & Koehn, 2000).

In consultation with relevant agencies with responsibilities within the Murray-Darling Basin, it is necessary to determine whether stronger regulations on the recreational catches of freshwater catfish need to be initiated. Further education of recreational anglers should also be undertaken to promote the conservation of this species.

Suggested Conservation Status: Inland Population / Coastal Population

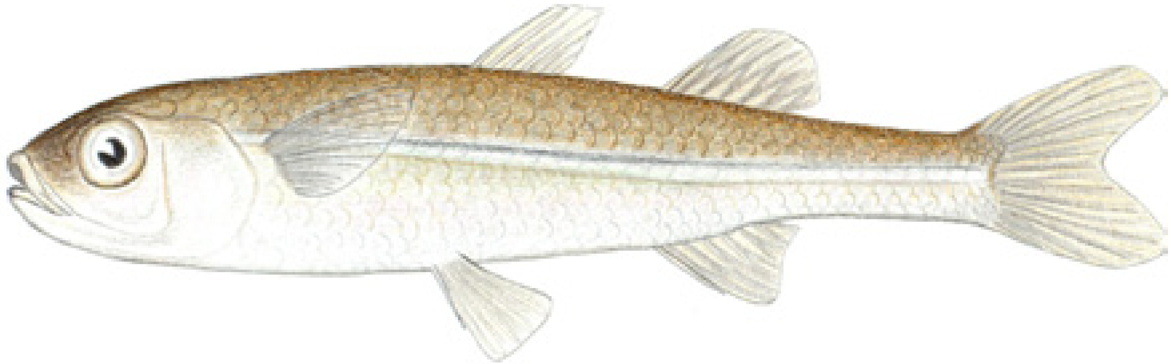
IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Vulnerable/ Lower Risk (Least Concern)	Vulnerable/ Lower Risk (Least Concern)	Vulnerable/ Lower Risk (Least Concern)	Vulnerable/ No Change	No Change/ N/A	Common/ Common	Protected/ N/A

References:

Cadwallader & Backhouse, 1983; Clunie & Koehn, 2000; Gehrke & Harris, 1996; Harris, 1985; Harris *et al*., 1992; Harris & Gehrke, 1997; Lake, 1971; Mallen-Cooper & Brand, 1992; Moffatt *et al.,* 1997; Musyl & Keenan, 1996; Pollard *et al.*, 1980; Thorncraft & Harris, 1996; Walker, 1980.

Murray hardyhead

Family Name:	1. Scientific Name:	Other Common Name(s):
Atherinidae	*Craterocephalus fluviatilis* McCulloch, 1912	N/A



Drawing by Jack Hannan

Taxonomy:
Paxton *et al.* (1989) considered *Craterocephalus fluviatilis* to be a synonym of *Craterocephalus eyresii*. However, it has since been recognised as a distinct species.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	SA
Endangered (A1c, B1 + 2)	Endangered	Vulnerable	Endangered	Endangered	Not Listed

Reasons for Concern:
Craterocephalus fluviatilis has a greatly reduced abundance and distribution, which is now limited to only a few sites in the lower Murray River system (Gehrke *et al.*, 1999; Harris & Gehrke, 1997). Taxonomic confusion also exists with other hardyhead species.

Australian Museum Records – No records listed.

Darling hardyhead

Family Name:	2. Scientific Name:	Other Common Name(s):
Atherinidae	*Craterocephalus amniculus* (Crowley & Ivantsoff, 1990)	N/A

Taxonomy:
This species was described from streams in the upper Darling River system in northern New South Wales and southern Queensland (Crowley & Ivantsoff, 1990).

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	QLD
Vulnerable (A1c)	Vulnerable	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Taxonomic confusion also exists between this and other hardyhead species.

Australian Museum Records – 16 records (10-57mm SL), ranging in distribution from below Bonshaw Weir (28° 58' S, 151° 16' E) in Queensland southwards to Bowmans Creek (32° 25' S, 151° 03' E) in New South Wales, and from the Swan Brook Creek (29° 46' S, 154° 26' E) in New South Wales westwards to the MacIntyre River (29° 56' S, 149° 46' E) in New South Wales; collected between circa 1915 and 1989.

Non-speckled hardyhead

Family Name:	3. Scientific Name:	Other Common Name(s):
Atherinidae	*Craterocephalus stercusmuscarum* var. *fulvus* (Ivantsoff, Crowley & Allen, 1987)	N/A

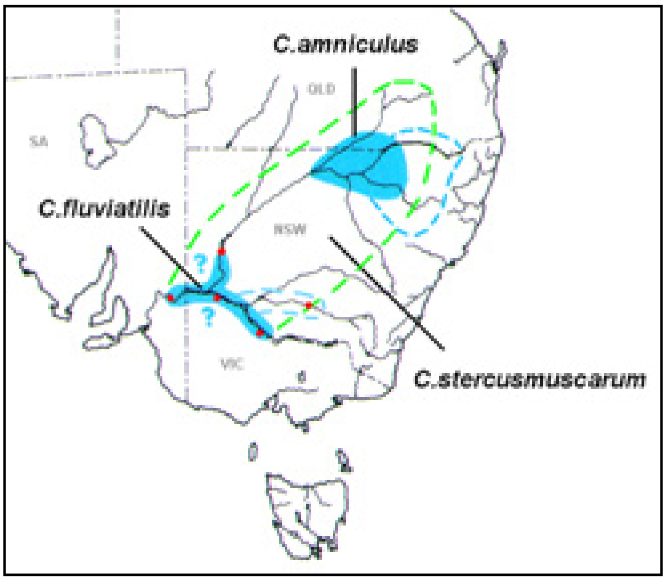
Taxonomy:
McCulloch's (1913) records of the distribution of *Craterocephalus fluviatilis* must now be considered equivocal, as some of the specimens he attributed to this species may include both *C. stercusmuscarum* var. *fulvus* and *C. amniculus.*

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Craterocephalus stercusmuscarum var. *fulvus* is now considered rare in the southern parts of its known distribution. Taxonomic confusion also arises with other hardyhead species (Ivantsoff & Crowley, 1996).

Australian Museum Records – 8 records (14-55mm SL), ranging in distribution from Lake Nuga Nuga (24° 59' S, 148° 41' E) in Queensland southwards to the Lachlan River (33° 29' S, 145° 32' E) in New South Wales, and from Tea Tree Creek (30° 30' S, 151° 20' E) in New South Wales westwards to Lake Pamamaroo (32° 18' S, 142° 30' E) in New South Wales; collected between circa 1960 and 1997.



Distribution of Hardyheads in the Murray-Darling Basin:
The distribution of *Craterocephalus fluviatilis* was formerly thought to be widespread throughout much of the Murray River system, but not in the Darling River and its tributaries. Specimens were recorded in 1986 in the lower Murray River, but this species now seems to be restricted to the Kerang Lakes area in Victoria (Wager and Jackson, 1993; T.Raadik, pers. comm. 2001), Lake Hawthorn in Victoria, Cardross Lakes near Mildura and other billabongs that connect frequently with the Murray River near Mildura (T.Raadik, pers. comm. 2001). Recent collecting in

the Murray River south of Renmark and in Lake Bonney in South Australia failed to yield any specimens, where this species had previously been reported by Lloyd & Walker (1986) from five sites in the lower Murray River in 1976 (FSC, 2000b). Surveys carried out between 1992 and 1996 found only one specimen in the Murray River (Gehrke *et al.*, 1999; Harris & Gehrke, 1997). The status of this species is uncertain in South Australia. Populations have been confirmed in Disher Creek near Berri, however further field studies need to be conducted to confirm speculative reports of other Murray hardyhead populations in South Australia (M.Hammer, pers. comm. 2001). This species has suffered a serious population decline in New South Wales such that no large populations are currently known. Despite considerable efforts by scientists over the past 20 years to collect the species in New South Wales's waters, the last recorded museum specimen was from the 1970s.

Craterocephalus amniculus is endemic to streams in the upper Darling River system and possibly also the headwaters of the Hunter River system, being collected from the MacIntyre, Peel, Cockburn and Boiling Rivers, and Warialda and Boiling Down Creeks by Crowley and Ivantsoff (1990) (T.Raadik, pers. comm. 2000). Specimens tentatively identified as *Craterocephalus amniculus* were also collected from the Hunter River drainage (eastern side of the Liverpool Range) in 1976 and 1980, though no further individuals have since been collected (T.Raadik, pers. comm. 2000, citing Crowley & Ivantsoff, 1990).

Craterocephalus stercusmuscarum var. *fulvus* is known to occur in most parts of the Murray-Darling Basin in New South Wales, Victoria and Queensland, being more common towards the northern extent of its range. It is now considered rare, if present at all, in more southern regions (Ivantsoff & Crowley, 1996).

Habitat:
Hardyheads are found around the margins of slow-flowing lowland rivers, and in lakes, billabongs and backwaters, amongst aquatic vegetation and over gravel substrates (Wager & Jackson, 1993; Ivantsoff & Crowley, 1996). *Craterocephalus fluviatilis* appears to be most common, however, in large saline lakes (Unmack, 2000).

Biology & Behaviour:
Hardyheads have been observed to spawn during the warmer months from October to February when water temperatures are above 24°C (Llewellyn, 1983). Eggs are large, fairly clear, adhesive and demersal (McCulloch, 1912), and are randomly dispersed (Llewellyn, 1983).

Diet:
Hardyhead larvae feed on small aquatic insects and crustaceans (McCulloch, 1912).

Size:
Adult hardyheads can reach lengths of over 100mm; however, they are more common at lengths less than 80mm (Llewellyn, 1983).

Reasons for Decline:
All known habitats of the Murray hardyhead are threatened by increasing salinisation (which changes macroinvertebrate community structure and aquatic vegetation structure, and may impact on fish spawning and recruitment). This has lead to their extinction in some of the Karang Lakes in the last 15 years (T.Raadik, pers. comm. 2001).

The key causes of the decline of hardyhead populations are unknown, but may include habitat changes due to agricultural practices, spawning failures due to cold water releases from dams, and predation by and competition with alien species such as redfin perch and gambusia.

Protected Areas in which the Species Occurs:
Kinchega National Park (NSW) (*Craterocephalus fluviatilis*)

Recovery Objectives / Management Actions Required:
Further studies are needed to establish the key causes of the decline of hardyhead populations in the Murray-Darling Basin and the current extent (i.e. distributions and population abundances) of known and yet to be discovered populations; the protection of known habitats also needs to be initiated. Because of their small size, hardyheads are likely to be heavily preyed upon by both native and alien fishes, therefore the eradication and/or control of alien species should significantly improve their chances of survival. Translocation or re-establishment of populations into suitable habitats may be possible, given that biological and environmental tolerances are met (Wager & Jackson, 1993). It is also likely that weirs and other barriers may impede spawning migrations and the upstream migrations of juveniles, and further research should be conducted to identify the effects of these factors.

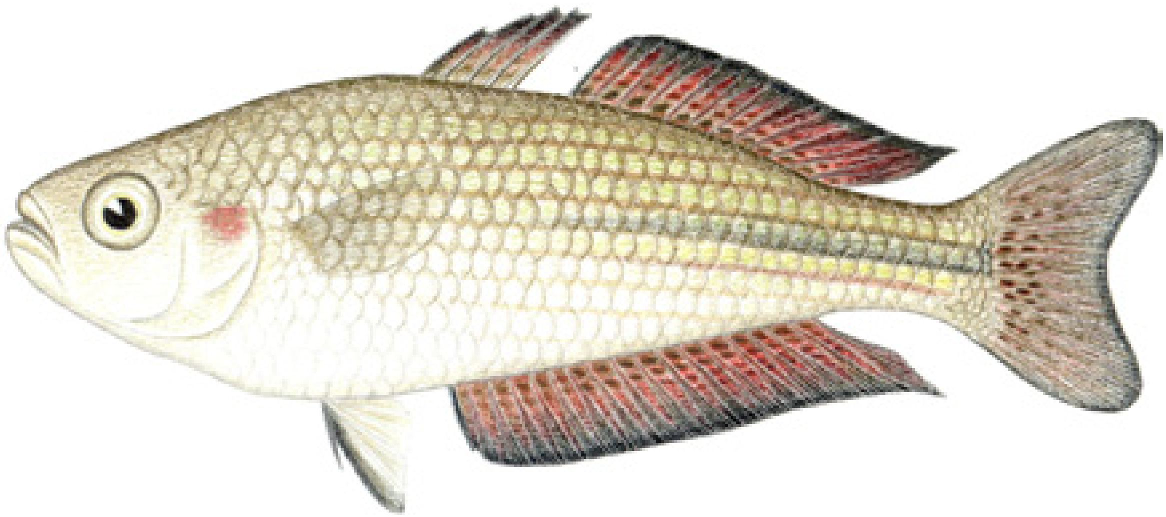
All known populations of Murray hardyhead need to be preserved to maintain the genetic diversity of this species. In Cadross Lakes deformed fish are common, which may suggest inbreeding. Gene flow between populations is unknown, but suspected as being limited or non-existent. Recovery actions need a genetic protocol for maintaining populations and further studies need to be conducted into the movements, feeding, habitat and threats to breeding success of this species.

Suggested Conservation Status:
The current conservation classification of *Craterocephalus amniculus* is sufficient until further surveys can ascertain the need for any changes. It is recommended that *Craterocephalus stercusmuscarum* var. *fulvus* be listed as 'Data Deficient' under the IUCN Red List of Threatened Species to promote further investigation into its conservation status. The status of *Craterocephalus fluviatilis* in South Australia is uncertain (M.Hammer, pers. comm. 2001). Refer to Tables 5 and 6 for further suggestions as to the conservation status of hardyheads in the Murray-Darling Basin.

References:
Crowley & Ivantsoff, 1990; FSC, 2000b; Gehrke *et al.*, 1999; M.Hammer, pers. comm. 2001; Harris & Gehrke, 1997; Ivantsoff & Crowley, 1996; Llewellyn, 1983; McCulloch, 1912; T.Raadik, pers. comm. 2000; Unmack, 2000; Wager & Jackson, 1993.

Crimson-spotted rainbowfish

Family Name:	Scientific Name:	Other Common Name(s):
Melanotaeniidae	*Melanotaenia fluviatilis* (Castelnau, 1878)	Murray River rainbowfish, inland rainbowfish



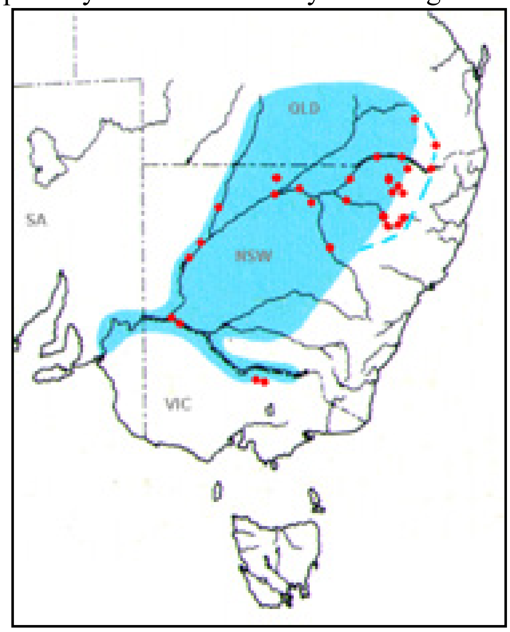
Drawing by Jack Hannan

Synonyms:
Aristeus fluviatilis Castelnau, 1878; *Melanotaenia neglecta* Rendahl, 1922.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Data Deficient	Not Listed	Not Listed

Reasons for Concern:
This species has reduced abundance and distribution, especially within the Murray River region in New South Wales (Harris & Gehrke, 1997) and northern Victoria (Allen, 1996).



Distribution:
This species occurs in the middle and lower sections of the Murray, Murrumbidgee and Macquarie Rivers, and in several other tributaries of the Darling River (Lake, 1971). Specimens collected from the Warrego, Paroo and upper Darling Rivers (and other streams between those tributaries) have been identified as *Melanotaenia splendida tatei* based on unpublished allozyme and mitochondrial DNA data (Unmack, 1997). Crimson-spotted rainbowfish are considered common and abundant in the Broken River and near Mildura in Victoria (T.Raadik, pers. comm. 2000), around the Murray-Darling confluence, and in parts of the Goulburn River in Victoria. This species is also present in the middle to upper parts of the Gwydir

River near Bingara, the Namoi River around the Peel River, Caroll Gap-Somerton on the Dumaresq River, and the Bogan River near Bogan Gate (Unmack, 2000). It has also recently been recorded in low numbers near Gin Gin on the Macquarie River and Gongologon on the Bogan River (Harris *et al*., 1998).

Australian Museum Records – 66 records (12-88mm SL), ranging in distribution from Wabby Lake (25^o 28’ S, 153^o 08’ E) in Queensland southwards to the Murray River (36^o 05’ S, 146^o 56’ E) in New South Wales, and from Crabbs Creek (28^o 28’ S, 153^o 30’ E) in New South Wales westwards to the Murray River (35^o 32’ S, 138^o 50’ E) in South Australia; collected between circa 1880 and 1999.

Habitat:
Melanotaenia fluviatilis inhabits rivers, streams, billabongs and swamps. It prefers slow-flowing or still waters with dense aquatic vegetation (Cadwallader & Backhouse, 1983).

Biology & Behaviour:
Breeding takes place between October and January as water temperatures rise. Spawning occurs during the early morning or evening just before dark. Each female lays several eggs a day, which are summarily fertilised by the male (Allen, 1996). Eggs are held amongst the foliage of aquatic plants by several long, thin filaments originating at one point on the egg membrane. The water-hardened eggs have a diameter of 1.3-1.8mm, and hatch into larvae 2.5-3.1mm in length 7 days after fertilisation (Cadwallader & Backhouse, 1983) at water temperatures between 25 and 29^{o}C (Allen, 1996). Newly hatched larvae congregate near the water’s surface within a few hours and begin feeding within 24 hours (Cadwallader & Backhouse, 1983).

Diet:
Melanotaenia fluviatilis is essentially carnivorous, feeding on both aquatic invertebrates associated with its weedy habitat and terrestrial arthropods which may fall onto or alight on the water’s surface (Cadwallader & Backhouse, 1983); however, it is also known to consume algae (Llewellyn, 1983).

Size:
Males reach a length of about 90mm while adult females are usually under 60-70mm in length (Allen, 1996).

Reasons for Decline:
Rainbowfish, like redfin perch, inhabit thickly vegetated areas and may be rapidly declining in some areas as a result of predation by the latter species, especially in enclosed waters (Cadwallader & Backhouse, 1983). Loss of riparian and instream vegetation may also have influenced their decline and resulted in the recent patchy distribution of this species, as this is a preferred habitat which is required for the adhesion and protection of the eggs during spawning. Larvae congregate near the water’s surface after hatching and in some areas may be preyed upon by the alien fish species gambusia.

There is also a high incidence of protozoan and bacterial infection of this species at low water temperatures (Allen, 1996), which may restrict population abundance in systems affected by cold water discharge from the bottom offtakes on dams.

Protected Areas in which the Species Occurs:
None known.

Recovery Objectives / Management Actions Required:
The small size of this species enables heavy predation by both native and alien fish species, therefore the eradication and/or control of alien species should significantly improve its chances of

survival. Crimson-spotted rainbowfish require adequate riparian cover and distinct seasonal water temperature changes to reproduce, so both the protection and restoration of riparian vegetation and control of coldwater releases from water storages within its range are crucial to its survival.

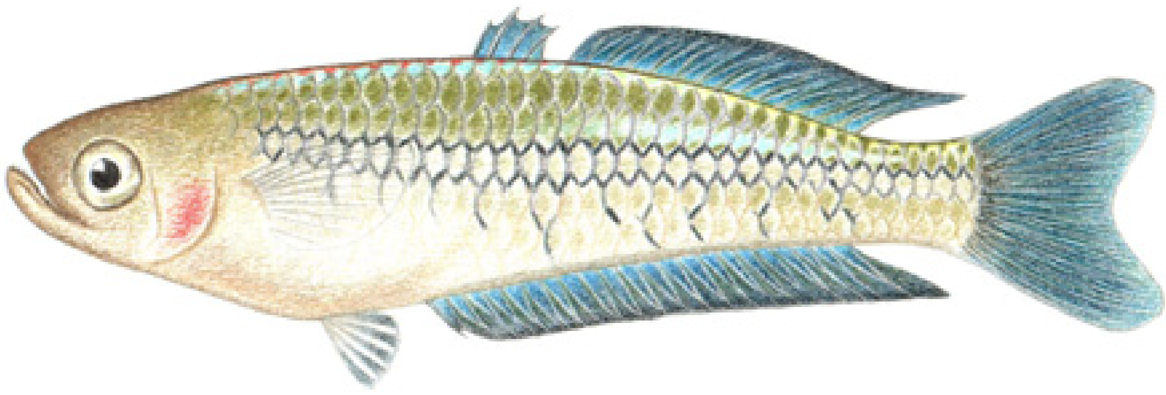
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Lower Risk (Least Concern)	Lower Risk (Least Concern)	No Change	No Change	No Change	Common	Protected

References:
Allen, 1996; Cadwallader & Backhouse, 1983; Gehrke *et al.,* 1999; Gehrke & Harris, 2000; Harris & Gehrke, 1997; Harris *et al*., 1998; Lake, 1971; Llewellyn, 1983; Moffatt *et al.,* 1997; Unmack, 1997; Unmack, 2000.

Ornate rainbowfish

Family Name:	Scientific Name:	Other Common Name(s):
Melanotaeniidae	*Rhadinocentrus ornatus* Regan, 1914	Soft-spined rainbowfish, southern soft-spined rainbowfish, sunfish, jewelfish, Fraser or Moreton Island sunfish



Drawing by Jack Hannan

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	QLD
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
This species has a patchy, localised distribution in northern New South Wales in coastal wallum stream and lake habitats (Allen, 1996).

Distribution:
The restricted range of this species comprises coastal drainages extending from Coffs Harbour (South-East Coast Drainage Division) in New South Wales northwards to the Maryborough district of southern Queensland (North-East Coast Drainage Division). It has also been collected from North Stradbroke, Moreton and Fraser Islands (Merrick & Schmida, 1984). It has most recently been found in a swamp adjacent to the Wooli Wooli River, in the Urumbilum River within the upper reaches of Orara Creek, in Bucca Bucca Creek (Lo, 2000), and in Musicians Creek in northern New South Wales (P.Jones, pers. comm. 2000). There is also an isolated population in Waterpark Creek near Yeppoon, Queensland (Unmack, 2000).

Australian Museum Records – 19 records (7-55mm SL), ranging in distribution from the Fitzroy River (22° 39' S, 150° 57' E) in Queensland southwards to Boambee Creek (30° 20' S, 153° 30' E) in New South Wales; collected between circa 1924 and 2000.

Habitat:
The ornate rainbowfish prefers sandy-substrate creeks, lakes and ponds, or streams with low flows, where water temperatures range from 20-28°C (Ivantsoff *et al*., 1996). This species exhibits an affinity for clear but darkly tannin-stained acidic waters (Allen, 1989), of pH between 5.5 and 6.8 (Merrick & Schmida, 1984).

Biology & Behaviour:
During spawning, several eggs, probably with threads which adhere to plants (Llewellyn, 1983), are laid each day and the larvae hatch in around 10 days (Allen, 1996). This species is known to survive water temperatures down to 8°C (Lo, 2000).

Diet:
The ornate rainbowfish is omnivorous (Merrick & Schmida, 1984), being known to consume insects and their aquatic larvae as well as microcrustaceans and algae (Allen, 1989).

Size:
The maximum size of male ornate rainbowfish is about 50mm SL, while females reach about 35mm SL (Allen, 1989).

Reasons for Decline:
Like the Oxleyan pygmy perch, which co-exists with the ornate rainbowfish, this species may be sensitive to the same environmental impacts, namely removal of components of its critical habitat. These include the removal of vegetation, alteration of the preferred low pH and turbidity levels of waters, and reduction of preferred insect prey (Warren, 1999). As its habitat has shrunk through development and modification, its distribution may have also declined. Coastal populations of Oxleyan pygmy perch, and thus also ornate rainbowfish, may be endangered by housing developments, road and forestry developments (including pine plantations), water pollution (nutrient enrichment, increased suspended solids and toxic substances) (Arthington & Marshall, 1996), mining operations and agriculture (Wager & Jackson, 1993). The alien gambusia is well established in several localities that support populations of both the Oxleyan pygmy perch (Arthington, 1996) and ornate rainbowfish. Arthington (1984) noted that the presence of gambusia in some dune lakes in north-eastern New South Wales had led to *Rhadinocentrus ornatus* being competitively eliminated from these swamp-fringed habitats (Timms, 1986).

Protected Areas in which the Species Occurs:
Blue Lake National Park (Stradbroke Island) (Qld)
Moreton Island National Park (Qld)
Noosa River National Park (Qld)
Cooloola National Park (Qld)
Great Sandy National Park (Fraser Island) (Qld)
Broadwater National Park, (NSW)
Yuragyir National Park (NSW)

Recovery Objectives / Management Actions Required:
The control and or eradication of pest species such as gambusia may significantly benefit this species. Populations of ornate rainbowfish that co-exist with Oxleyan pygmy perch in Broadwater National Park could also benefit from recovery actions involving the rehabilitation of degraded creeks, which have been cleared for the construction of drains (J.Knight, pers. comm. 2000) and the possible declaration of coastal wallum heathland waterbodies as critical habitat under the NSW Fisheries Management Act 1994 (1997 amendments).

Suggested Conservation Status:

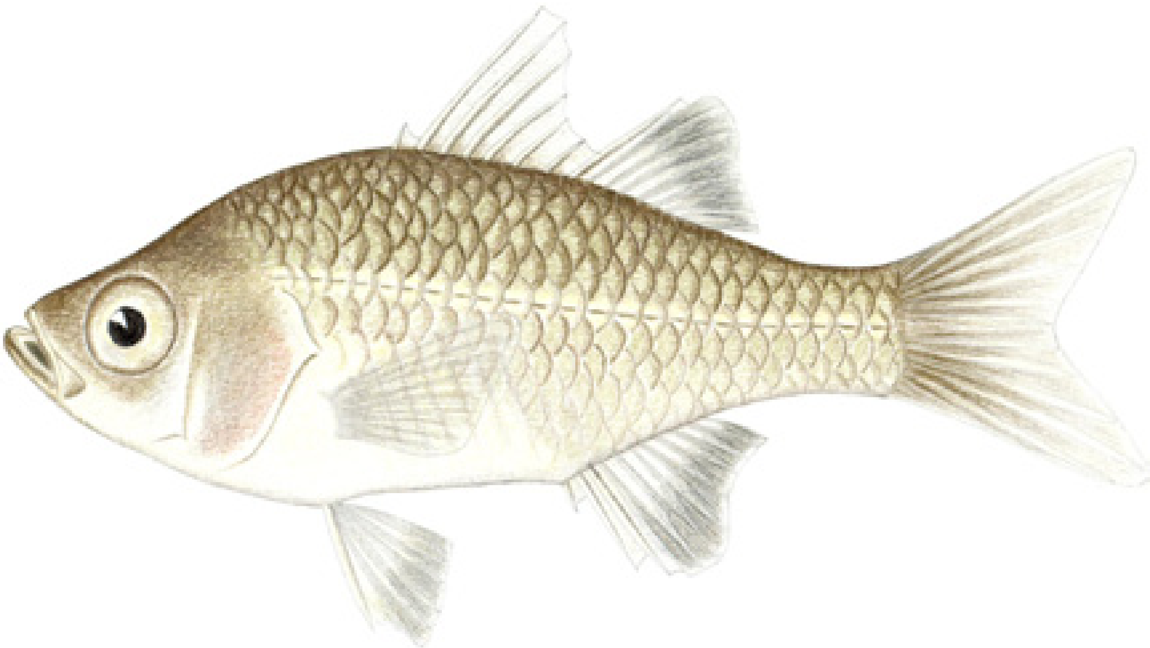
IUCN Red List	ASFB	EPBCA	NSW	QLD
Data Deficient	Data Deficient	Near Threatened	No Change	Rare

References:

Allen, 1989; Allen, 1996; Arthington, 1996; Arthington & Marshall, 1996; Ivantsoff *et al*., 1996; P.Jones pers.comm. 2000; J.Knight, pers. comm. 2000; Llewellyn, 1983; Lo, 2000; Merrick & Schmida, 1984; Timms, 1986; Unmack, 2000; Wager & Jackson, 1993; Warren, 1999.

Olive perchlet

Family Name:	Scientific Name:	Other Common Name(s):
Ambassidae (Chandidae)	*Ambassis agassizii* Steindachner, 1866	Glass perchlet, silver spray, doody, Agassiz's glassfish, western chanda perch.



Drawing by Jack Hannan

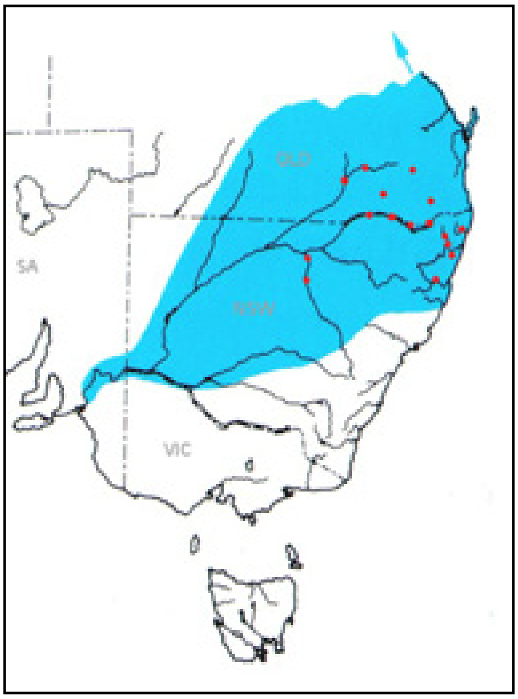
Synonyms:
Pseudoambassis castelnaui Macleay, 1881; *Pseudoambassis nigripinnis* De Vis, 1884; *Priopis olivaceus* Ogilby, 1910; *Priopis nigripinnis* Ogilby, 1910; *Ambassis nigripinnis* De Vis, 1884.

Current Conservation Status: Inland Population / Coastal Population

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Data Deficient/ Not Listed	Not Listed/ Not Listed	Not Listed/ Not Listed	Not Listed/ Not Listed	Extinct/ N/A	Not Listed/ Not Listed	Protected/ N/A

Reasons for Concern:
Ambassis agassizii has suffered reduced distribution and abundance within its southern range in the Murray-Darling Basin (Harris & Gehrke, 1997).

Distribution:
The olive perchlet's previous range encompassed tributaries of the Murray-Darling River system in western Queensland, western New South Wales, northern Victoria, and south-eastern South Australia. It is also found in coastal drainages east of the Great Dividing Range from Lake Hiawatha in northern New South Wales northwards to the Mowbray River in north Queensland (Allen & Burgess, 1990). This species has been found in Lake Broa in Queensland as well as in the Severn and MacIntyre Rivers on the New South Wales/Queensland border (Moffatt *et al.,* 1997). Presently, this species is also known to occur in the Dumaresq River around Bonshaw and in two



waterbodies near Charleville in the Warrego River catchment, and it is not uncommon in parts of the Condamine River (Unmack, 2000) as well as in rivers in northern coastal New South Wales (Harris & Gehrke, 1997; Gehrke & Harris, 2000). It has also been recorded in very low numbers in the Bogan River near Gongologon and Nyngan in New South Wales. This species was recorded near Mildura in an irrigation channel in the 1920s, but has not been recorded in Victoria since (T.Raadik, pers. comm. 2000).

Australian Museum Records – 94 records (7-63mm SL), ranging in distribution from the Archer River (13° 27' S, 142° 57' E) in northern Queensland southwards to near Narrandera (34° 36' S, 146° 25' E) in New South Wales, and from Emigrant Creek (28° 47' S, 153° 30' E) in New South Wales westwards to the Nicholson River (17° 45' S, 139° 33' E) in Queensland; collected between circa 1903 and 1998.

Habitat:
Ambassis agassizii inhabits the vegetated margins of rivers, lakes, creeks and swamps (Allen & Burgess, 1990). It is usually found in waters ~1m deep, with little or no flow, near overhanging vegetation, and especially in backwaters (Hansen, 1999). It is most commonly found amongst logs, dead branches and boulders (Allen, 1996).

Biology & Behaviour:
Olive perchlets often form large aggregations containing hundreds of individuals that disperse during darkness and congregate amongst suitable shelter during the day (Allen & Burgess, 1990). *Ambassis agassizii* spawns between November and December, or when the water temperature reaches 23°C. The adhesive eggs are about 0.7mm in diameter and are scattered amongst aquatic vegetation. Females 49mm long contain around 2350 eggs (Allen, 1996). Hatching of larvae ~2mm in length occurs within 12-36 hours and growth is rapid, individuals attaining a length of 35-40mm TL in around 150 days (Allen & Burgess, 1990). *Ambassis agassizii* prefers water temperatures between 15-25°C, a water hardness range of 5-100 ppm and a pH range of 6.0-7.5 (Hansen, 1999).

Diet:
Ambassis agassizii is a nocturnal feeder, preying mainly on microcrustaceans, aquatic and terrestrial insects, small arachnids, algae and very small fishes (Allen & Burgess, 1990).

Size:
The maximum length of *Ambassis agassizii* is about 70-80mm, but it is more commonly found at lengths of under 60mm (Allen, 1996).

Reasons for Decline:
It is most likely that a combination of various environmental pressures has led to the decline of this species in the Murray-Darling Basin. The removal of woody debris, associated pressures of alien species, thermal pollution and the loss of the natural flow regime have all contributed to the removal of this species from most floodplain and riverine habitats within the southern half of the Murray-Darling Basin.

Protected Areas in which the Species Occurs:
None known.

Recovery Objectives / Management Actions Required:
The small size of this species enables heavy predation by both native and alien fish species, therefore the eradication and/or control of alien species should significantly improve its chances of survival. The installation of thermal pollution mitigation devices on dams may also prevent the continued decline of this species. This, in combination with a return to natural flow regimes in floodplain habitats, and reintroduction of woody debris, as well as improvements to fish passage, may initiate a gradual repopulation of areas that have recently suffered a decline in this species.

Suggested Conservation Status: Inland Population / Coastal Population

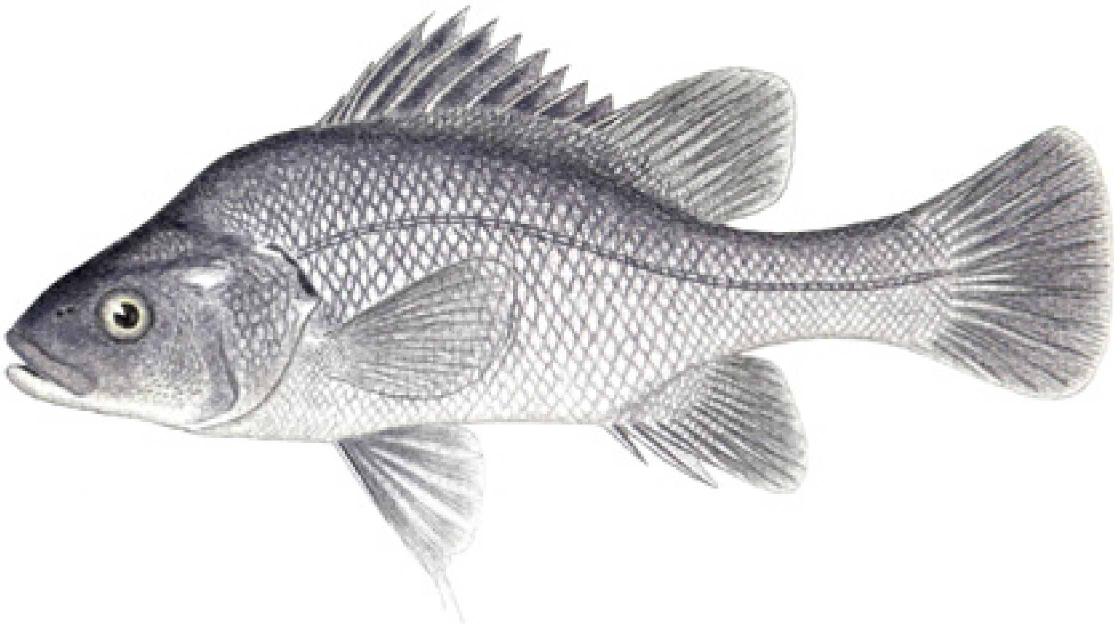
IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Lower Risk (Least Concern)/ No Change	Uncertain Status/ No Change	Near Threatened/ No Change	Endangered Population/ No Change	No Change/ N/A	Common/ Common	No Change/ N/A

The NSW Fisheries Scientific Committee is of the opinion that in the case of the western population of *Ambassis agassizii* the numbers have been reduced to such a critical level that it is in immediate danger of extinction in inland New south Wales. Therefore this inland population qualifies for inclusion under Part 2 of Schedule 4 of the Fisheries Management Act 1994 as an Endangered Population (FSC, 2001a).

References:
Allen, 1996; Allen & Burgess, 1990; FSC, 2001a; Gehrke & Harris, 2000; Hansen, 1999; Harris & Gehrke, 1997; Moffatt *et al.,* 1997; Unmack, 2000.

Macquarie perch

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae	*Macquaria australasica* Cuvier, 1830	Mountain perch, black bream, silver-eye, white-eye, Murray perch



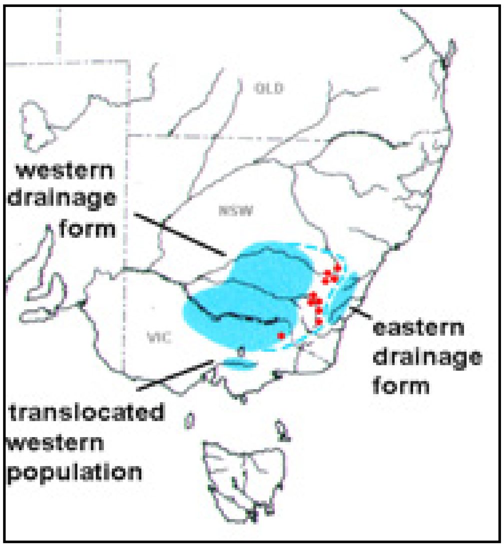
Drawing by Jack Hannan

Synonyms:
Dules viverrinus Kreft, 1868; *Dules christyi* Castelnau, 1872; *Murrayia guntheri* Castelnau, 1872; *Murrayia cyprinoides* Castelnau, 1872; *Murrayia bramoides* Castelnau, 1872; *Riverina fluviatilis* Castelnau, 1872; *Murrayia riverina* Macleay, 1881; *Murrayia jenkinsi* Macleay, 1885.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT
Endangered	Endangered	Endangered	Vulnerable	Endangered	Endangered

Reasons for concern:
Populations of the western drainage fish are now restricted, fragmented, and absent from much of the species' former known range (Harris & Gehrke, 1997). The species is also susceptible to the EHN virus, which is spread by redfin perch throughout much of the former western distribution of Macquarie perch (Wager & Jackson, 1993).



Distribution:
This species' former distribution extended throughout the cooler reaches of the Murray-Darling drainage in New South Wales and Victoria (Wager & Jackson, 1993), but it is also known from some major coastal drainages and their tributaries, including the

Hawkesbury and Shoalhaven River catchments (Cadwallader, 1981; Gehrke *et al*., 1999; Gehrke *et al*., 2001). Whitley (1964) also mentions Macquarie perch as being present in tributaries of the Murray-Darling River system in southern Queensland (Cadwallader, 1977). Transfers of Australian native fish from one catchment to another have been poorly documented in the past, and this can result in some confusion in separating the relationships between various stocks of the same or closely related species (Cadwallader, 1981). Problems also arise from catch-recording forms issued to commercial fishers in western New South Wales, which have resulted in catches of Murray cod being incorrectly recorded as Macquarie perch. This in turn has led to spurious records of Macquarie perch as once being abundant in some rivers where the species had never occurred (Reid *et al*., 1997). Although several impoundments in the Shoalhaven and Hawkesbury River systems have been stocked with Macquarie perch from the Murray-Darling Basin, two, and possibly three, separate species are thought to exist; one in the Murray-Darling Basin, one in the Shoalhaven Basin and possibly a third in the Hawkesbury Basin. Macquarie perch have also proliferated in the past in some impoundments such as Cataract Dam in the Hawkesbury Basin and Lake Dartmouth in northern Victoria (Cadwallader, 1986). This species has also been stocked in the Wannon, Barwon and Yarra Rivers in Victoria (Wager & Jackson, 1993). Currently, however, wild populations of the western drainage fish are now very restricted and fragmented, and absent from significant sections of this species' former range. Harris and Gehrke (1997) recorded a small population in the Abercrombie River and populations are also known from the Queanbeyan, upper Murrumbidgee and Goodradigbee rivers (Lintermans, 2000). Eastern drainage fish are relatively more abundant, but some decline in their populations is also evident. In the Australian Capital Territory the Macquarie perch is restricted to four rivers, the Murrumbidgee, Molonglo, Paddys and Cotter Rivers (ACT Government, 1999c; Lintermans, 2000).

Australian Museum Records – 92 records (33-425mm SL), ranging in distribution from near Moree (29^o 28' S, 149^o 51' E) in New South Wales southwards to Seven Creeks (36^o 45' S, 145^o 34' E) in Victoria, and from Bowen's Creek (33^o 27' S, 151^o 29' E) in New South Wales westwards to the Murray River (35^o 43' S, 144^o 15' E) in Victoria; collected between circa 1878 and 1994.

Habitat:
Most riverine populations of Macquarie perch are found in the upper reaches of catchments where siltation loads are not heavy and where there are still deep holes interspersed with shallow riffles (Cadwallader, 1981).

Biology & Behaviour:
From studies carried out on western drainage populations, *Macquaria australasica* is a relatively fecund, fast growing and early maturing species, sometimes seen in large shoals near river margins (Cadwallader & Backhouse, 1983). Despite these characteristics, most known populations are small (FSC, 1999). Males breed at two years of age and 210mm, females at three years and 300mm. They spawn just above riffles (shallow, fast-running waters) (Wager & Jackson, 1993) in shallow upland streams in October and November. Populations in Lake Eildon, Victoria, had a spawning migration towards and into inflowing rivers. The fish congregate below the upstream limit of the slack water (at the head of a riffle area and on or near the downstream lip of a pool) when water temperatures rise to around 16^oC. On release, the cream-coloured eggs have a diameter of 1-2mm. The eggs become transparent and increase to 4mm in diameter 20-30 minutes after fertilisation. Eggs and milt are swept downstream until the adhesive eggs are lodged between small boulders and pebbles, some as far as 30m downstream of the spawning site. Fecundity varies from ~50,000 to 110,000 eggs per female. Eggs hatch after 10-18 days at $11\text{-}18^oC$ and larvae shelter amongst pebbles. Spawning is continued on the same bed for around two weeks and some populations have been known to use the same sites in the following year (Cadwallader & Rogan, 1977). There was no significant difference in growth rate between males and females from studies conducted in Lake Dartmouth (125mm in their first year, and up to 370mm after 5 years for fish in the Murray-Darling River drainage) (Harris & Rowland, 1996). Eastern populations of this species

mature at sizes as small as 75mm TL and inhabit rivers with very different hydrology from the inland form (Unmack, 2000).

Diet:
Newly hatched larvae feed on zooplankton; older fish feed mainly on benthic invertebrates, particularly insects (Cadwallader & Backhouse, 1983). This species has been shown to adapt to eating several types of foods in captivity that would not normally be encountered in its natural riverine habitats (Cadwallader, 1986).

Size:
In drainages flowing west of the Great Dividing Range, Macquarie perch have been recorded at sizes up to 460mm and 3.5kg, but are not commonly caught at weights of more than 1.5kg. Fish in drainages flowing east of the Great Dividing Range are distinctly smaller in both maximum size and size at maturity, generally reaching lengths of less than 180mm (Harris & Rowland, 1996).

Reasons for Decline:
The causes of declines in *Macquaria australasica* populations are likely to include overfishing by recreational fishers, EHN disease (carried by redfin perch and considered highly infectious to Macquarie perch), habitat degradation (especially increased catchment erosion leading to siltation of spawning and aggregating sites and narrowing of channels), destruction of invertebrate food fauna, and the infilling of deep holes and snag removal (Wager & Jackson, 1993). Competition with and predation by trout, carp and redfin perch have also led to the decline of Macquarie perch populations (FSC, 1999). Barriers in the form of large water storage dams have fragmented populations and prevented successful spawning in several locations. Macquarie perch are dependent on a high quality habitat with natural flow and temperature regimes, and access to gravel spawning beds in flowing waters, for their successful reproduction (ACT Government, 1999c). Declining relict populations have been noted in Burrinjuck, Googong and Cotter Dams since their construction (Harris & Rowland, 1996; Lintermans, 2000). Dams also modify water flows and temperatures, sometimes for great distances downstream, which may lead to spawning failure or inhibit spawning cues as well as reducing the availability of preferred spawning habitats (ACT Government, 1999c).

Protected Areas in which the Species Occurs:
Protected Water Catchment Areas upstream of the Upper Nepean water storages (NSW)
Seven Creeks Wildlife Reserve (Vic)
Namadgi National Park (ACT)
Gigerline Nature Reserve (ACT)
Woodstock Nature Reserve (ACT)
Bullen Range Nature Reserve (ACT)
Stoney Creek Nature Reserve (ACT)
Googong Foreshores (NSW)
Lower Molonglo Nature Reserve (ACT)

Recovery Objectives / Management Actions Required:
Habitat management, monitoring and the restoration of areas containing original stocks of this species, and the prohibition of stocking trout in such locations, are important conservation measures (Wager & Jackson, 1993). Prevention of siltation and protection of appropriate river flows for spawning are practical objectives in known spawning locations (Gehrke & Harris, 1996). There is a need to ensure tight controls on the translocation and introduction of this species outside its original distribution, so as not to cause further taxonomic confusion and possible hybridisation (Cadwallader, 1981). Further ecological work is also required on this species to determine its environmental tolerances, interactions with alien species, and resolution of the species' taxonomic status (Wager & Jackson, 1993).

Macquarie perch in the Australian Capital Territory should benefit from new environmental flow guidelines, which prescribe minimum flows and higher seasonal flows in the Cotter River. These populations should also benefit from the prohibition on the stocking of alien species and the continued ban on angling in Cotter Dam. Translocation of these populations past the barrier posed by Vanity's Crossing in this system, further monitoring of these populations, and possible future stocking at additional locations will also be undertaken by Environment ACT (ACT Government, 1999c).

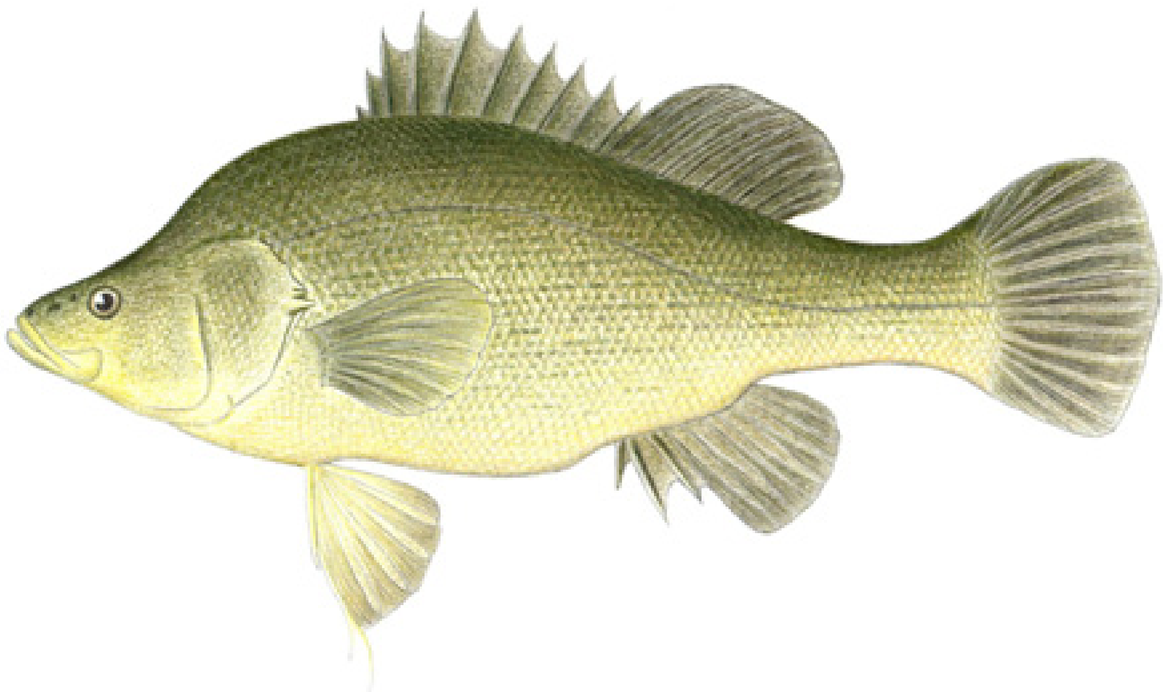
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT
No Change	No Change	No Change	No Change	No Change	No Change

References:
ACT Government, 1999c; Cadwallader, 1977; Cadwallader, 1981; Cadwallader, 1986; Cadwallader & Backhouse, 1983; Cadwallader & Rogan, 1977; FSC, 1999; Gehrke & Harris, 1996; Gehrke *et al*., 1999; Gehrke *et al*., 2001; Harris & Rowland, 1996; Lintermans, 2000; Unmack, 2000; Wager & Jackson, 1993.

Golden perch

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae	*Macquaria ambigua* (Richardson, 1845)	Yellowbelly, callop

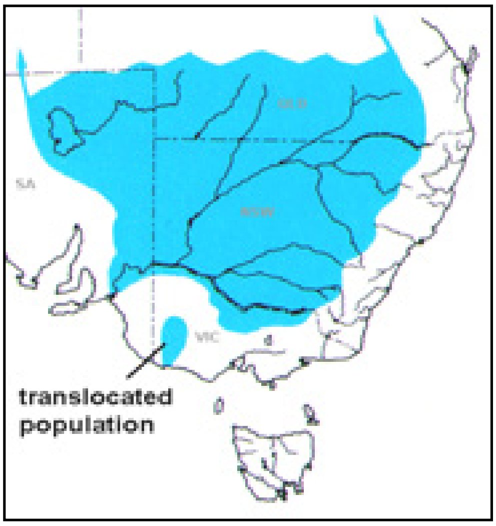


Drawing by Jack Hannan

Synonyms:
Datnia ambigua Richardson, 1845; *Ctenolates macquariensis* Günther, 1871; *Dules auratus* Castelnau, 1872; *Dules flavescens* Castelnau, 1875; *Plectroplites ambiguus* McCulloch.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed



Reasons for Concern:
Although relatively common throughout the Murray-Darling system, possibly between 3 and 5 different sub-species of golden perch may exist in different areas (Keenan *et al.,* 1997). Abundance in the Murray River around Euston appears to have declined by ~50% since the 1940s (Mallen-Cooper, 1992).

Distribution:
Golden perch occur throughout the Murray-Darling River system, except at higher altitudes (NSW Fisheries Freshwater Fish Database, 2000). This fish also occurs in the Lake Eyre and Bulloo internal drainage systems of Queensland, New South Wales

and South Australia, and the Dawson River system of coastal central Queensland (Harris & Rowland, 1996). In the Darling region in New South Wales, golden perch are still the fourth most common native species (Gehrke & Harris, 2000), but numbers in the Murray region are low in comparison.

Australian Museum Records – 52 records (21-470mm SL), ranging in distribution from the Georgina River (19° 46' S, 138° 18' E) in Queensland southwards to the Murrumbidgee River (36° 07' S, 149° 07' E) in New South Wales, and from the Namoi River (30° 44' S, 150° 45' E) in New South Wales westwards to the Georgina River (19° 46' S, 138° 18' E) in Queensland; collected between circa 1885 and 1997.

Habitat:
The golden perch is found in habitats ranging from clear, rocky headwaters to generally turbid, slow-flowing rivers, creeks, billabongs and backwaters. It is also found in large, shallow, turbid lakes in western New South Wales, as well as in deep pools containing cover such as dead trees or fallen timber, undercut banks or rocky ledges (Battaglene, 1987). Juvenile golden perch may occur in large numbers in extensive inundated floodplain habitats adjacent to western rivers that retain a natural flow regime (Gehrke *et al*., 1999).

Biology & Behaviour:
Golden perch are a migratory species, with both adults and juveniles moving upstream following increases in flow during spring and summer (Harris & Rowland, 1996). Triggered by a rise in water temperature to 23°C, sexually mature specimens begin to congregate for spawning. Females can hold eggs at an advanced stage of development for 3-5 months until conditions are suitable for spawning. Up to 650,000 eggs are shed together only once per season (Cadwallader &Backhouse, 1983), and after hatching the small (3.5-4.0mm TL), transparent pelagic larvae are poorly developed and have a relatively small yolk sac. Four days after hatching the larvae (then 5.0-5.5mm TL) commence schooling, and at 5 days they disperse and commence feeding (Rowland, 1996).

Diet:
Golden perch are opportunistic carnivores. Fry feed on large zooplankton, mainly copepods and cladocerans (Cadwallader & Backhouse, 1983), other small crustaceans, aquatic insects and small fish. Adults and juveniles prey largely on fish in winter and yabbies in summer (Battaglene, 1987). Golden perch are also known to consume freshwater molluscs.

Size:
Golden perch have been recorded up to 760mm and 23kg, but are more commonly caught at sizes of less than 5kg. Fish stocked in impoundments are often larger than fish in river habitats (Harris & Rowland, 1996).

Reasons for Decline:
Impacts derive from the removal of inundated floodplains and river flow regulation due to the construction and poor management of dams and weirs, unnatural seasonal flow and temperature regimes, and the effects of alien fish species (Gehrke, 1992a; Gehrke, 1992b; Gehrke, 1992c; Gehrke *et al.,* 1995). Poor water quality as a result of altered flow regimes can make some floodplain nurseries uninhabitable (Gehrke, 1994). These factors impede fish movement, recruitment and dispersal, as well as removing the frequency of key environmental triggers needed for reproduction.

Walker in (Williams, 1980) concluded that the absence of this species from the Murray River near Albury-Wodonga was linked to the environmental changes following construction of Lake Hume, the establishment of alien species, and variations in water levels due to irrigation management.

Protected Areas in which the Species Occurs:
Willandra National Park (NSW)
Kinchega National Park (NSW)
Kosciusko National Park (NSW)

Recovery Objectives / Management Actions Required:
Improving flow regimes at critical times of the year (i.e. when spawning) and correcting any impediments to fish passage to allow better dispersal and recruitment are two important management actions necessary for the recovery of golden perch. Because golden perch are heavily stocked, and the possibility of between 3 and 5 sub species existing within the Murray-Darling Basin, it is recommended that further studies be conducted into the genetics of this species to investigate the possible negative effects of any stocking.

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Lower Risk (Least Concern)	Lower Risk (Least Concern)	No Change	No Change	No Change	No Change	No Change	No Change

References:
Battaglene, 1987; Cadwallader & Backhouse, 1983; Gehrke, 1994; Gehrke, 1992a; Gehrke, 1992b; Gehrke, 1992c; Gehrke *et al.*, 1995; Gehrke *et al.*, 1999; Gehrke & Harris, 2000; Harris & Rowland, 1996; NSW Fisheries Freshwater Fish Database, 2000; Rowland, 1996.

Eastern cod

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae	*Maccullochella ikei* Rowland, 1986	Eastern freshwater cod, east coast cod, Clarence River cod.

Drawing by Jack Hannan

Current Conservation Status:

IUCN 2000 Red List	EPBCA	ASFB	NSW
Endangered (A1acd)	Endangered	Endangered	Endangered

Reasons for Concern:
Wild populations of this species are now restricted to isolated tributaries of the Clarence River. It is now considered to be extinct in the Richmond River catchment except for stocked fish (Rowland, 1993).

Distribution:
The eastern cod was formerly distributed in all or most freshwater reaches of the Clarence River and its tributaries, and probably also the Richmond River system. Fish up to around 30kg were frequently caught in the Clarence and Orara Rivers, but now this species is very rare or absent in the major northern tributaries of the Clarence River system. Since the 1960s only small numbers of eastern cod have been captured from tributaries such as the Nymboida, Little Nymboida, Boyd and Mann Rivers (Rowland, 1993). They are now only found naturally in a few tributaries of the Clarence system, with wild populations now thought to be extinct in the Richmond system (NSW Fisheries, 2000).

Australian Museum Records – 15 specimens (295-456mm SL), ranging in distribution from the Richmond River (28^o 43' S) southwards to the Nymboida River (29^o 51' S) in northern New South Wales; collected between circa 1934 and 1998.

Habitat:
Maccullochella ikei inhabits clear, flowing streams with rocky substrates and deep holes, generally under and around sunken instream cover. Riparian vegetation, large boulders and woody debris provide a complex array of habitats for each stage of its life cycle (Eastern Cod Recovery Team, 1999), while also having a strong influence on the quality of food and habitat resources available (Lehtinen *et al.,* 1997).

Biology & Behaviour:
Maccullochella ikei is an aggregating, aggressive fish, with no distinct pattern of migratory movements (Eastern Cod Recovery Team, 1999), which becomes sexually mature at 4-5 years of age and 700g to 1.5kg in weight. The eastern freshwater cod spawns in spring when water temperatures rise above 16^{o}C. It deposits large (3mm) strongly adhesive eggs onto rocks or logs, and these begin to hatch after 8 days. Hatching is complete 12 days after fertilisation at water temperatures of around 17-20^{o}C, and fry commence feeding on zooplankton about 12 days after hatching (Rowland, 1996).

Diet:
The eastern cod is known to prey upon other fishes, crustaceans, frogs and snakes. Larvae feed on zooplankton and aquatic insects (Harris & Rowland, 1996).

Size:
This species has been recorded up to 41kg in weight, but most fish now caught only range up to around 5kg (Harris & Rowland, 1996); the eastern cod is thus one of Australia's larger freshwater fish. It has a maximum standard length of about 800mm, but it is more commonly caught at lengths of around 400-500mm (Allen, 1989).

Reasons for Decline:
Both the distribution and abundance of *Maccullochella ikei* declined initially during the 1920s and 1930s due to the combined effects of agricultural development and overfishing (Wager & Jackson, 1993) and heavy natural flooding of its habitat following severe bush fires, causing a deterioration of water quality and leading to widespread fish kills. Additionally, releases of contaminated water from the tailings dams at gold and tin mines upstream are also thought to have caused the decline of populations of eastern cod and other fish species in parts of the Clarence River system (NSW Fisheries, 2000). Its continued decline in numbers is possibly due to the effects of these large initial losses, which would have reduced the eastern cod's ability to recover within the presently small and isolated populations remaining in this system (Rowland, 1993). The low fecundity of this species presumably limits the resilience of eastern cod to environmental disturbance (Ingram *et al.,* 1990).

It is possible that the eastern cod could also be adversely affected by the introduction of Murray cod into parts of its coastal distribution. Murray cod may either compete with or hybridise with eastern cod, further depleting their natural genetic diversity. Other species such as barred grunter *Amniataba percoides,* goldfish *Carassius auratus* and gambusia *Gambusia holbrooki* have also been introduced or translocated to areas within the range of the eastern cod, and thus may also potentially compete with this species for resources (Eastern Cod Recovery Team, 1999) and or expose it to disease and predation (NSW Fisheries, 2000).

Habitat modification has reduced river features such as riparian vegetation, instream rocks and woody debris, undercut banks, diverse water velocities and pool-riffle sequences. Agriculture has also increased the effects of pollution from fertilisers, pesticides, animal waste, acid runoff and siltation. Major potential pollution sources also include urban development, mining, industry, municipal waste and forestry operations. Suitable river substrates for invertebrate food production have also been reduced and there is evidence of increases in sedimentation and deposited solids from the combined effects of agriculture, forestry, mining and civil construction works (NSW Fisheries, 2000). Reductions in river flows by creating weir pools for municipal water supply is a major concern within the species' distribution.

The Nymboida Weir presents a major barrier to fish passage for eastern cod, being located within the range of the remnant natural populations. This may prevent access to spawning and feeding areas, fragment surviving populations and interrupt genetic flow. Despite its current protected status, illegal fishing for eastern cod is still taking place which, although undocumented, may be responsible for removing a significant number of fish. There is an increasing trend towards catch and release fishing for eastern cod, which may render the species susceptible to handling-induced mortality (NSW Fisheries, 2000).

Protected Areas in which the Species Occurs:
Border Ranges National Park (NSW)
Guy Fawkes National Park & Nature Reserve (NSW)
Nymboida National Park (NSW)
Mann River Nature Reserve (NSW)

Recovery Objectives / Management Actions Required:
Actions necessary for the conservation of *Maccullochella ikei* include habitat protection, education, research, stock enhancement and stock translocation (Eastern Cod Recovery Team, 1999), with the main aim being the re-establishment of self-maintaining populations (Ingram *et al.*, 1990). Careful planning of any future artificial breeding and stocking is needed if the risk of causing harmful changes to this species' genetic characteristics are to be avoided. NSW Fisheries is working with local community groups such as Project Big Fish to design an ongoing stocking program to ensure that the best genetic mix is maintained and that appropriate stocking sites are chosen. NSW Fisheries has also intensified research to provide ongoing information concerning current and past stocking strategies (NSW Fisheries, 2000) as well as the distribution and abundance of wild populations (I.Wooden, pers. comm. 2001).

Suggested Conservation Status:

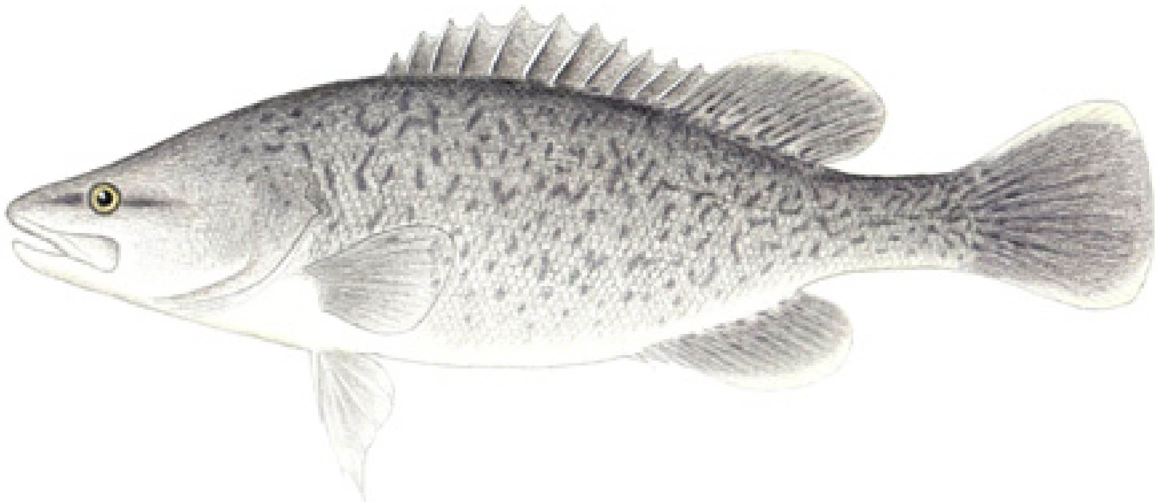
IUCN Red List	EPBCA	ASFB	NSW
No Change	No Change	No Change	No Change

The classification of eastern cod as 'Endangered' should remain until it is determined that the remaining populations are fully self-maintaining and preferably increasing throughout a substantial portion of their natural distribution in the Clarence and Richmond River systems (Faragher *et al.*, 1993).

References:
Allen, 1989; Eastern Cod Recovery Team, 1999; Faragher *et al.*, 1993; Harris & Rowland, 1996; Ingram *et al.*, 1990; Lehtinen *et al.,* 1997; NSW Fisheries, 2000; Wager & Jackson, 1993; I.Wooden, pers. comm. 2001.

Trout cod

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae	*Maccullochella macquariensis* (Cuvier, 1829)	Blue-nose cod



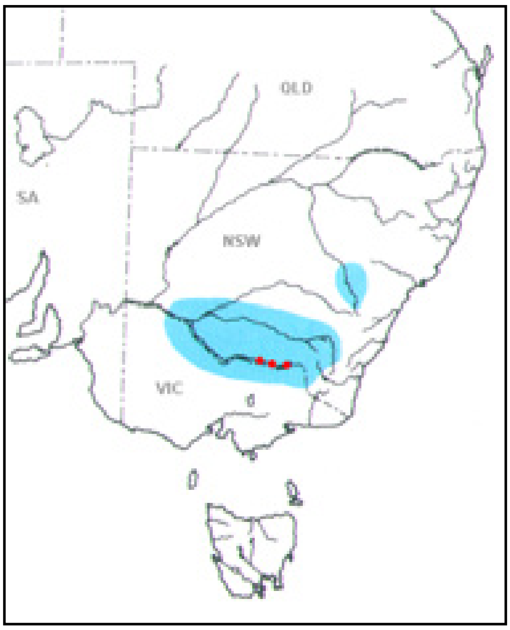
Drawing by Jack Hannan

Synonyms:
Grystes brisbani Lesson, 1825; *Grystes macquariensis* Cuvier, 1829; *Grystes brisbani* Lesson, 1830; *Oligorus mitchelli* Castelnau, 1873; *Oligorus gibbiceps* Macleay, 1885.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT	SA
Endangered (C2a)	Endangered	Critically Endangered	Endangered	Critically Endangered	Endangered	Protected

Reasons for Concern:
This species was formerly distributed widely in the upper reaches of the Murray-Darling River system, being recorded from the Macquarie River in New South Wales downstream as far as Mannum in South Australia (Wager & Jackson, 1993), and as being widespread in the Murrumbidgee River. The only known surviving wild population is in the Murray River below Yarrawonga downstream to Tocumwal (Ingram *et al.*, 1990). The trout cod was only formally recognised as a separate species from the Murray cod in the 1970s (Berra & Weatherly, 1972), by which time the species had already declined.



Distribution:
The trout cod is now only found in a few restricted freshwater sites in south-eastern Australia, though its natural range was formerly throughout much of the upper reaches of the Murray-Darling Drainage Division (Wager & Jackson, 1993). It has been

recorded downstream as far as Mannum in South Australia (Wager & Jackson, 1993), and as far north as the Macquarie River in New South Wales. Formerly widespread in the Murrumbidgee River in the Canberra region, the last records from the ACT were in the mid 1970s, from the Gigerline Gorge near Tharwa (Lintermans *et al.,* 1988; Lintermans, 2000). Small numbers of these fish have been found negotiating Yarrawonga Lock fishway (Harris & Thorncraft, 1997). The current extent of the trout cod population is restricted to a single natural sub-population in the Murray River from Mulwala to Tocumwal (Douglas *et al*., 1994), and a single re-stocked sub-population in Seven Creeks, Goulburn River system, Victoria (Brown *et al.,* 1998). Occasional catches have also been taken further downriver towards the Barmah State Forest. Trout cod have been stocked in most of the more southerly upper reaches of the Murray-Darling drainage, with initial and recent surveys suggesting little expansion of range or abundance. In New South Wales, stocked populations exist in the upper Murray River above Hume Weir, the upper Murrumbidgee River between Adaminaby and Murrells Crossing near Cooma, the middle sections of the Murrumbidgee River from Burrinjuck to Yanco Weir, the Macquarie River at Dubbo and Bathurst, as well as Talbingo Dam in the Kosciusko National Park.

Stocked populations exist in Victoria in Koetong, Hughes, Ryans and Buffalo Creeks and the Coliban and Broken Rivers. In the Australian Capital Territory, populations have been stocked in the Bendora Reservoir on the Cotter River, in the Namadgi National Park and at Angle Crossing on the Murrumbidgee River (Pogonoski *et al.,* 2001). Further surveys using improved stock identification techniques (e.g. genetic analysis) may yield a greater level of confidence in the results of this trout cod stocking program.

Australian Museum Records – Over 100 specimens (40-730mm in SL), ranging in geographical distribution from the Macquarie River in New South Wales southwards to Seven Creeks in Victoria; collected from around 1880 to 1993.

Habitat:
This species is found in two distinct types of habitats. In the Murray River it is associated with various substrates and around instream cover of snags and woody debris, whereas in Seven Creeks it is found in a narrow stream with rock, gravel and sand substrates, as well as in pools mixed with rapids and cascades (Harris & Rowland, 1996).

Biology & Behaviour:
Trout cod spawn during spring and early summer, roughly two weeks before Murray cod, when water temperatures are around 17-18^{o}C. Sexual maturity is reached at 3-5 years of age, weights of 0.75-1.5kg (Harris & Rowland, 1996), and lengths of 350mm and 430mm for males and females, respectively. Males and females form pairs, and all eggs are released at one expulsion (Koehn & O'Connor, 1990). The eggs, numbering between about 1200 and 11,000, are large (2.5-3.6mm), adhesive and opaque, and are probably deposited on hard surfaces on or near the stream bottom. Larvae hatch in 5-10 days at 20^{o} C, form clumps, and after the yolk sac is absorbed, actively swim up into the water column. At 6-9mm they begin feeding on zooplankton (Harris & Rowland, 1996). Juveniles exhibit territorial aggression at around 40-50mm in length (Koehn & O'Connor, 1990). Larger fish seek refuge in deep holes, while smaller fish find cover beneath and amongst boulders (Barnham, 1998). Generally, trout cod are more active at lower temperatures than Murray cod. Snags also form a large component of the trout cod's habitat, and in lowland habitats this species is in constant competition with Murray cod for space. Trout cod usually congregate around medium to large snags that occur singly. These single snags are usually located in the midstream, orientated to give the highest water flow (Schiller & Wooden, 2000). Little is known about the biology of trout cod in the wild, and much of the known biological information comes from hatchery-reared fish. Preliminary research in the Murray River demonstrates that trout cod display high site fidelity and a small home range. There is no evidence of extended migrations in regulated rivers (Pogonoski, *et al.,* 2001).

Diet:
Adult and juvenile trout cod feed on other fish, crustaceans, aquatic insects and molluscs, while the larvae feed on zooplankton (Harris & Rowland, 1996).

Size:
This species is known to reach 800mm in length and 16kg in weight, but the average size caught is around 400-500mm and 1.5-3kg (Barnham, 1998).

Reasons for Decline:
Over the past half-century, trout cod have undergone a dramatic decline in both their distribution and abundance. The effects of fishing and the construction of dams, weirs and river improvement works (e.g. desnagging and channel modifications) are suspected as being the major factors affecting trout cod numbers (Douglas *et al*., 1994). As a result of de-snagging (a limiting factor in trout cod abundance), their habitat is now patchily distributed and limited in availability. Brown & Nicol (1998) identified de-snagging as the main causal factor in the decline of trout cod populations, together with interspecific competition, flow regulation and illegal fishing as probable and possible secondary causes. Overfishing by recreational and commercial fishers has also impacted upon trout cod populations by removing many of the larger breeding individuals. Additionally, interactions with introduced species have been implicated in trout cod declines through competition and predation. These declines have led to fragmentation of their populations over their range. As a result, the genetic diversity of trout cod populations has decreased. In some impoundments (e.g. Cataract Dam on the Nepean River, New South Wales) hybridisation (crossbreeding) with Murray cod has taken place. Nonetheless, the captive breeding program has an important role to play in ensuring the survival of the species by re-introducing populations into suitable habitat within their former distribution. Since 1986, approximately 750,000 trout cod, bred at the Narrandera Fisheries Centre, New South Wales (nearly 500,000) and Snob's Creek Hatchery, Victoria (261,000), have been released as fingerlings or juveniles into sites within the trout cod's natural range (Pogonoski, *et al*., 2001). However, there is no evidence that stocked trout cod have since bred in natural habitats and thus helped to successfully re-establish local populations (Koehn *et al.*, 1999). Ongoing study of stocked populations is required to determine their reproductive status and recruitment success.

Limited prior knowledge of this species makes it difficult to assess the extent to which any or all of the implicated factors have contributed to the declines observed in natural populations (Ingram *et al*., 1990). Presently, loss of riparian vegetation and the establishment of exotic plants and alien fish species, such as trout, redfin and carp, hinder trout cod from extending their natural and artificially stocked range and abundance (Douglas *et al.*, 1994). Stocked juveniles in the Murrumbidgee River have competed with established and recently stocked brown trout and rainbow trout (Faragher *et al.* 1993). Areas in north-eastern Victoria where trout cod have been eliminated are those which have been most heavily stocked with trout (Ingram & Richardson, 1989). Because of their low fecundity, trout cod are vulnerable to overfishing (Ingram & Richardson, 1989). The continual decline in trout cod numbers has also been related to their hybridisation with Murray cod (Brown *et al.,* 1998).

Past effects of commercial and recreational fishing on trout cod are difficult to quantify because they have often been confused with Murray cod. Identification problems have thus hindered the examination of historical data from catch records. However, it is suspected that fishing has significantly reduced the numbers of trout cod. The effect of post-hooking cryptic mortality from angling also threatens trout cod caught in waters where they are currently fished and released. There is now a total ban on the taking of trout cod from all New South Wales, Victorian and Australian Capital Territory waters. If caught, trout cod must be carefully returned to the water. Similarly, bans on set lining for all fish species between Yarrawonga Weir and the Tocumwal Road Bridge on the Murray River should help to alleviate the fishing stress on trout cod. A seasonal closure to all fishing between Yarrawonga Weir and Tocumwal Road Bridge exists from the start of September to the end of November to protect breeding trout cod and other native fishes. Illegal trout cod fishing, however, still poses a threat to remaining populations (Pogonoski *et al.,* 2001).

The regulation and modification of river flows adversely affects the functioning of natural riverine ecosystems. This is evident through a number of impacts, including thermal pollution, altered frequency and duration of high and low flows, changes in flow variability over various time scales, and the construction of weir pools which disrupt fish migration pathways (Gehrke *et al*., 1995; Gehrke & Harris, 2001b; Pogonoski *et al.,* 2001).

The alteration of river flow regimes results from the combined effects of dam and weir construction, flow regulation from these structures, and the extraction of water for irrigation, town water supplies and stock and domestic supplies. These changes have hampered the dispersal of trout cod by impeding fish passage and reducing colonisation of former habitats. Modifications to the natural flow regime and the downstream displacement of fishes to degraded or unsuitable habitats threaten the Seven Creeks population in Victoria. Natural barriers (i.e. steep gorges) prevent the recolonisation of upstream sites in this instance. Releasing cold water from the bottoms of dams can hinder the natural breeding cycles of native fishes by lowering water temperatures, which may delay the onset of spawning. The re-alignment or removal of snags has decreased the available habitat for trout cod and this trend needs to be reversed (i.e. by resnagging of waterways) to increase the amount of critical habitat. Deterioration in water quality and pollution of freshwater creeks and rivers has also adversely affected trout cod numbers. Increased runoff and siltation caused by logging in riverine areas has probably also contributed to the overall deterioration in water quality implicated in the decline of the trout cod. The loss of native riparian vegetation has led to erosion of riverbanks and has possibly affected the extent of shelter available for juvenile trout cod. Private landholders on properties adjoining river reaches inhabited by trout cod have an obligation to maintain river health by ensuring that farming practices do not adversely impact upon water quality (Pogonoski *et al.,* 2001).

It is likely that trout cod have also been adversely affected by alien fish species such as trout, carp, redfin and goldfish. Alien species compete with trout cod for resources such as food (e.g. adult trout cod compete with trout and redfin for smaller fishes and invertebrates) and prey directly on juvenile trout cod (e.g. trout). Areas in northern Victoria where trout cod have been eliminated were areas that have been heavily stocked with trout. This suggests that, of all alien species, trout may pose the greatest threat to trout cod (Pogonoski *et al.,* 2001).

Trout cod are known to be affected by protozoan parasites such as *Chilodinella* sp. in aquaculture environments and this may also be a threat to trout cod in the wild. Trout cod are also known to be prone to copepod parasites (fish lice). The degrees to which parasites and diseases affect trout cod are not well known. However, it is accepted that alien fishes have the potential to transfer parasites and diseases to native fishes (Ingram & Rowland, 1990).

Bushfires have the potential to adversely affect trout cod populations by runoff of water containing particulate matter or sediments, resulting in siltation and the lowering of oxygen levels. Although runoff is a natural process, the effects of runoff after bushfires have been exacerbated through human activities such as excessive clearing of riparian forests (Pogonoski *et al.,* 2001).

Protected Areas in which the Species Occurs:
Seven Creeks Wildlife Reserve (Vic)
Buffalo National Park (Vic)
Kosciusko National Park (NSW)
Namadgi National Park (ACT)
Gigerline Nature Reserve (ACT)
The entire length of the Murrumbidgee River in the ACT, managed as a Nature Reserve

Barmah State Forest (Vic)
Koetong Creek State Forest (Vic)
The trout cod also occurs in Ryans Creek water catchment (Vic) on public land.
Victoria's principal viable population of trout cod in Seven Creeks is protected by a total closure to fishing of the section of stream between Polly McQuinns Weir downstream to below Gooram Falls (Barnham, 1998).
There is currently a total ban on the taking of trout cod in all Victorian, NSW and ACT waters.

Recovery Objectives / Management Actions Required:
The major recovery objective is to achieve the downlisting of trout cod from Critically Endangered to Vulnerable within 25 years. This will mean the establishment of at least one secure self-sustaining population in both of the Murray and Murrumbidgee Rivers, as well as extending the existing Murray River population to include self-maintaining stocks in Lake Mulwala and the Ovens River (Brown *et al.,* 1998). Rainbow trout and brown trout comprised a significant proportion of the fish samples taken from the Murrumbidgee River during the NSW Rivers Survey (Faragher & Lintermans, 1997). It is likely that both of these species are major predators of trout cod juveniles, and as such the continued stocking of trout in this area may jeopardise the success of the trout cod stocking program (Faragher *et al.,* 1993). Modifications to existing dams and weirs to allow greater native fish passage, improved floodplain management, improvements to riparian and instream cover, and a reduction in trout stockings are important and necessary measures to allow native fish such as trout cod to recolonise their lost habitats. Such improvements should be coordinated with trout cod translocations, stockings and the protection of natural populations (Brown *et al.,* 1998).

Management of remaining trout cod habitats and restoration of previously inhabited areas could benefit from resnagging, as this would provide both cover for the fish and their macro-invertebrate food communities, whilst also helping to control bank erosion (Lloyd & Walker, 1988).

The National Trout Cod Recovery Team recommended that the trout cod be listed as Critically Endangered (based on IUCN criteria), including a greater than 80% decline in its extent of occurrence over the last 30 years. It is recommended that the trout cod continues to be listed as Endangered under the Commonwealth's Endangered Species Protection legislation. Victoria's only known self-sustaining (i.e. not re-stocked) translocated population of trout cod at Seven Creeks is protected by a total fishing closure between Polly McQuinns Weir (near Strathbogie) downstream to the Galls Gap Bridge below Gooram Falls. Additionally, the entire length of the Murrumbidgee River in the ACT is managed as a Nature Reserve. Monitoring of trout cod populations in the wild is necessary to accumulate information on their abundances and distribution over time. This is especially important in relation to the existence and/or effects of threatening processes within these areas. Continued protection in New South Wales, Victorian and Australian Capital Territory waters should contribute towards conserving this species, but any illegal captures of trout cod in these areas may harm the species' chances of survival (Pogonoski *et al.,* 2001; ACT Government, 1999b).

Limited biological information exists on wild populations of trout cod, so further studies on the biology of the species in the wild are recommended. In particular, information on population structures (including age/size classes, age/size at maturity, sex ratios and fecundity levels), recruitment processes, dispersal, growth rates, mortality, density-dependent relationships, responses to fishing and the habitat requirements of the different life-history stages is needed. A research project entitled 'The Distribution, Abundance and Management of Threatened Fish in the Murrumbidgee River Catchment, with Special Reference to the Endangered Trout Cod" is currently being carried out by NSW Fisheries and Environment ACT. The aim of this work, with respect to trout cod, is to provide information on the distribution and relative abundance of this species in relation to its habitat, the size structure of populations, its habitat preferences, the effectiveness of stocking, and future management guidelines for state, territory and local government agencies in the Murrumbidgee catchment. This project is anticipated to provide the information necessary to identify suitable stocking areas based on previous stocking success, habitat preferences and habitat availability (Pogonoski *et al.,* 2001). Research into the habitat requirements of trout cod is a high priority. The Victorian Department of Natural Resources and Environment has commenced a program to examine the feasibility and usefulness of reintroducing snags to large lowland rivers, based on the Murray River between Yarrawonga and Tocumwal. A total of 390 snags will be re-introduced at 21 sites and their subsequent use by native fishes, including trout cod, will be investigated. The effects of altered flow and thermal regimes can, in part, be effectively mitigated by the allocation of appropriate environmental flows from impoundments in regulated catchments. If trout cod populations are to survive in the wild, the continuing protection of this species from fishing and other threatening processes in all waters where it occurs is crucial (Pogonoski *et al.,* 2001).

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT	SA
Critically Endangered	Critically Endangered	No Change	No Change	No Change	No Change	No Change

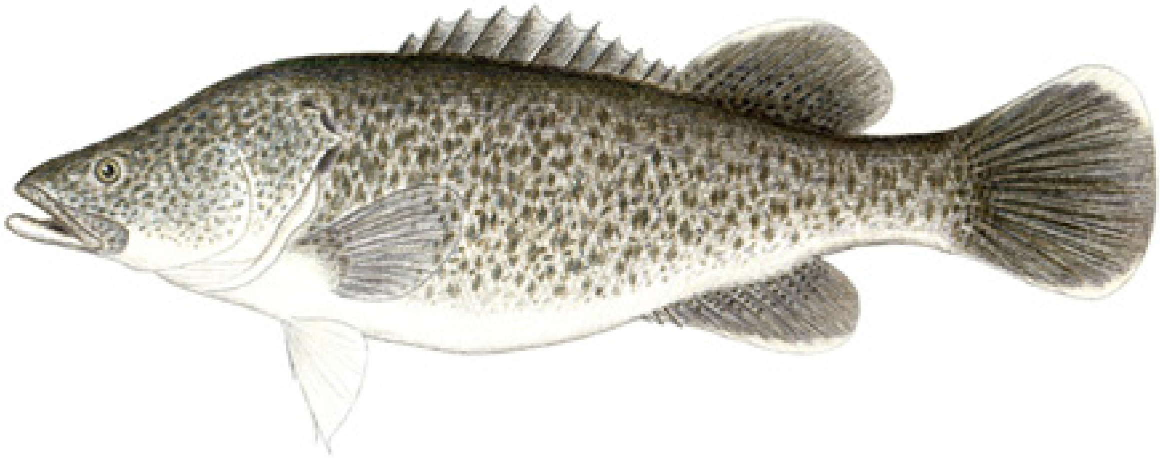
Based on evidence obtained since 1994, the Trout Cod Recovery Team considers that the trout cod meets the IUCN criteria required for its classification as 'Critically Endangered' (Brown *et al.,* 1998).

References:

ACT Government 1999b; Barnham, 1998; Berra & Weatherly, 1972; Brown *et al.*, 1998; Douglas *et al.*, 1994; Faragher *et al.*, 1993; Gehrke *et al.*, 1995; Gehrke & Harris, 2001b; Ingram & Richardson, 1989; Ingram *et al.,* 1990; Koehn & O'Connor, 1990; Lloyd & Walker, 1988; Pogonoski *et al.,* 2001; Schiller & Wooden, 2000.

Murray cod

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae	*Maccullochella peelii* (Mitchell, 1838)	Freshwater cod



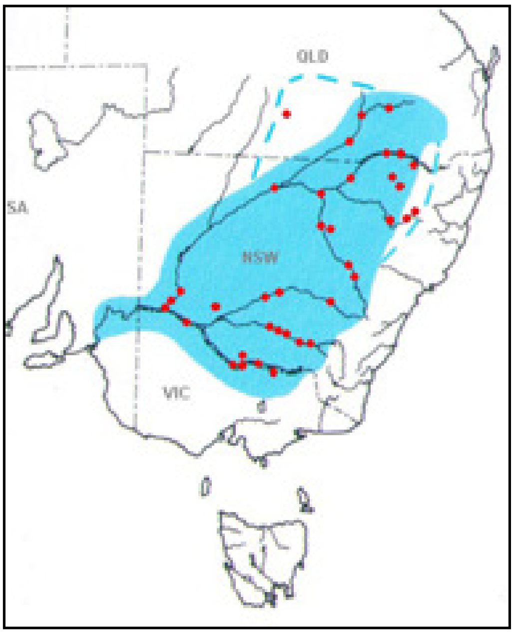
Drawing by Jack Hannan

Synonyms:
Acerina (Gristes) peelii Mitchell 1838.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Vulnerable	Not Listed	Not Listed	Not Listed

Reasons for Concern:
This species was formerly distributed widely in the Murray-Darling River system, from the Condamine River in Queensland to the lower reaches of the Murray River in South Australia. Its abundance has declined dramatically in most areas, especially in the Murray region of New South Wales and Victoria where the population is fragmented and the species is now relatively uncommon (Gehrke & Harris, 2000).



Distribution:
The natural range of the Murray cod encompasses most of the Murray-Darling River system in South Australia, Victoria, New South Wales and Queensland (Allen, 1989). This species was formerly widespread in the upper Murrumbidgee, Molonglo and lower Queanbeyan Rivers (Lintermans, 2000), in the Darling, Barwon, Edward and Wakool Rivers, and in the lower reaches of the Murray and Murrumbidgee Rivers (Rowland, 1988). There are presently few localities within Victoria (Cadwallader & Backhouse, 1983) and New South

Wales (Harris & Rowland, 1996) where Murray cod can be considered common. Only small numbers have been recorded during recent surveys in the Murray and Murrumbidgee Rivers (Gehrke *et al.,* 1999), at Yarrawonga Lock fishway (Harris & Thorncraft, 1997), below Goondiwindi Weir rockramp fishway (Thorncraft & Harris, 1996), below Bourke Weir (Harris *et al.,* 1992) and near Dubbo and below Marebone Weir on the Macquarie River (Gehrke *et al.,* 1999). During the NSW Rivers Survey of 1996, no Murray cod were collected from the randomly selected sites sampled in the Murray region (Murray, Murrumbidgee and Lachlan Rivers and tributaries), indicating that this species is now patchily distributed. Small numbers were, however, located in the upper and lower reaches of the Darling River system (Harris & Gehrke, 1997). Murray cod have been recently recorded in the Barwon River in northern New South Wales, the McIntyre and Dumaresq Rivers on the New South Wales/Queensland border and in the Balonne, Condamine and Warrego Rivers in Queensland (Moffatt *et al.,* 1997). It is often difficult to determine whether recent catches of Murray cod by anglers or fish survey teams represent natural populations or are the result of stocked fish reared in hatcheries (I.Wooden, pers. comm. 2000).

Australian Museum Records – 130 specimens (30-697mm SL), ranging in distribution from Tenterfield Creek (29° 02' S, 151° 46' E) in New South Wales southwards to Lake Charlegrark (37° 01' S, 141° 18' E) in Victoria; collected between circa 1903 and 1993.

Habitat:
This species is found in habitats ranging from small, clear, rocky streams in the upper-western slopes of New South Wales to the generally turbid, slow-flowing rivers and creeks of the western plains. The species prefers deeper holes near cover such as fallen trees, rocks and overhanging vegetation (Harris & Rowland, 1996).

Biology & Behaviour:
Murray cod reach sexual maturity at 4-5 years of age when they are 2.5 to 4kg in weight. In the Murray River, mature adults may migrate 80-100 kilometres upstream to spawn in small anabranch streams during spring-summer when water temperatures are approximately 20°C (Rowland, 1988). After spawning, they migrate back to the exact location from which they started. Eggs are shed in hollow objects, under fallen timber and on the substratum; they are 2.5-3.0mm in diameter, swelling to 3-4mm when water hardened, and are adhesive, demersal, opaque and pale in colour. Larvae hatch after 4.5-13 days, depending on water temperature, and are 6-9mm long at hatching. These newly hatched fry clump together near the spawning site. Murray cod larvae migrate downstream at a clearly defined size of 9-14mm, which is equivalent to an age of 1.5-2 weeks (C.Schiller, pers. comm. 2000). Larvae commence feeding on zooplankton between 10 and 19 days after hatching. At 40-50mm juvenile cod become aggressive and territorial. The growth rate of Murray cod is on average around 100mm per year for the first six years, but varies according to food availability and water temperature (Cadwallader & Backhouse, 1983). Optimum larval conditions for survival include food productivity and recruitment dispersal triggered by inundation of floodplains during spring-summer (Rowland, 1988).

Diet:
Adult Murray cod feed on other fishes, crustaceans and molluscs. Larvae and juveniles feed on zooplankton and aquatic insects (Harris & Rowland, 1996).

Size:
Considered to be Australia's largest truly freshwater fish, the Murray cod has been recorded to 1800mm and 113.5kg. It is more commonly caught at sizes of around 10kg or less (Allen, 1989).

Reasons for Decline:
Overfishing by a large commercial fishery caused a decline in Murray cod populations between the mid 1800s and the 1930s. Floodplain management in the 1900s led to the construction of weirs and dams which have adversely altered the flow and thermal regimes of the major inland rivers in the

Murray-Darling Basin. This river regulation has seriously affected juvenile recruitment and dispersal by reducing the frequency of floods and the consequent large blooms of aquatic microorganisms that larval cod feed on (Rowland, 1988), leading to a drastic and lasting decline in stocks since the 1950s (Harris & Rowland, 1996). River "improvements" such as de-snagging have removed fallen timber (Cadwallader & Backhouse, 1983), which is necessary for refuge and concealment. The relative numbers or presence of Murray cod have been found to be proportional to the abundance of snags (Schiller & Wooden, 2000). Competition with alien species may also be having an effect on populations of Murray cod, especially during their larval and juvenile life-history stages. Murray cod were eliminated from the Molonglo River in and near the Australian Capital Territory by heavy metal contamination from the mines at Captains Flat (Lintermans, 2000).

Protected Areas in which the Species Occurs:
Woodstock Nature Reserve (ACT)
Stony Creek Nature Reserve (ACT)
Bullen Range Nature Reserve (ACT)
Lower Molonglo Nature Reserve (ACT)
Googong Foreshores Nature Reserve (NSW)

Recovery Objectives / Management Actions Required:
The introduction of a closed fishing season during the breeding period (September - November) is suggested (Lintermans, 2000). Improved river management to restore Murray cod habitats around snags and to restore key elements of river flow regimes is fundamental to managing Murray cod populations. Unobstructed migration to and from upstream spawning sites is important to maintain the reproductive cycle.

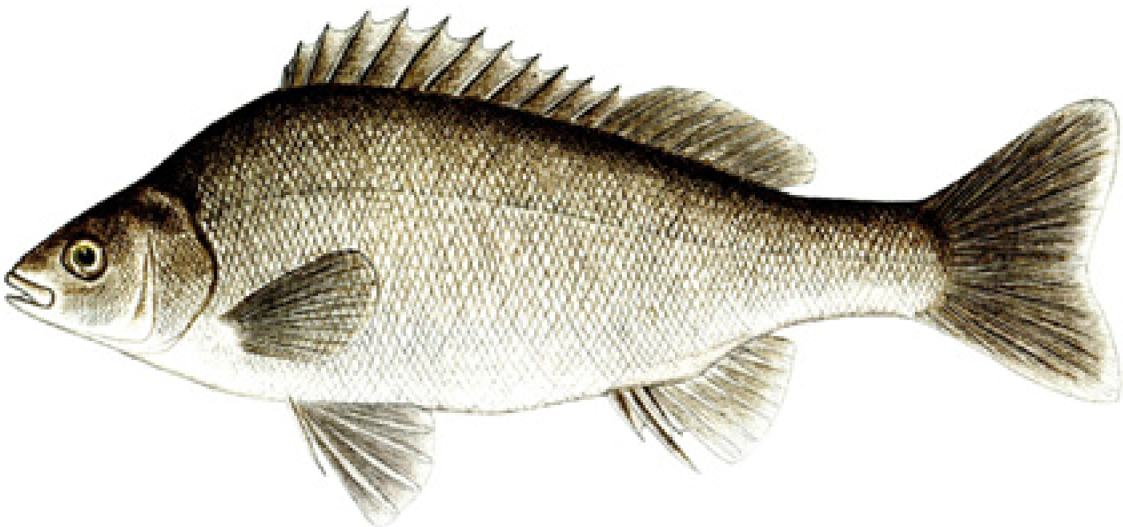
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Lower Risk (Near Threat-ened)	Lower Risk (Near Threat-ened)	Near Threat-ened	No Change	Vulnerable	Vulnerable	Rare	Protected

References:
Allen, 1989; Cadwallader & Backhouse, 1983; Gehrke *et al.,* 1999; Harris *et al.,* 1992; Harris & Gehrke, 1997; Harris & Rowland, 1996; Harris & Thorncraft, 1997; Moffatt *et al.,* 1997; Rowland, 1988; Schiller & Wooden, 2000; C.Schiller, pers. comm. 2000; Thorncraft & Harris, 1996; I.Wooden, pers. comm. 2001.

Silver perch

Family Name:	Scientific Name:	Other Common Name(s):
Terapontidae	*Bidyanus bidyanus* (Mitchell, 1838)	Bidyan, black or silver bream



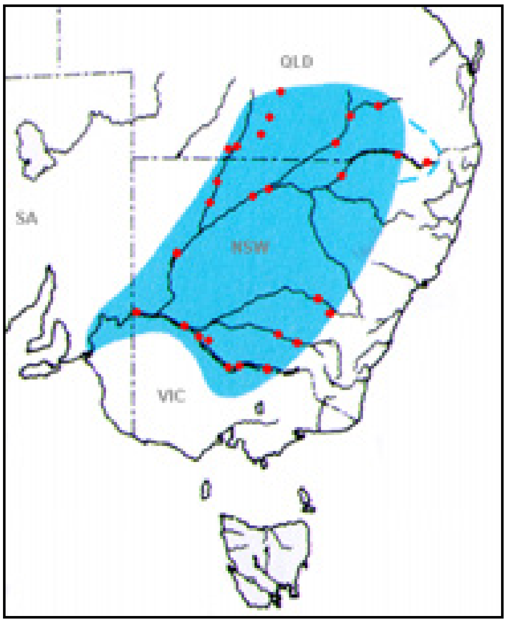
Drawing by Jack Hannan

Synonyms:
Acerina (Cernua) bidyana Mitchell, 1838; *Therapon ellipticus* Günther, 1859; *Therapon niger* Castelnau, 1872; *Therapon richardsonii* Castelnau, 1872; *Therapon macleayana* Ramsay, 1882.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Vulnerable (A1cd)	Vulnerable	Not Listed	Vulnerable	Critically Endangered	Not Listed	Not Listed	Protected

Reasons for Concern:
The original distribution of silver perch covered most of the Murray-Darling River system of Queensland, New South Wales, Victoria, and South Australia, excluding the cool, high, upper reaches of tributary streams. Although strong populations are apparently still present in the Queensland portion of the Murray-Darling Basin (Moffatt *et al.,* 1997), this species has declined to the point where only one abundant, self-sustaining population is currently known in the lower parts of the system – between Torrumbarry and Euston Weirs on the Murray River. Between the early 1940s and 1990s, the relative abundance of silver perch declined by 93% at Euston (Mallen-Cooper, 1993). Broad scale surveys in recent years have only caught isolated individuals (Harris & Gehrke, 1997; Gehrke *et al*., 1999).



Distribution:
The silver perch's natural range previously included most of the Murray-Darling River drainage in Queensland, New South Wales, Victoria and South Australia, excluding the cool, high, upper reaches of streams along the western side of the Great Dividing Range. It has also been introduced into several eastern coastal river systems in New South Wales and south-eastern Queensland (Merrick, 1996). In New South Wales, there is essentially only one self-sustaining wild population of silver perch that can be considered to be relatively abundant. It occurs in the Murray River between Torrumbarry and Euston Weirs, in possibly the longest remaining unregulated reach of this river (Inland Rivers Network, 1999). Small numbers of this species have been recorded above and below the Murtho fishway (Mallen-Cooper & Brand, 1992). Seventy-three silver perch were observed negotiating Yarrawonga Lock fishway between December 1996 and February 1997 (Harris & Thorncraft, 1997). This species has been found in much smaller numbers near Porters Plain on the Murray River, in the Darling River, the Mullawoolka Basin on the Paroo River (Gehrke *et al*., 1999), between Yarrawonga and Tocumwal in the Barmah Forest in Victoria (Mallen-Cooper & Brand, 1992), near Goondiwindi on the McIntyre River, near Mathoura on the Murray River (Thorncraft & Harris, 1996), and in inundated floodplain habitats near the Murrumbidgee River between Narrandera and Wagga Wagga (Gehrke *et al*., 1999). It has also been recorded in the Darling River below Bourke Weir (Harris *et al*., 1992), in the Barwon River in northern New South Wales and in the Dumaresq River on the New South Wales/Queensland border (Moffatt *et al.,* 1997). Recent surveys for trout cod have also found silver perch upstream of Narrandera in the Murrumbidgee River (I.Wooden, pers. comm. 2000). Only nine individuals were collected from all of New South Wales during the NSW Rivers Survey (Harris & Gehrke, 1997). Major stockings have been made in Lakes Windamere and George, and in Wyangala and Googong Reservoirs (Lintermans, 2000). More recent stockings of silver perch have also taken place at Burrinjuck, Pindari, Copeton, Glenbawn and Chaffey dams, totalling ~500,000 fingerlings (NSW Fisheries, 2000). It has also been introduced in the past into Cataract Reservoir on the Hawkesbury-Nepean River system where a substantial breeding population still exists (Gehrke & Harris, 1996). This species has not been recorded from the Australian Capital Territory since the mid 1980s (M.Lintermans, pers. comm. 2000).

Australian Museum Records – 81 records (33-450mm SL), ranging in distribution from the Diamantina River (22^{o} 17' S, 142^{o} 28' E) in Queensland southwards to the Murrumbidgee River (36^{o} S, 149^{o} E) in New South Wales, and from Cataract Dam (34^{o} 12' S, 150^{o} 47' E) westwards to Cooper Creek (27^{o} 45' S, 140^{o} 44' E) in South Australia; collected between circa 1882 and 1997. Records from the Lake Eyre Basin are most likely of *Bidyanus welchi* (Unmack, 2000).

Habitat:
This species inhabits both warm, sluggish, standing waters with cover provided by woody debris and reeds (*Phragmites)*, as well as fast-flowing turbid waters (Koehn & O'Connor, 1990).

Biology & Behaviour:
Silver perch are a schooling fish with distinct migratory movements before and after spawning, which takes place in spring-summer in areas behind the peaks of floods (Merrick, 1996). Recruitment of silver perch may be more localised and opportunistic than previously believed and fish may spawn both during inchannel flows and during large floods (Clunie & Koehn, 2000). Females shed 300,000 or more semi-buoyant eggs (about 2.75mm in diameter) in a few days. These eggs develop to free-feeding stages that drift downstream. Males mature at around 3 years of age when about 250mm in length, and females mature at around 5 years when about 290mm in length. Silver perch have been recorded to live to at least 27 years of age (Merrick, 1996).

Diet:
Adults and juveniles feed on small aquatic insects, molluscs, earthworms and green algae. Larvae feed on zooplankton (Merrick, 1996).

Size:
Silver perch commonly grow to around 300-400mm and 0.5kg-1.5kg, but are known to attain 8kg.

Reasons for Decline:
Factors leading to the general decline of silver perch populations include degradation of instream habitats, alterations to river flow and water temperature regimes, and the construction of weirs and dams. All of the above may affect spawning success, recruitment and migration, or influence future patterns of distribution and abundance (Inland Rivers Network, 1999). River regulation has reduced the abundance of floodplain habitats such as backwaters and billabongs, which are known habitats of silver perch (Clunie & Koehn, 2000). Flow alteration has been noted as being inversely proportional to native fish biodiversity in general (Gehrke *et al.*, 1995). Lake (1971) recognised that floods are necessary during spring as a trigger for spawning, and that therefore flow regulation may impede the onset of spawning. Lake (1971) also suggested that the reduced extent and duration of flooding and altered flow regimes have adversely affected the survival of juvenile silver perch (Pollard *et al.*, 1980); this could be due to the reliance of these fish on such events for the provision of food resources necessary for larval growth and development and for dispersal (Clunie & Koehn, 2000).

Cold water pollution is likely to have played a role in the decline of silver perch in some river reaches within the Murray-Darling River system where there are bottom offtakes on dams. Survival and growth of silver perch juveniles is greatly reduced by such cold water releases from the bottoms of dams (Astles *et al.*, 2000). Reduced water temperatures may also affect general metabolic functioning, feeding, maturation, growth rates and susceptibility to disease (Gehrke, 1988a). Areas affected by cold water pollution have experienced documented declines in silver perch populations. These areas include downstream of Hume Dam on the Murray River, Burrinjuck Dam on the Murrumbidgee River, Wyangala Dam on the Lachlan River, Burrendong Dam on the Macquarie River and Lake Eildon on the Goulburn River (Clunie & Koehn, 2000).

Because of the migratory nature of this species, it is likely that barriers have had a detrimental effect by limiting or preventing adults and juveniles from gaining access to upstream habitats, resulting in localised extinctions in particular river stretches. The existing population between Torrumbarry and Euston on the Murray River may be a result of the relatively large stretch of this river that is free of barriers, in which larvae can develop and juveniles then recolonise (Clunie & Koehn, 2000). Lake (1971) identified waters behind barriers with anoxic lower layers as being detrimental to the survival of the demersal eggs and larvae of this species (Pollard *et al.*, 1980).

Populations of silver perch downstream of Lake Mulwala and above Torrumbarry Weir are threatened by genetic “pollution” from introduced and escaped aquaculture fish (T.Raadik, pers. comm. 2000). The introduction of exotic fish species has probably led to predation on and competition with silver perch. There is no direct evidence, however, of carp or redfin perch preying on their eggs and juveniles or contributing significantly to the decline of silver perch populations in the Murray-Darling Basin. Perceived problems associated with carp include increased water turbidity and siltation, decreased macrophyte biomass and diversity, increased water nutrient loads and algal concentrations, reduced native fish and macroinvertebrate diversity, and the erosion of streambanks (Gehrke & Harris 1994; Koehn *et al.,* 2000; Clunie & Koehn, 2000). Redfin perch have been implicated in spreading EHN disease amongst silver perch populations (Inland Rivers Network, 1999). Goldfish Ulcer Disease (GUD), caused by an exotic bacterium originating on imported goldfish, has also been recorded on silver perch (Humphery & Ashburner, 1993). This type of ulcer disease can also be found on the alien roach (*Rutilus rutilus*) and there are concerns about the possible translocation of this disease via its host’s use as a bait by anglers (A.Baxter, pers. comm. 2000). The Asian fish tapeworm *Bothriocephalus acheilognathi* has a wide distribution in the Murray-Darling River system and has low host specificity; as such it could also become established in silver perch populations (Dove *et al.,* 1997).

The loss of riparian vegetation, mainly due to forestry and agriculture activities, may adversely affect instream habitats and decrease their diversity; however, whether these changes have affected silver perch is difficult to determine and yet to be documented. The removal of woody debris, although its effects have also not been documented, could also have impacts as it provides a refuge for silver perch. Whether such habitat is also important for organisms making up part of this species' diet is not known. Silver perch in general seem relatively tolerant to many water quality problems, and it thus seems unlikely that the latter have played a key role in this species' decline. Particular water quality problems, however, such as pesticide pollution, may have caused local declines in certain areas (Clunie & Koehn, 2000).

Recreational and commercial fishing is also not considered to be a key reason for the decline of silver perch; however, once a species such as silver perch has experienced a significant decline in abundance and distribution due to other factors, it may then become more vulnerable to fishing pressure (Clunie & Koehn, 2000).

Protected Areas in which the Species Occurs:
Barmah State Forest (Vic)
A self-maintaining population originating from stocked fish exists in Cataract Reservoir (NSW)

Recovery Objectives / Management Actions Required:
The recovery of silver perch stocks requires a range of actions, including some specific to this species as well as broader actions to address rehabilitation of its aquatic and surrounding riparian environments. Targeted surveys and monitoring of sites where abundant populations are either suspected to occur or occurred previously should be undertaken so that such sites can be identified and subsequently provided with priority protection. Flow allocations should be altered in a holistic approach to attempt to reinstate key features of hydrological regimes. Further research and monitoring of these changes should endeavour to identify the effects of the key components of flow regimes upon the current distribution of the different life-history stages of silver perch, and make recommendations for future flow alterations (Clunie & Koehn, 2000).

In order to address the previously underestimated issue of cold water pollution, the Silver Perch Recovery Plan supports the establishment of a Cold Water Pollution Reduction Program, as identified by Lugg (1999a & 1999b). It also encourages the development of a strategy for the Murray-Darling system to address the need for variable level offtakes or alternative options for large dams where thermal pollution is a problem. The construction of new dams should not take place without the ability to provide natural water temperatures downstream, while research should also be conducted on the effects of cold water on the biology and movement patterns of larval, juvenile and adult silver perch (Clunie & Koehn, 2000).

A management process is already in place to address improvement of fish passage in the Murray-Darling Basin, which is likely to include benefits to silver perch. Modifications to facilitate movements over barriers in areas where healthy populations of silver perch exist may enable an expansion of these populations (given that all other problems in surrounding areas are addressed) and thus reduce the potential for their isolation. Further research is required to better understand the swimming ability of silver perch and the migratory patterns of various populations in the Murray-Darling Basin during all life-history stages, as well as comparing the structure of populations in a range of areas where there are varying distances between barriers (Clunie & Koehn, 2000).

The control of carp in areas still inhabited by reasonable populations of silver perch, such as below Torrumbarry Weir on the Murray River, would be beneficial to this species' survival. Further research into the interactions between carp and silver perch, including as well as whether carp affect the reproductive success of silver perch, is also recommended (Clunie & Koehn, 2000). Research should also investigate interactions between redfin perch and silver perch and determine whether redfin perch prey on or compete with any of the life-history stages of silver perch. Such information may assist stocking programs for silver perch in areas where redfin perch occur (e.g. by the selection of larger silver perch for stocking releases). Experiments should be conducted to determine which diseases silver perch are susceptible to, whether these fish experience lethal or sub-lethal effects, and the prevalence of any diseases known to affect silver perch (Clunie & Koehn, 2000).

Further research is needed to clarify the significance of water quality problems such as sedimentation, increasing salinity, algal blooms and pollution on silver perch biology and behaviour. Determination of the species' structural habitat requirements, and how different habitats may influence food availability and the species' different life-history stages is also required. The protection and rehabilitation of riparian zones in areas where significant populations of silver perch occur should be encouraged via state agency and community group action and education (Clunie & Koehn, 2000).

Further release to the wild of hatchery bred silver perch is considered potentially damaging to this species' genetic diversity, and as such any stocking should only be continued with the intention of improving such effects (Inland Rivers Network, 2000). A review of the policies in each state within the Murray-Darling Basin area concerning the stocking and translocation of silver perch between smaller drainage basins needs to be undertaken, and such programs should only be exercised in areas where they are considered to have a high chance of success. Further research should trial stockings in a range of suitable habitats with varying sizes of fingerlings and yearlings to determine which sizes of fish are most successful and feasible in this regard. Genetic testing needs to be undertaken to further understand the genetic compositions of riverine and impoundment stocks (Clunie & Koehn, 2000).

In consultation with relevant agencies with jurisdiction within the Murray-Darling Basin, it is also necessary to determine whether stronger regulations on the recreational catch of silver perch need to be initiated. Further education amongst recreational anglers should also be undertaken to promote the plight of this species (Clunie & Koehn, 2000).

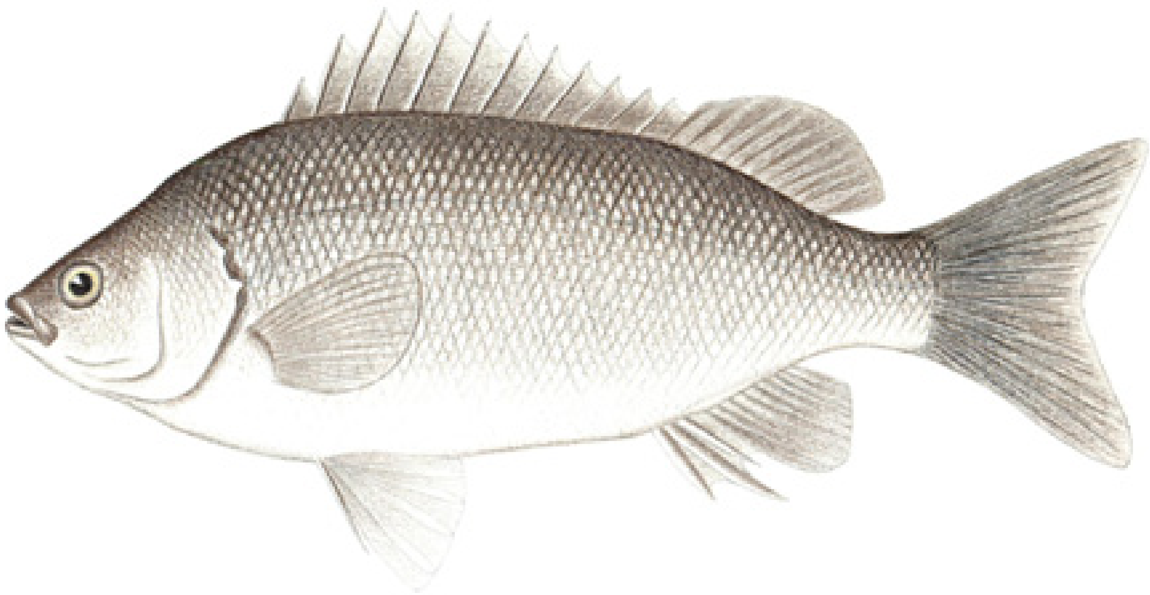
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT	QLD	SA
Endangered	Endangered	Endangered	No Change	No Change	Endang-ered	No Change	Pro-tected

References:
Astles *et al*., 2000; Clunie & Koehn, 2000; Dove *et al.,* 1997; Gehrke, 1988a; Gehrke & Harris, 1996; Gehrke *et al.,* 1999; Harris *et al.,* 1992; Harris & Gehrke, 1997; Harris & Thorncraft, 1997; Humphery & Ashburner, 1993; Inland Rivers Network, 1999; Inland Rivers Network, 2000; Koehn & O'Connor, 1990; Mallen-Cooper *et al.,* 1995; Mallen-Cooper & Brand, 1992; Merrick, 1996; Moffatt *et al.,* 1997; NSW Fisheries, 2000; Thorncraft & Harris, 1996; Unmack, 2000; I.Wooden, pers. comm. 2000.

Welch's grunter

Family Name:	Scientific Name:	Other Common Name(s):
Terapontidae	*Bidyanus welchi* (McCulloch and Waite, 1917)	Black bream, Paroo grunter



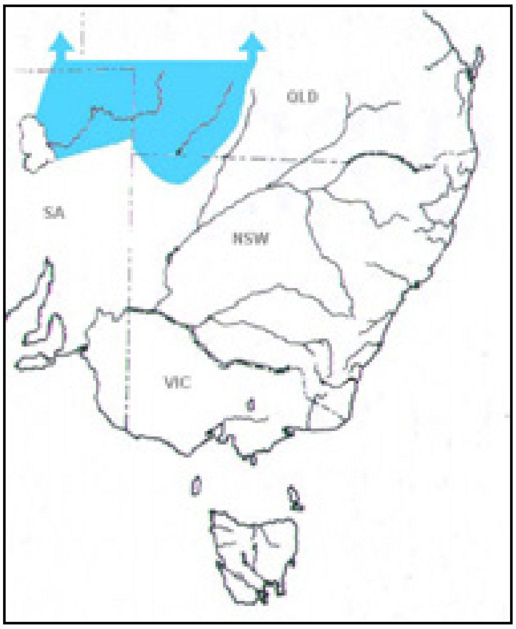
Drawing by Jack Hannan

Synonyms:
Therapon welchi McCulloch & Waite, 1917; *Datnia elliptica* Richardson, 1848.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Bidyanus welchi has not been recorded recently in New South Wales waters, despite being previously known from the Bulloo and Bancannia internal drainages (Unmack, 2000). There is some taxonomic concern as to whether this species is distinct from *Bidyanus bidyanus* or just a different form of the same species (Vari, 1978).



Distribution:
This species has been only found in streams and rivers of the Lake Eyre (Lake, 1978) and Bulloo-Bancannia inland drainages of Central Australia (Unmack, 2000).

Australian Museum Records – 7 records (72-280mm SL), ranging in distribution from the Georgina River (19^{o} S, 138^{o} E) in Queensland southwards to Lake

Eyre (27° 43' S, 142° 44' E) in South Australia; collected between circa 1939 and 1975.

Habitat:
Schools of Welch's grunter congregate near fallen timber or other cover, usually in waterholes (Wager & Unmack, 2000). This species also inhabits rivers that are often sluggish, turbid and have high concentrations of salts (Lake, 1978).

Biology & Behaviour:
Welch's grunter spawns from December to February (Llewellyn, 1983) and it is likely that flooding is necessary for spawning (Wager & Unmack, 2000). Hormonal-induced spawning indicates that the semi-buoyant, non-adhesive eggs, which are between 1.8mm and 2mm in diameter, develop while being carried downstream by the current, and hatch after 30 hours at temperatures of around 24°C. Larvae begin to feed five days after spawning. Females mature at lengths of around 280mm and can produce up to 100,000 eggs (Lake, 1978). Laboratory studies suggest that males less than 240mm are immature; however, males of 180-200mm caught in early summer have been found to be running ripe. This suggests that spawning may occur at smaller sizes. Sexual dimorphism is not apparent in this species (Wager & Unmack, 2000).

Diet:
Welch's grunter is carnivorous. Gut contents examined have included shrimps and small fishes (Wager & Unmack, 2000).

Size:
The maximum body length of Welch's grunter is around 350mm standard length, but fish are more commonly found around to standard lengths of 230mm (Allen, 1989).

Reasons for Decline:
The uncertainty as to the taxonomic validity of this species makes it difficult to identify whether any population decline has actually occurred. The main reason for concern is the limited distribution of these fish ascribed to this species. Like most other fish in the more remote regions of inland Australia, these fish relatively few direct threats from human activities. However, they are susceptible to overfishing in receding waterholes, and to large-scale water resource development which may prevent refilling of semi-permanent waterbodies. The fragile and unpredictable nature of inland aquatic systems is easily damaged by activities that change the distribution of floodwaters and the frequency of flooding. Genetic issues associated with stocking related species may pose serious problems for all species with restricted distributions (P. Unmack, pers.comm. 2000).

Protected Areas in which the Species Occurs:
None known.

Recovery Objectives / Management Actions Required:
A high priority for the conservation of Welch's grunter is further taxonomic study to determine the validity of the species. If it is simply a variant of silver perch, then conservation objectives for that species may require revision to include this and possibly other related forms.

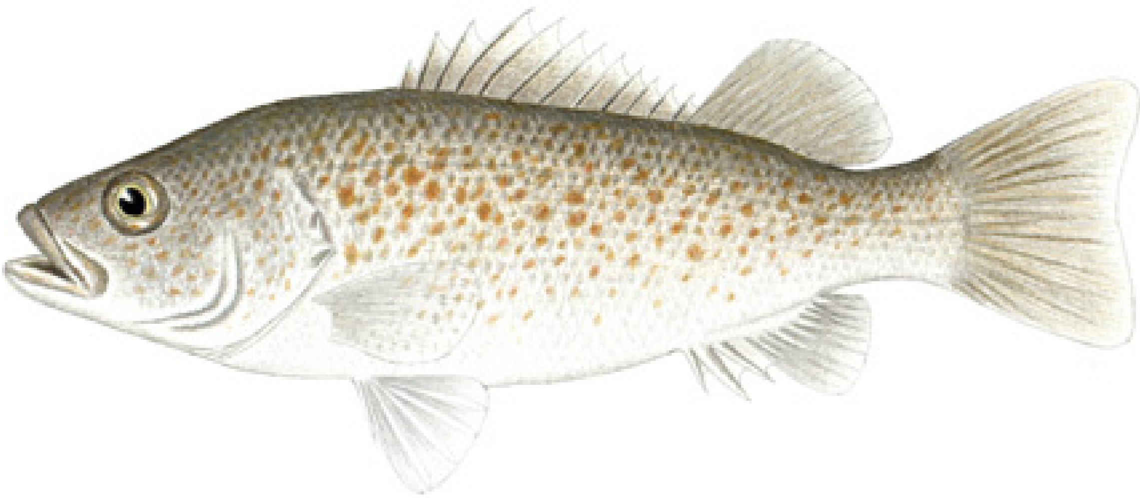
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	QLD	SA
Lower Risk (Least Concern)	Lower Risk (Least Concern)	No Change	No Change	No Change	No Change

References:
Allen, 1989; Lake, 1978; Llewellyn, 1983; Unmack, 1997; Unmack, 2000; Vari, 1978.

Spangled perch

Family Name:	Scientific Name:	Other Common Name(s):
Terapontidae	*Leiopotherapon unicolor* (Günther, 1859)	Jewel perch, bobby perch, cod



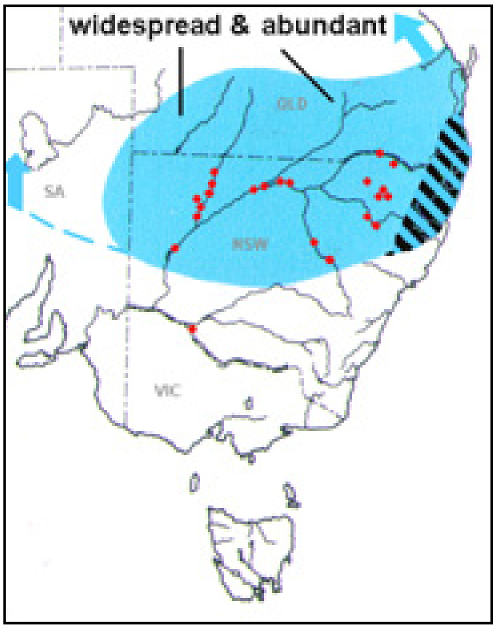
Drawing by Jack Hannan

Synonyms:
Therapon unicolor Günther, 1859; *Datnia brevipinnis* Steindachner, 1867; *Therapon truttaceus* Macleay, 1881; *Therapon longulus* Macleay, 1881; *Therapon elphinstonensis* De Vis, 1884; *Therapon idoneus* Ogilby, 1907.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Leiopotherapon unicolor is generally restricted to the warmer reaches of the Murray-Darling River system (Harris & Gehrke, 1997). This species may thus be susceptible to cold water pollution emanating from water storages (Lake, 1971; Llewellyn, 1973; Gehrke & Fielder, 1988).



Distribution:
This is probably the most widely distributed native freshwater fish species in Australia, being found in warm temperate and tropical coastal rivers from the Indian Ocean Drainage Division in Western Australia north and eastwards through the Timor Sea, Gulf of Carpentaria and North-east Coast Drainage Divisions in the Northern Territory and Queensland. Spasmodic reports also place spangled perch in rivers in the South-east Coastal Drainage Division in northern New South Wales. The species also lives in the Lake Eyre, Bulloo-Bancannia and Murray-Darling drainage systems (Vari, 1978; Gehrke *et al.,* 1999; Bishop *et al.,* 1999). It is found in New South Wales in the

Darling River and its warmer tributaries (Lake, 1967; Llewellyn, 1973), but is only very infrequently collected from the cooler waters of the Murray and Murrumbidgee River systems (Harris & Gehrke, 1997). Spangled perch are generally locally abundant in waters north of latitude 30°S (Gehrke *et al.*, 1999).

Australian Museum Records – 353 records (11-290mm SL), ranging in distribution from Wenlock River (12° 23' S, 142° 11' E) in Queensland southwards to Surveyors Pool (34° 40' S, 116° 40' E) in Western Australia, and from Flaggy Creek (29° 36' S, 152° 03' E) in New South Wales westwards to East Carnarvon (24° 53' S, 113° 40' E) in Western Australia, collected between circa 1881 and 1999.

Habitat:
This species is found in all types of waterbodies (Llewellyn, 1983), but prefers main river channels, seasonal streams, sandy lowland creekbeds, lowland backflow billabongs and corridor waterbodies. *Leiopotherapon unicolor* thrives in natural and man-made lakes and is also occasionally found in floodplain billabongs in the Murray-Darling River system. It usually occupies areas with little vegetation, in both turbid and clear waters over sand, but is also found over mud, clay, leaf-litter, boulders and rocks (Bishop *et al.,* 1999).

Biology & Behaviour:
Leiopotherapon unicolor spawns from November to mid-February (studies in northern Queensland found both sexes to mature rapidly in the months immediately prior to spawning). However, rising water levels are not a universal requirement for spawning as this species will spawn in isolated waterbodies without rainfall or runoff. In the Northern Territory spawning takes place in still, backflow billabongs or sandy creeks. If spawning takes place during floods, eggs, larvae and juveniles are swept downstream into corridor waterbodies. Eggs are demersal, spherical, transparent and non-adhesive, and are randomly dispersed as the fish swims through the shallows, where they settle on the bottom (Llewellyn, 1973; Bishop *et al.,* 1999). Fecundity varies from 24,000 eggs in fish weighing 24g to 113,200 eggs in a fish of 65g. The eggs hatch 45-55 hours after fertilisation at 23-26.4°C, and the newly hatched, poorly developed larvae are 2.2mm in length. Males may mature at 58mm in length and 2.7g in weight, while females mature at 78mm in length and 8.7g in weight (Pollard *et al.*, 1980). *Leiopotherapon unicolor* can tolerate extremes in water temperatures from 5 to 39°C for short periods of time (Pollard *et al.*, 1980; Gehrke & Fielder, 1988), and at dissolved oxygen concentrations as low as 5% of saturation (Gehrke & Fielder, 1988; Bishop *et al.,* 1999). In southeast Queensland spangled perch cease feeding and lose weight during winter if water temperatures fall below approximately 16°C (Gehrke, 1988a). During prolonged exposure to temperatures around 10°C they become susceptible to fungal and other infections and die (Llewellyn, 1973).

Because of their reported ability to rapidly colonise new waterbodies, it has often been proposed that this species may be able to aestivate, either as eggs or adults. However, no evidence has been found to support this contention (Llewellyn, 1973; Beumer, 1979; Gehrke, 1987; Gehrke & Fielder, 1988). This species has exceptionally good dispersal abilities and has been recorded travelling up to 16 kilometres in two hours along wheel ruts during thunderstorms (Shipway, 1947), only to perish after the storm when the water seeped into the soil. Spangled perch are also reported to have appeared as a result of being swept up in strong winds and scattered on the ground after heavy rainfall, but many of these reports cannot be substantiated and it is more likely that the fish migrated to the point at which they were observed in runoff water (Glover, 1990).

Diet:
Leiopotherapon unicolor is an opportunistic omnivore, feeding on a variety of aquatic and terrestrial invertebrates, fish, detritus, algae and macrophytes (Gehrke, 1988b; Gehrke, 1998c; Bishop *et al.,* 1999).

Size:
Leiopotherapon unicolor is common up to around 150mm in length, but can reach up to 300mm (Wager & Unmack, 2000) and 0.5kg in weight (Bishop *et al.,* 1999).

Reasons for Decline:
The main reasons for the decline of this species in the southern half of the Murray-Darling Basin can be attributed to cold water pollution and barriers to fish migration. Water temperatures below 10^{o}C can lower metabolic rates and induce the development of fungal infections, with death occurring if temperatures fall below 5^{o}C (Lake, 1971; Llewellyn, 1973; Gehrke & Fielder, 1988).

Protected Areas in which the Species Occurs:
Sturt National Park (NSW)

Recovery Objectives / Management Actions Required:
This species is likely to benefit from the installation of thermal pollution mitigation devices on large dams as well as proposed improvements to fish passage and river flows within the Murray-Darling Basin.

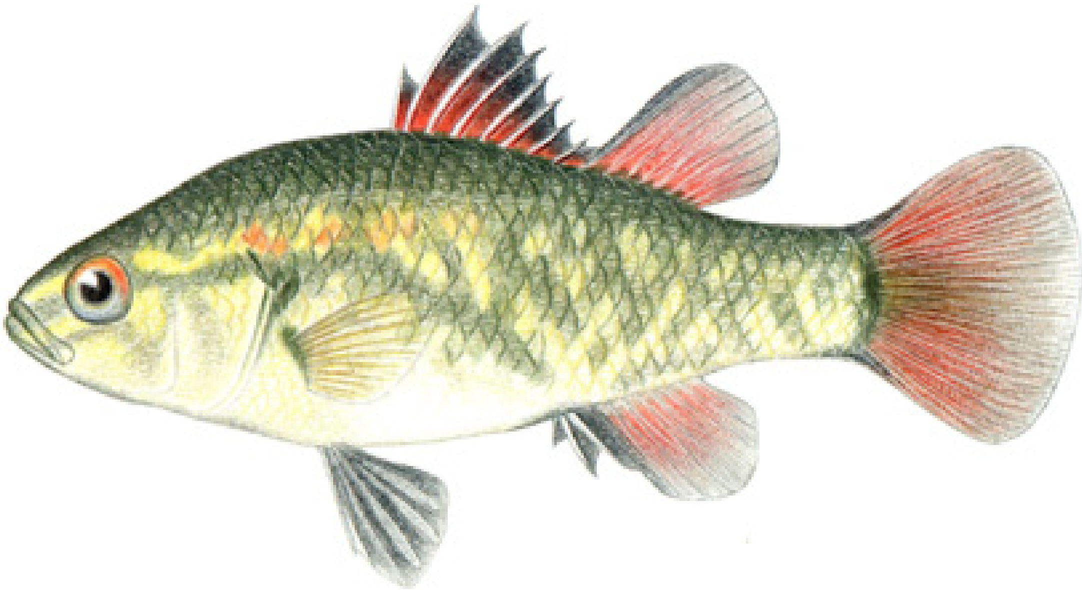
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	QLD	SA
Lower Risk (Least Concern)	Lower Risk (Least Concern)	No Change	No Change	No Change	No Change

References:
Beumer, 1979; Bishop *et al.,* 1999; Gehrke, 1987; Gehrke, 1988a; Gehrke, 1988b; Gehrke, 1988c; Gehrke & Fielder, 1988; Gehrke *et al.*, 1999; Glover, 1990; Harris & Gehrke, 1997; Lake, 1967; Lake, 1971; Llewellyn, 1973; Llewellyn, 1983; Moffatt *et al.,* 1997; Pollard *et al.*, 1980; Shipway, 1947; Wager & Unmack, 2000.

Southern pygmy perch

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae (Nannopercidae/ Kuhliidae)	*Nannoperca australis* Günther, 1861	N/A



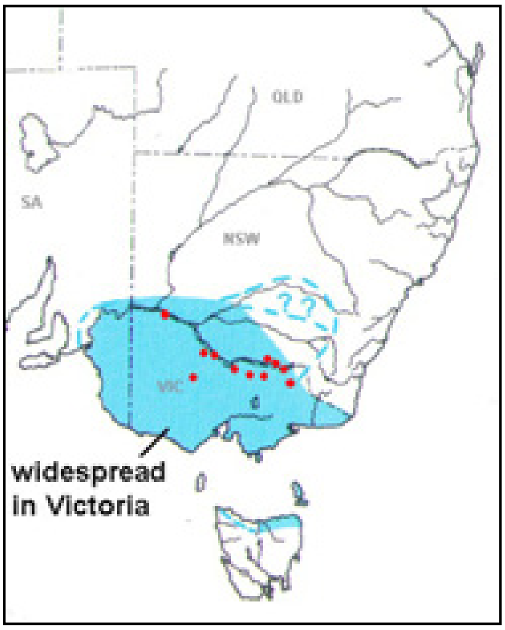
Drawing by Jack Hannan

Synonyms:
Nannoperca australis Günther, 1861; *Paradules leetus* Klunzinger, 1872; *Nannoperca riverinae* Macleay, 1881; *Microperca tasmaniae* Johnston, 1888; *Nannoperca australis flindersi* Scott, 1971.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	SA
Not Listed	Not Listed	Not Listed	Vulnerable	Not Listed	Protected

Reasons for Concern:
Southern pygmy perch have experienced large-scale reductions in range since European settlement due to habitat loss and predation by alien fish species. This species is now absent from much of the Murrumbidgee and Murray rivers regions, and was not recorded during the NSW Rivers Survey (Harris & Gehrke, 1997).



Distribution:
Southern pygmy perch are common in southern Victoria and abundant in some tributaries of the Yarra River. They can also be found in lakes and wetlands in northern Tasmania and on King and Flinders Islands in Bass Strait (Kuiter *et al.*, 1996). Historical records indicate that the former range of southern pygmy perch also encompassed the lower reaches of the Murray River in South Australia, Victoria and New

South Wales; however, populations have declined throughout the Murray River and this species may now be close to extinction in New South Wales. The species is now absent from the Murrumbidgee River and much of the Murray River system (FSC, 2000a), being restricted to a number of billabongs and small creeks in the Albury area. It has recently been recorded in small numbers from Billabong Creek in the Holbrook area, New South Wales (FSC, 2000a), the Buchan River, Victoria (R.Faragher, pers. comm. 2000) and the Murray River around Gunbower Island (Unmack, 2000). The southern pygmy perch is still considered to be widespread in Victoria, where it can be found in the Ovens River, Broken River, Goulburn River, Loddon River, and the Murray River near Mildura (T.Raadik, pers. comm. 2000). It is also known from the Mitta Mitta River, Kiewa River and Avoca River in Victoria (Unmack, 2000).

Australian Museum Records – 26 records (15-60mm SL), ranging in distribution from Barron Box Swamp (34^{o} 09' S, 145^{o} 50' E) in New South Wales southwards to Deep Creek (41^{o} 42' S, 146^{o} 25' E) in Tasmania, and from the Snowy River (37^{o} 45' S, 148^{o} 25' E) in Victoria westwards to Mount Compass (35^{o} 20' S, 138^{o} 36' E) in South Australia; collected between circa 1884 and 1992. Records from the Museum of Victoria extend as far eastwards as the Genoa River drainage in Victoria (Unmack, 2000).

Habitat:
This species frequents weedy, slow-flowing or still waters, lakes and irrigation channels. It is known to inhabit small creeks in vegetated areas (Kuiter *et al.,* 1996), dams and billabongs (Cadwallader & Backhouse, 1983).

Biology & Behaviour:
Southern pygmy perch spawn from late winter to early spring in response to rising water temperatures. During the breeding season, males defend a territory in which, after a courtship display, spawning takes place. Eggs are small, about 1.3-1.4mm in diameter, demersal, transparent and slightly adhesive. They are scattered over the bottom, adhering loosely to rocks and vegetation. Females in captivity can spawn several times during the spawning season. Fish in natural populations, however, release all of their eggs at once, with fecundity varying from 500 to 4000 eggs per female. Newly hatched larvae 3-4mm long emerge 2-4 days after fertilisation. *Nannoperca australis* reaches sexual maturity in its second year, when males are about 36mm and females 33mm long (Cadwallader & Backhouse, 1983). Juveniles and adults both form loose aggregations. *Nannoperca australis* has a high potential for mosquito control in enclosed areas (Kuiter *et al.*, 1996).

Diet:
This species is a distinct carnivore, feeding on mayflies, midges, caddisflies and planktonic crustaceans (Cadwallader & Backhouse, 1983).

Size:
Southern pygmy perch are usually found at lengths of around 65mm (Kuiter *et al.,* 1996) to 80mm. Females are generally larger than males (Cadwallader & Backhouse, 1983).

Reasons for Decline:
The causes of the decline in *Nannoperca australis* are likely to include loss of aquatic vegetation, alienation of floodplain habitats by flood mitigation works, seasonal flow reversal, and spawning failures due to cold water releases from dams, as well as predation by, and competition with, alien fish species such as redfin perch *Perca fluviatilis* and gambusia *Gambusia holbrooki* (FSC, 2000a). Habitat and population fragmentation is occurring rapidly and may hinder the recolonisation of habitats where individual populations have been wiped out (Kuiter *et al.*, 1996).

Southern pygmy perch which, like redfin perch, inhabit thickly-vegetated areas, may be seriously reduced in numbers as a result of predation by the latter, especially in enclosed waters

(Cadwallader & Backhouse, 1983). Predation of southern pygmy perch by alien trout may also be significant in areas where their distributions overlap (Kuiter *et al.*, 1996).

Protected Areas in which the Species Occurs:
Occurs in various national parks and nature reserves in Victoria.

Recovery Objectives / Management Actions Required:
Future surveys of freshwaters in southern New South Wales are necessary to accurately assess the distribution and hence the conservation status of this species. Biological and environmental requirements need to be ascertained, as well as captive breeding requirements, so that any necessary restocking can be initiated as soon as possible. In the Murray River near Albury, where one of the last known populations of southern pygmy perch exists (FSC, 2000a), seasonal flow patterns are now almost the opposite of those which occured under natural conditions. Ensuring the maintenance of flow regimes that protect their habitats is an integral step in ensuring the perpetuation of these populations.

Brown and rainbow trout have been identified as predators of the southern pygmy perch (Kuiter *et al.,* 1996), and as such any future stockings of such alien species must take into account the presence of this threatened species. The alienation of floodplain habitats, loss of aquatic vegetation and the threat of predation are all likely to lead to this species becoming endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate (FSC, 2000a). This species could be considered for selection in community action projects, and possibly through groups such as ANGFA, for captive breeding programs, particularly because of its high potential as an aquarium fish and/or for the control of mosquitos in agricultural areas – an ability it has been credited with by Kuiter *et al* (1996). Such exercises should utilise stocking techniques that ensure the genetic integrity and diversity of this species.

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	SA
Lower Risk (Least Concern)	Lower Risk (Least Concern)	Near Threatened	Endangered	No Change	No Change

References:
Cadwallader & Backhouse, 1983; FSC, 2000a; Harris & Gehrke, 1997; Kuiter *et al.,* 1996; Lake, 1971; Unmack, 2000.

Oxleyan pygmy perch

Family Name:	Scientific Name:	Other Common Name(s):
Percichthyidae (Nannopercidae/ Kuhliidae)	*Nannoperca oxleyana* Whitley, 1940	N/A

Drawing by Jack Hannan

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	QLD
Endangered (A1ce + 2ce)	Endangered	Endangered	Endangered	Vulnerable

Reasons for Concern:
Within New South Wales the Oxleyan pygmy perch is now only known to be present at a few disjunct locations on the far north coast (Harris & Gehrke, 1997).

Distribution:
The Oxleyan pygmy perch is known only from south-eastern Queensland and north-eastern New South Wales, where it occurs in small, swampy, coastal drainage systems. It is found on Fraser and Moreton Islands (Queensland), as well as throughout the Noosa River system (Queensland) (Arthington, 1996). It has previously been recorded from Lake Hiawatha near Wooli, and between Lismore and Coraki on the Richmond River (Kuiter *et al*., 1996) in northern New South Wales. Recent surveys in northern New South Wales have also identified additional populations in a lake in Bundjalung National Park (Arthington, 1996) and within a number of coastal creeks and dune lakes in and around Broadwater National Park (Knight, 2000). Oxleyan pygmy perch were also recorded from a lake near Wooli in 1995 (Lawrence, 1998).

Australian Museum records also include specimens captured at Tick Gate Swamp and Wooli Creek in Yuragyir National Park (formally North Red Rock National Park), New South Wales, in 1977.

Queensland mainland locations include Blue Gum Creek near the Glasshouse Mountains, Marcus Creek, Searys Creek, Carland Creek and Coondoo/Tinana Creek, a tributary of the Mary River. It has only recently been recorded from Rocky and Coongul Creeks on Fraser Island, though it had previously been recorded from Woralie and Bogimbah Creeks. On Moreton Island, populations are present in Lake Jabiru, Spitfire Creek, North and South Warrajamba Creek, Blue Lagoon and North Eagers Creek on the eastern coast, and in Ben Ewa Swamp and associated streams, including Craven Creek and Tempest Creek, on the western coast. On North Stradbroke Island a small population is present in 18 Mile Swamp, and there are unconfirmed reports of populations in waters in the southern part of the island (Thompson *et al*., 2000).

Australian Museum Records – 21 specimens (11-38mm SL), ranging in distribution from the Maryborough District (25^{o} S, 152^{o} E) in Queensland southwards to Tick Gate Swamp (29^{o} 54’ S, 153^{o} 15’ E) in New South Wales; collected between 1929 and 1977.

Habitat:
This species is generally found in dune lakes and slow-flowing streams and rivers with sandy bottoms and weedy or reedy margins. Its preferred habitat includes clear and brown water creeks, swamps and dune lakes in wallum country (i.e. *Banksia* dominated heathlands). Wallum lakes are characterised by low salinity, low magnesium and calcium hardness, and slow moving or still acidic waters (pH 3.5-6.7), often with a high organic content and low conductivity (<330μS. cm^{-1}) (Arthington & Marshall, 1996; Ecolab, 1999; Knight, 2000). This species can be found amongst or near vertical or undercut banks and the fine rootlets of riparian vegetation growing into the stream (Warren, 1999; Knight, 2000), and is generally more abundant near submerged vegetation, being found more rarely amongst emergent sedges (Arthington, 1996).

Biology & Behaviour:
The Oxleyan pygmy perch tolerates temperatures of 12-28^{o}C (Kuiter *et al*., 1996; Knight, 2000) and has an extended breeding season, stimulated by water temperatures above 19^{o}C, from spring through autumn, though spawning is concentrated from October to December. Wager (1992) described courtship involving a pair of fish casually approaching each other and, as they near, quickly shuddering and releasing eggs and milt (Thompson *et al*., 2000). Females may breed at 30mm and males at 27mm. Spawning is protracted, with a few eggs laid demersally each day, scattered over the substrate or aquatic vegetation. The young fish hatch in 3-4 days and commence feeding in a day or two (Thompson *et al*., 2000). Adult fish mature at 4-5 months (Kuiter *et al*., 1996). The Oxleyan pygmy perch co-exists with *Rhadinocentrus ornatus, Hypseleotris galii, Hypseleotris compressa* and *Gobiomorphus australis* in northern New South Wales, as well as with the Vulnerable honey blue-eye, *Pseudomugil mellis*, in south-eastern Queensland waters.

Diet:
Nannoperca oxleyana is a microphagic carnivore (Thompson *et al*., 2000). Large fish feed on copepods, cladocerans (water fleas) and aquatic insects (especially chironomid midge larvae), as well as diatoms, filamentous algae and a few terrestrial insects. Larvae and young juveniles feed on rotifers and protozoans (Kuiter *et al*., 1996).

Size:
This species has been recorded at lengths of up to around 45mm in length, though it is most commonly found at lengths of around 30mm (Knight, 2000).

Reasons for Decline:
This species is sensitive to changes in components of its critical habitat. These include the removal of instream vegetation, alteration of the preferred low pH and turbidity levels of waters, and reduction or removal of preferred invertebrate prey (Warren, 1999; Knight, 2000). As its habitat has shrunk through development and modification, the distribution of this species has also declined. Coastal populations are endangered by housing developments, road and forestry developments (including the expansion of pine plantations), water pollution (nutrient enrichment, increased suspended solids and toxic substances) (Arthington & Marshall, 1996; Knight, 2000), as well as mining operations and agriculture (Wager & Jackson, 1993; Thompson *et al*., 2000). The introduced gambusia *Gambusia holbrooki* is well established in several localities that support populations of the Oxleyan pygmy perch. Gambusia is thought to prey upon the eggs and early developmental stages of Oxleyan pygmy perch and could compete with the pygmy perch for food and habitat space (Arthington, 1996).

Protected Areas in which the Species Occurs:
Yuragyir National Park (NSW)
Bundjalung National Park (NSW)
Broadwater National Park (NSW)
Moreton Island National Park (Qld)
Forestry Scientific Reserve near Beerwah (Qld)
Cooloola National Park (Qld)
Fraser Island National Park (Qld)

Recovery Objectives / Management Actions Required:
The conservation of this species is dependent on careful coordination between the National Parks and Wildlife Service and NSW Fisheries (Knight, 2000). Better protection of coastal areas supporting creeks and dune lakes as well as research into the population ecology, environmental tolerances and conservation genetics of Oxleyan pygmy perch are all necessary (Arthington & Marshall, 1996). Further surveys also need to be done to find the current extent of this species' distribution in New South Wales. Populations of *Gambusia holbrooki* within or near waterbodies occupied by *Nannoperca oxleyana* should be monitored, interactions between the two species studied, and management initiatives developed to reduce the threat posed by this introduced pest species (Knight, 2000).

Genetic analysis of populations of *Nannoperca oxleyana* in south-eastern Queensland revealed relatively high levels of allozyme and mitochondrial DNA variation among discrete populations (Hughes *et al*., 1999), suggesting that dispersal between populations is extremely limited (Thompson *et al*., 2000), and that once eliminated, individual populations are unlikely to be restored via natural dispersal. It is thus considered crucial to conserve all existing populations of this species to maintain maximum genetic diversity (Arthington, 1996; Hughes *et al*., 1999; Wager & Jackson, 1993). Habitats found to support this species could be identified based on the habitat requirements outlined in Knight (2000) and declared as Critical Habitat under part 7a of the *Fisheries Management Act,* 1994 (1997 amendments).

Provided that the potential habitat of this species is not removed or disturbed, appropriate vegetation is planted and sediment controls are implemented, extinction of the remaining local populations is considered unlikely (Warren, 1999). Removal of structures on private property that impede fish passage would benefit local fish communities in general within its habitat (Ecolab, 1999). Further education of local government and community groups is also required to prevent the further loss of this species' habitat through land development. The education of local park staff to increase buffer zones around known habitats of this species so that chemicals such as pesticides and fire fighting foams are not used in their vicinity, and critical waterbodies are not used as water sources during bush fire fighting, are important protective measures for the conservation of the remaining *Nannoperca oxleyana* populations in New South Wales (Knight, 2000). Recovery actions could involve rehabilitation of degraded creeks, which have in the past been cleared for the construction of drains. Several techniques may be necessary, including reconstruction of stream morphology and channel characteristics, and the replanting of riparian vegetation (Knight, 2000).

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	QLD
No Change	No Change	No Change	No Change	No Change

References:
Arthington, 1996; A.Arthington, pers. comm. 2000; Arthington & Marshall, 1996; Bishop, 1999; Ecolab, 1999; Harris & Gehrke, 1997; Hughes *et al*., 1999; Knight, 2000; J.Knight, pers. comm. 2000; Kuiter *et al*., 1996; Lawrence, 1998; Thompson *et al*., 2000; Wager & Jackson, 1993; Warren, 1999.

Two-spined blackfish

Family Name:	Scientific Name:	Other Common Name(s):
Gadopsidae	*Gadopsis bispinosus* Sanger 1984	Slippery, slimy, greasy, tailor, marbled cod, nikki, longtom

Drawing by Jack Hannan

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	ACT
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Vulnerable

Reasons for Concern:
Gadopsis bispinosus now has a disjunct and scattered distribution throughout much of its former range in southern New South Wales and the Australian Capital Territory (Lintermans, 2000).

Distribution:
There is little information on the historical distribution of the two-spined blackfish because of its relatively recent description as a species separate from *G. marmoratus* (Lintermans, 2000). The distribution of *Gadopsis bispinosus* covers a narrow band to the north of the Great Dividing Range, running northwards through north-eastern Victoria into south-eastern New South Wales and the Australian Capital Territory (Jackson *et al*., 1996). An extensive survey of the New South Wales southern highlands located this species in the upper Murray River (Lintermans, 1998), including the lower reaches of the Swampy Plains, Tooma and Geehi Rivers; the upper Tumut system, including the lower reaches of the Goobarragandra River; the Goodradigbee River; Mountain Creek; and the upper Murrumbidgee River between Yaouk and Cooma. In the Australian Capital Territory this species can only be found in the Cotter River catchment, upstream of the Cotter Dam (ACT Government, 1999a). *Gadopsis bispinosus* was formerly present in the Murrumbidgee and Paddys Rivers, and is suspected of being historically present in the Naas/Gudgenby River system (Lintermans, 2000). This species is widespread and often abundant in north-eastern Victoria at altitudes of 200-700m (Jackson *et al*., 1996).

Australian Museum Records – 16 records (24-195mm SL), ranging in distribution from Mountain Creek (35^{o} 12' S, 148^{o} 49' E) in New South Wales south-westwards to the King River (36^{o} 47' S, 146^{o} 26' E) in Victoria; collected between circa 1931 and 1992.

Habitat:
Gadopsis bispinosus is restricted to cool, clear upland or montane streams with abundant instream cover, usually in the form of boulders, coarse gravel and cobbles. It is most common in medium to large streams in which there is a greater water depth and lower stream velocity. This species is also generally found in forested catchments, where there is little sediment input to the stream from soil erosion or other adverse land use practices (Lintermans, 2000).

Biology & Behaviour:
Gadopsis bispinosus breeding is seasonal and is probably induced by a relatively rapid rise in water temperature and change in day length. Fecundity is low and positively correlated with fish length. Egg laying commences in November in at least the second or third year of life. The natural spawning habitat is unknown but is suspected of being on the underside of boulders or cobbles. Between 80 and 420 large (3.5mm in diameter), yolky and adhesive eggs are released at once. They are guarded by the male until the larvae have almost completely utilised their yolk reserves and are free-swimming. Hatching occurs in roughly 16 days at water temperatures of 15^{o}C (Lintermans, 1998; Lintermans, 2000).

Movement of this species is extremely limited, with the home range of adult fish estimated at approximately 15 metres. High velocity winter flows are avoided by the fish sheltering amongst rocks and boulders on the streambed (Lintermans, 1998; Lintermans, 2000).

Diet:
Adult *Gadopsis bispinosus* feed predominantly on terrestrial invertebrates and aquatic insect larvae, while juveniles consume mayflies, caddisflies and midges (Lintermans, 2000).

Size:
Gadopsis bispinosus can grow up to 300-320mm and 250g, but typically smaller fish, rarely larger than 250mm, are more common (Jackson *et al*., 1996).

Reasons for Decline:
Alterations to flow regimes in conjunction with reductions of instream habitat and water quality due to increased sediment loads may be implicated in the demise of the Murrumbidgee River populations of *G. bispinosus.* General land degradation from overclearing and inappropriate land management, a proliferation of extractive industries, and the construction of dams and urban development within the upper Murrumbidgee catchment have undoubtably contributed to the general siltation of this river. This species seems susceptible to this degrading process as the interstitial spaces between stones used for cover and as spawning sites fill up with sediment. This can also be very damaging to benthic macroinvertebrate communities, the main dietary component of this species (ACT Government, 1999a). Terrestrial insects make up a significant part of the diet, indicating that intact riparian vegetation communities and their associated insect fauna are important sources of food (Lintermans, 2000).

Competition with and predation by brown and rainbow trout is also likely to have played a significant part in the decline of this species (Lintermans, 1998).

Protected Areas in which the species occurs:
Stony Creek Nature Reserve (ACT)
Namadgi National Park (ACT)
Kosciusko National Park (NSW)

Recovery Objectives / Management Actions Required:
In order to protect the last known population of this species in the Australian Capital Territory, Environment ACT will highlight the importance of maintaining the integrity of Cotter Dam and Bendora Dam to prevent upstream colonisation by brown trout, carp and redfin perch. The policy of not stocking fish for recreational purposes in streams of the Australian Capital Territory or the Cotter River catchment will also be maintained. The risk of introducing fish will also be minimised in the Cotter River below Bendora Dam by continuing to declare this area as a trout water for artificial lure fishing only. Although not heavily targeted as a recreational angling species, the continued ban on angling in the Cotter Reservoir and an educational program to enable anglers to distinguish this species from others caught, and to release accidentally caught individuals, should further serve to protect the species (ACT Government, 1999a).

Further surveys in the upper Murrumbidgee River should be carried out to locate populations outside the Australian Capital Territory, while unconfirmed observations of ‘blackfish’ in the Lachlan River also need to be investigated further. A long term monitoring program capable of detecting changes in the distribution and abundance of this species is also required (ACT Government, 1999a).

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	ACT
Lower Risk (Near Threatened)	Lower Risk (Near Threatened)	Near Threatened	No Change	No Change	No Change

Environment ACT is intending to declare *Gadopsis bispinosus* a protected fish under the Nature Conservation Act 1980 (M.Lintermans, pers.comm. 2000).

References:
ACT Government, 1999a; Harris & Gehrke, 1997; Jackson *et al*., 1996; Koehn, 1990; M.Lintermans, pers.comm. 2000; Lintermans, 1998; Lintermans, 2000; Sanger, 1984; Sanger, 1990.

River blackfish

Family Name:	Scientific Name:	Other Common Name(s):
Gadopsidae	*Gadopsis marmoratus* Richardson 1848	Freshwater blackfish, slippery, slimy, greasy, tailor, marbled river cod

Drawing by Jack Hannan

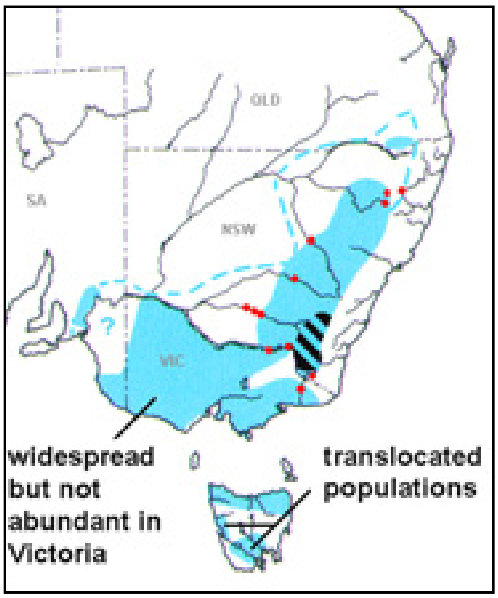
Synonyms:
Gadopsis gibbosus McCoy, 1870; *Gadopsis gracilis* McCoy, 1870; *Gadopsis fuscus* Steindachner, 1884.

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed	Protected

Reasons for Concern:
Gadopsis marmoratus is restricted to altitudes above 150m in the Murray River region and seems susceptible to increased sediment loads. This species is now rare in many areas where it was previously known to be common (Harris & Gehrke, 1997).

Distribution:
There are two forms of blackfish currently included within the species *Gadopsis marmoratus* (Sanger, 1984). The 'southern' form is confined to coastal drainages in Tasmania, Victoria and southern New South Wales. The 'northern' form is confined to the inland drainage of the Murray-Darling Basin. The 'northern' river blackfish is restricted to the smaller and higher tributaries of the Murray-Darling system at altitudes above 150m (Harris & Gehrke, 1997), although it is usually replaced by *G. bispinosus* in the more montane, rocky-bottomed streams. In New South Wales, it is now rare in many areas where it was previously thought to be common (Lake, 1971). This species is thought to be still widespread, but not abundant, in Victorian tributaries of the Murray River (T.Raadik, pers. comm. 2000); however, recent surveys in the Murray and Murrumbidgee River



systems in New South Wales found only a few specimens in the Murrumbidgee River and associated creeks (Gehrke *et al*., 1999). Recent trout cod surveys have also found reasonable numbers of river blackfish in the Murrumbidgee River between Yanco and Codac (I.Wooden, pers. comm. 2000). Montane tributaries of the Gwydir and Namoi Rivers in New South Wales also contain known populations (Harris & Gehrke, 1997; Gehrke & Harris 2000). It can also be found in the upper Murray River near Jingellic (Unmack, 2000), and is also present in the Condamine River drainage in Queensland. Both Stead in Ogilby (1913) and Whitley (1964) noted that blackfish were introduced into the Snowy River system, where this species was recorded by Lintermans (1998) and Harris and Gehrke (1997). However, the blackfish present in the Snowy River system are of the 'southern' form, which is restricted to coastal drainage systems (Lintermans, 1998; Sanger, 1986), indicating that the historical translocations from inland drainages, if they occurred, did not result in successful establishment.

Australian Museum Records – 64 records (33-240mm SL), ranging in distribution from near Warwick (28^o 13' S, 152^o 02' E) in southern Queensland southwards to Mount Gambier (37^o 50' S, 140^o 47' E) in South Australia; collected between circa 1880 and 1998.

Habitat:
This species is known to inhabit habitats ranging from small snaggy streams (Lake, 1971) and fast flowing rivers, to murky sluggish streams and dams (Llewellyn, 1983). Most specimens captured during recent trout cod surveys were located less than 1m from the riverbank (I.Wooden, pers. comm. 2001).

Biology & Behaviour:
Gadopsis marmoratus is a secretive, benthic-dwelling fish, which spawns from spring to early summer when water temperatures exceed 16^{o}C. Fecundity is low and proportional to the size of the fish (Cadwallader & Backhouse, 1983), with females producing around 500 eggs in one spawning (Lake, 1971). Eggs are 3.5-4.0mm in diameter, demersal, and strongly adhesive. These orange coloured eggs are deposited in hollow logs or rock crevices (Cadwallader & Backhouse, 1983) and are guarded and cleaned by the male (Jackson *et al.,* 1996). After about the 16th day, larvae 6-8mm in length free themselves from the egg membrane. The yolk sack remains within the egg membrane up until around 19 days before the larvae are able to swim away. Feeding commences around 7 days after hatching, when the yolk sac has been almost completely absorbed (Cadwallader & Backhouse, 1983) and the young fish are about 15mm in length. As these fish grow larger they progressively move to deeper waters (Jackson *et al.,* 1996). Jackson (1978) established that river blackfish and trout can coexist in at least some streams, probably because the two species occupy different habitats and have different requirements (Koehn & O'Connor, 1990). The northern form of this species has a life span of roughly 5 years while the southern form attains an age of at least 10 years at low altitudes (Cadwallader & Backhouse, 1983).

Diet:
The river blackfish is essentially an insectivore which feeds on caddisfly larvae and beetles, though it also consumes crustaceans, molluscs (Lake, 1971) and small fishes (Cadwallader & Backhouse, 1983).

Size:
The 'southern' form of this species is larger, growing to around 600mm and 6kg, while the 'northern' form is a much smaller fish, growing to about 300mm (Lintermans, 2000).

Reasons for Decline:
Populations of river blackfish have been known to fluctuate dramatically in any one area over a period of a few years for reasons that are not known (Pollard *et al.*, 1980). Habitat degradation (Jackson *et al.*, 1996) caused by soil erosion and clearing of timber and vegetation from both the watershed and some of the streams themselves has restricted the abundance of river blackfish in

many of the upper tributaries where it was previously common (Lake, 1971). Doeg and Koehn (1994) reported a 93 percent reduction in population density of this species immediately below a site of sediment addition in a small Victorian creek (ACT Government, 1999a). *Gadopsis marmoratus* is especially sensitive to increased siltation, particularly from weir desilting operations. Increased sedimentation has been known to smother eggs and kill juveniles (Jackson *et al.*, 1996).

River blackfish are not a migratory species and so barriers to movement are not likely to have played a significant role in the decline of the species; however, the construction of dams has probably led to increasing sedimentation and cold water pollution within its habitat (ACT Government, 1999a). As this species lays eggs on or in logs, the removal of such spawning sites is likely to lead to reduced breeding success (Koehn & O'Connor, 1990). The 'southern' form may also be sensitive to angling pressure in the southern parts of its range due to its low fecundity and its popularity as an angling target species (Jackson *et al.*, 1996).

Competition may occur between river blackfish and alien trout in degraded habitats due to their ecological requirements becoming more similar and the aggressive, territorial nature of trout (Fletcher, 1986).

Protected Areas in which the Species Occurs:
Snowy River National Park (Vic)

Recovery Objectives / Management Actions Required:
There is currently no specific action plan for *Gadopsis marmoratus,* but the ACT Action Plan for *Gadopsis bispinosus* suggests that further research, monitoring and surveys into the distribution, abundance, environmental requirements and reasons for decline of this species are also required (ACT Government, 1999a). Education of landholders and community groups as to the conservation status of the species is also necessary to assist anglers and others to recognise the conservation needs of this potentially threatened species. Further protective measures need to be implemented to preserve the remaining populations.

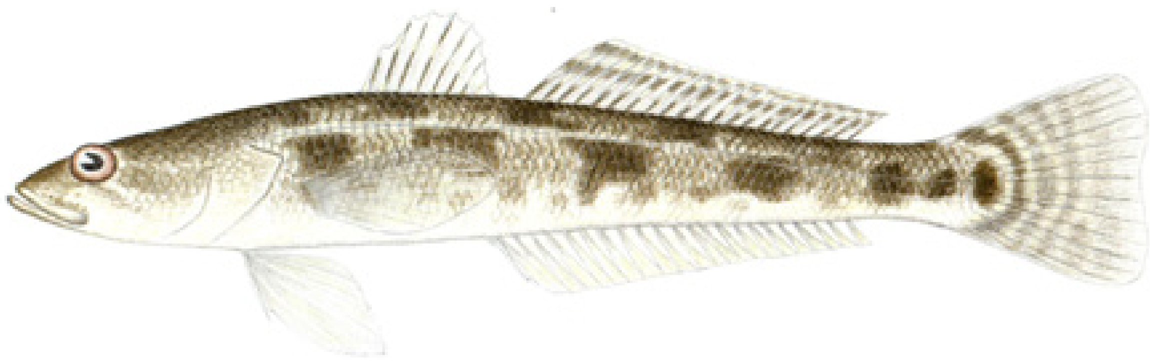
Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Lower Risk (Near Threatened)	Lower Risk (Near Threatened)	Near Threatened	No Change	No Change	Rare	No Change

References:
ACT Government, 1999a; Cadwallader & Backhouse, 1983; Fletcher, 1986; Gehrke *et al.*, 1999; Gehrke & Harris, 2000; Harris & Gehrke, 1997; Jackson *et al.*, 1996; Koehn & O'Connor, 1990; Lake, 1971; Pollard *et al.,* 1980; Unmack, 2000; I.Wooden, pers. comm. 2001.

Congolli

Family Name:	Scientific Name:	Other Common Name(s):
Bovichthyidae	*Pseudaphritis urvillii* Valenciennes, 1832	Sandy, marble fish, sand trout, tupong



Drawing by Jack Hannan

Current Conservation Status:

IUCN 2000 Red List	ASFB	EPBCA	NSW	VIC	SA
Lower Risk	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed

Reasons for Concern:
Pseudaphritis urvillii was not recorded in southern coastal rivers of New South Wales by Llewellyn (1983), but recorded from all river drainages from the Snowy to the Clyde by Gehrke and Harris (2000). Barriers to migration have probably led to reduced abundances upstream in south coast rivers.

Distribution:
Pseudaphritis urvillii is restricted to coastal streams of southern Australia between Streaky Bay (South Australia) at the eastern end of the Great Australian Bight to the Clyde River on the south-east coast (New South Wales), including Tasmania (Andrews, 1996; Harris & Gehrke, 1997), sometimes occurring up to 120km inland (Gomon *et al*., 1994). It is also known from the lower Murray River in South Australia (Merrick & Schmida, 1984). There are increasing reports in recent years of anglers catching congolli in Victorian waters. This increase may or may not reflect an increase in abundance (A.Baxter, pers. comm. 2000). This species is also very abundant in Tasmania (T.Raadik, pers. comm. 2000).

Australian Museum Records – 49 records (27-267mm SL), ranging in distribution from the Tuross River (34° 14’ S, 149° 46’ E) in New South Wales southwards to the Plenty River (42° 51’ S, 146° 53’ E) in Tasmania, and westwards to St Vincent Gulf (35° 12’ S, 138° 28’ E) in South Australia; collected between circa 1884 and 1999.

Habitat:
This species is found in both freshwater and estuarine to marine habitats, but more commonly near the mouths of slow-flowing coastal streams, where it often remains partly buried among rocks or leaf litter and under sunken logs and overhanging banks (Andrews, 1996). Small fish are commonly found amongst large boulders on the stream bottom (Cadwallader & Backhouse, 1983).

Biology & Behaviour:
Pseudaphritis urvillii is primarily an estuarine species which migrates far inland up coastal rivers (Kuiter, 1993). At the southern extent of its range, spawning occurs between autumn and winter after migration to estuarine habitats. Spawning occurs in the upper reaches of estuaries under tidal influence, mainly in sandy and weedy areas (Cadwallader & Backhouse, 1983). Little else is known of the breeding biology of this species (Gomon *et al.,* 1994). Late postflexion larvae have been caught near Adelaide, South Australia, from July to September. Settlement larvae have been caught in the Gippsland Lakes (Victoria) in November (Sutton & Bruce, 1998).

Diet:
Pseudaphritis urvillii is a generalised carnivore, feeding on a variety of benthic organisms (Cadwallader & Backhouse, 1983), including insect larvae, worms, small crustaceans and small fish (Andrews, 1996). Insects are the main diet in freshwater, while in estuarine systems crustaceans form the main dietary component (Cadwallader & Backhouse, 1983).

Size:
Pseudaphritis urvillii reaches lengths of 95mm, 165mm, 200mm, 255mm and 300mm after one to five years, respectively (Cadwallader & Backhouse, 1983).

Reasons for Decline:
As this species migrates far inland up rivers (Kuiter, 1993), it is likely that weirs and other barriers may impede spawning migrations and the upstream migrations of juveniles, thus reducing recruitment into the habitat occupied by previous generations. This impact may now be greater as a result of this species' irregular recruitment.

Protected Areas in which the Species Occurs:
Snowy River National Park (NSW/Vic)
This species occurs in various national parks and nature reserves situated along the southern coastline of New South Wales and other parts of south-eastern Australia.

Recovery Objectives / Management Actions Required:
Further studies need to be conducted in order to establish the key causes of any declines in populations of this species. Monitoring programs on the remaining populations need to be undertaken to accurately assess their current distributions and abundances. Further education of local governments and communities as to the conservation status of this species is also necessary. Amending any impediments to fish passage to allow better dispersal and recruitment may also be important management actions necessary for the recovery of this species.

Suggested Conservation Status:

IUCN Red List	ASFB	EPBCA	NSW	VIC	SA
Lower Risk (Least Concern)	Lower Risk (Least Concern)	No Change	No Change	No Change	No Change

References:
Andrews, 1996; Cadwallader & Backhouse, 1983; Gomon *et al.,* 1994; Harris & Gehrke, 1997; Kuiter, 1993; Merrick & Schmida, 1984; Sutton & Bruce, 1998.

Southern purple-spotted gudgeon

Family Name:	**Scientific Name:**	**Other Common Name(s):**
Eleotridae	*Mogurnda adspersa* (Castelnau, 1878)	Purple-spotted gudgeon, purple-striped gudgeon, checkered gudgeon, trout gudgeon, koerin, kurrin

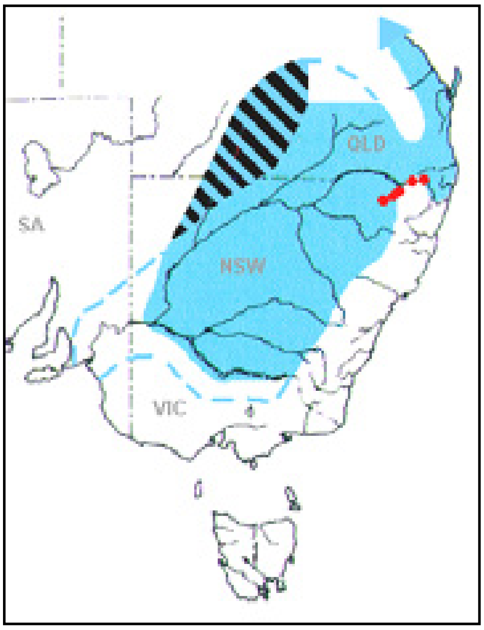
Drawing by Jack Hannan

Synonyms:
Eleotris adspersa Castelnau, 1878; *Eleotris concolor* De Vis, 1884; *Eleotris minus* DeVis, 1884.

Current Conservation Status:

IUCN 2000 Red List	**ASFB**	**EPBCA**	**NSW**	**VIC**	**QLD**
Lower Risk (Least Concern)	Lower Risk (Least Concern)	Not Listed	Endangered Population (Western Population)	Critically Endangered	Not Listed

Reasons for Concern:
Mogurnda adspersa has suffered a considerably reduced distribution and abundance, especially throughout the southern portion of the Murray-Darling Basin. This species was recorded by Llewellyn (1983) from the Murray and Murrumbidgee Rivers, but not found by Harris and Gehrke, (1997) during the NSW Rivers Survey. Its coastal distribution in New South Wales is limited to far north coast streams.



Distribution:
Mogurnda adspersa was formerly distributed throughout the entire Murray-Darling drainage system, and also the Torrens and Onkaparinga Rivers in South Australia (Wager & Jackson, 1993). It was also common in the Murrumbidgee River and Barren Box Swamp in New South Wales (Llewellyn, 1983). Small populations found previously near Mildura in Victoria (Cadross Lakes) have not been seen during recent

surveys (J.Koehn, pers. comm. 2000), and the species is only patchily distributed in a few streams around the Queensland-New South Wales border (Briggs, 1998). This species has previously been recorded in the Dumaresq, Condamine, McIntyre and Severn River systems in Queensland (Wager & Jackson, 1993). It can also be found near Inverell (Briggs, 1998) and Tenterfield in New South Wales (NSW Fisheries Freshwater Fish Database, 2000), in the Severn River at Dundee in New South Wales, and the Gwydir River at Bingara in New South Wales (Unmack, 2000). *Mogurnda adspersa* has also been confirmed as occurring at Murray Bridge in South Australia after being reintroduced there from a remnant population in Queensland (Austin, 1999).

Australian Museum Records – 96 records (98-12mm SL), ranging in distribution from Gerehu Creek (9° 23' S, 147° 10' E) in Papua New Guinea southwards to the Murray River (37° S, 148° E) in New South Wales, and from the Stanley River (26° 50' S, 153° 52' E) in Queensland westwards to near Moonta (34° 04' S, 137° 35' E) in South Australia; collected between circa 1885 and 2000.

Habitat:
Mogurnda adspersa occurs in weedy (Llewellyn, 1983), slow moving or still waters of rivers, billabongs and creeks (Cadwallader & Backhouse, 1983). It can be found amongst benthic structures such as rocks and snags, and amongst aquatic vegetation (Wager & Jackson, 1993) such as *Nitella* spp. and *Ottelia ovalifolia* (Briggs, 1998).

Biology & Behaviour:
Mogurnda adspersa spawns during summer when water temperatures exceed 20°C and food is abundant (Larson & Hoese, 1996). The male cleans a prospective egg-deposition site such as a rock or log, and then exhibits an elaborate courtship display. Up to 1300 elongate, transparent eggs of 2.0-3.8mm in length and 1.0-1.3mm in width can be laid in a single batch. Eggs adhere to the surface of the spawning site in a circular cluster (Tappin, 1997) via a sticky basal mass at one end. Males fan and protect the eggs during incubation, and after 3-8 days (depending on the water temperature), larvae 3.5-4.0mm long hatch (Cadwallader & Backhouse, 1983). Feeding commences after about 6 days, when the yolk is fully absorbed. Males reach maturity at a length of 45mm, while females reach maturity at 49mm (Larson & Hoese, 1996). In general, this species is considered to need water temperatures of at least 15-20°C, yet fish from northern New South Wales appear to survive healthily at winter water temperatures as low as 10.5°C (Briggs, 1998).

Diet:
Mogurnda adspersa feeds mainly on insect larvae, but also consumes worms, tadpoles and small fish (Cadwallader & Backhouse, 1983). It is also known to consume algae, pollen and miscellaneous forms of organic matter (Tappin, 1997).

Size:
This species reaches 120mm, but is more commonly found at around 70mm (Larson & Hoese, 1996).

Reasons for Decline:
Historically, this species was widespread throughout most of the Murray-Darling River system, being commonly used as bait for Murray cod by line fishermen. Today this distribution has been massively reduced (Briggs, 1998). The decline of *Mogurnda adspersa* has been correlated with the invasion of gambusia *Gambusia holbrooki* into its habitat (Wager & Jackson, 1993).

Although they are numerous throughout the Murray-Darling Basin, most existing terrestrial protected areas offer little real protection to instream habitat essential for fish survival, or from adverse upstream influences (Wager & Jackson, 1993). Redfin perch are known to prey upon *Mogurnda adspersa* (Larson & Hoese, 1996). Also, the adhesive eggs of gudgeons are deposited in patches (T.O'Brien, pers. comm. 2000) and would probably not be able to survive marked water level fluctuations (Pollard *et al.*, 1980). Such rapid fluctuations in water levels (due to water regulation) can also have deleterious effects on successful recruitment (FSC, 2001b). Habitat destruction, and especially the loss of macrophytes from large sections of the Murray and Darling Rivers, may have also contributed to the decline of this species (Harris & Gehrke, 1997). Populations previously found near Mildura in Victoria occurred in lakes with increasing salinities caused by changes to irrigation system management (T.O'Brien, pers. comm. 2000).

Protected Areas in which the Species Occurs:
Occurs in various national parks and nature reserves situated along the coastlines of Queensland and northern New South Wales.

Recovery Objectives / Management Actions Required:
The decline of *Mogurnda adspersa* in the Murray-Darling Basin is an important but little known conservation issue (Briggs, 1998). Further study needs to be conducted in order to establish the extent of this species' current distribution and abundance, and the key causes of its decline (Wager & Jackson, 1993). The small size of *Mogurnda adspersa* allows heavy predation by both native and alien fish species, and therefore the eradication and/or control of alien species should significantly improve its chances of survival.

Suggested Conservation Status: Inland Population / Coastal Population

IUCN Red List	ASFB	EPBCA	NSW	VIC	QLD	SA
Endangered/ Lower Risk (Least Concern)	Endangered/ Lower Risk (Least Concern)	Endangered/ No Change	No Change/ No Change	No Change/ N/A	Rare/ Common	No Change/ N/A

References:
Austin, 1999; Briggs, 1998; Cadwallader & Backhouse, 1983; Harris & Gehrke, 1997; FSC, 2001b; Larson & Hoese, 1996; Llewellyn, 1983; Moffatt *et al.,* 1997; NSW Fisheries Freshwater Fish Database, 2000; T.O'Brien, pers. comm. 2000; Pollard *et al.*, 1980; Tappin, 1997; Unmack, 2000; Wager & Jackson, 1993.

5. SYNTHESIS FROM SPECIES CONSERVATION SYNOPSES

5.1. Critical Habitats

The habitat requirements of Australian freshwater fish are complex, and it is unlikely that they will ever be fully understood. Part of the reason for this is that Australian freshwater fish, and particularly those living in inland river drainages, are adapted to live in variable and unpredictable environments, and so have not developed the strong habitat associations that are characteristic of highly specialised fish in more predictable river systems in other countries. Many Australian fish species have evolved to survive under a wide range of environmental conditions, and those conditions and the habitats created can change dramatically over time. Fish use their habitats in dynamic ways, and it is simplistic to generalise about prescriptive habitat requirements. A more sensible approach is simply to refer to habitats used by particular species under different conditions at different stages of their life cycles (Gehrke & Harris, 2000).

This approach is fundamental to the niche concept in ecological literature (Li & Moyle, 1993). The niche represents a species' total requirements to survive under a range of environmental conditions throughout its distribution and includes, for example, habitat preferences, environmental tolerances, diet, feeding behaviour and spawning locations. Fish in coastal rivers of New South Wales and the Murray-Darling Basin tend to have relatively broad niches and use different habitats at different times or locations. A species may show strong preferences for a particular habitat in one part of its distribution, but may occur in different habitats in other locations where the first habitat is rare. Consequently, classifying particular habitats as critical can be problematic for many species. From a broader perspective, it can thus be dangerous to define habitats as "critical" because, by definition, other habitats must then be non-critical. If nominal non-critical habitats are modified on the basis of being less important, and subsequently prove to be equally important to other species, then fish communities will continue to decline as a result of habitat degradation. By applying the niche concept at the scale of entire fish communities, it becomes readily apparent that all habitats are important, and that defining a subset of habitats as critical is likely to contribute to further loss of biodiversity.

A special case of this holistic approach to habitat definition is possible with threatened species that have highly restricted distributions. Because the range of habitats occupied by these species can be very small, it may be possible to protect all habitats within the species' localised distribution. This action could simultaneously protect the habitats of other species in the same fish community.

Not withstanding the inherent problems in identifying and defining critical habitats for fish, important habitats for fish communities include main river channels, tributary and effluent streams, ephemeral flood-runners, pools, riffles, runs, eddies, lakes, gravel beds, snags, aquatic vegetation and floodplain wetlands. These all play a role in maintaining the diversity of fish by offering food sources, shelter from predators, breeding sites or migration corridors that all species need at different stages of their life cycles. Diverse habitats also provide a variety of water velocities and depths for fish of different sizes and with different swimming abilities.

An important habitat feature in maintaining the diversity of fish in the Murray-Darling Basin and coastal rivers of New South Wales is the occurrence of natural disturbances, especially floods and droughts (Gehrke *et al*., 1995; Gehrke *et al*., 1999). Natural disturbances reset aquatic habitats, and prevent common species from becoming so abundant that they completely dominate fish communities. In highly stable environments, the species best adapted to environmental conditions often become highly abundant while other species decline, creating low species diversity. At the other extreme, a high frequency of disturbance prevents species from becoming well established, which also results in low diversity. However, at some intermediate point between these two extremes, the level of disturbance allows species to become established whilst not allowing any species to exclude others, thus creating maximum species diversity (Connell, 1978; Ward & Stanford, 1983). Natural disturbances of these types can affect all aspects of riverine ecosystems, and are a key factor in maintaining the diversity of aquatic habitats for all fish, including threatened species.

5.2. Key Threatening Processes

Altering or blocking rivers flow is one factor which probably has the most serious ramifications for freshwater fish communities. Barriers erected across permanent or intermittent watercourses obstruct fish migrations, preventing access to spawning and feeding areas, fragmenting populations, and interrupting gene flow. Altered river flows also reduce the amount of instream habitat available for fish and other aquatic fauna. Importantly, Australian freshwater fish are naturally adapted to highly variable flow regimes, and imposing more stable flows on rivers reduces the environmental variability fish need to survive and reproduce. Water released from the bottoms of dams is often cold and deficient in oxygen to such an extent that native fish avoid affected downstream river reaches. Large rivers warm up quite slowly, and may still be cooler than natural ambient temperatures for more than 300km downstream of a dam. Dams and weirs create impounded waters upstream, which change flowing habitats into still water habitats that can extend for over a hundred kilometres, and also drown habitat features that once formed part of the original riverine habitat. Many life history stages of native species are cued to river flow cycles, so that modifying flow regimes both upstream and downstream of dams and weirs alters the ability of species to successfully complete their life cycles. There is evidence that flow alteration has significantly reduced biodiversity in both inland and coastal rivers (Sheldon & Walker, 1997; Gehrke & Harris, 2000). Moreover, habitats with altered flows provide favourable conditions for alien species such as carp.

Removing snags from rivers has been commonplace in previous years to improve navigation and to prevent bank erosion. Snags provide habitat diversity for fish and other animals. Desnagging to increase channel capacity or to improve navigation reduces aquatic biodiversity and affects ecosystem functions and fish populations both directly and indirectly. Direct impacts include loss of substrate, resting, feeding or breeding sites. Indirect impacts include short-term turbidity increases and long-term changes in stream morphology. Desnagging has been noted as an important factor in the decline of the endangered trout cod.

Good water quality is a critical component of fish habitat. Fish kills often result from accidental chemical spills into waterways, overuse of agricultural chemicals or deliberate waste water discharges. Discharge of water with elevated nutrient levels, low dissolved oxygen levels, altered pH, turbidity, temperature and salinity, or containing chemical contaminants, degrades aquatic habitats and causes fish to avoid affected areas. Impacts of pollution can sometimes be detected hundreds of kilometres downstream of their point of entry.

Alien species usually have negative effects on native species through predation, competition, disease, or by habitat destruction. For example, carp affect sediment distribution and turbidity, nutrient availability, aquatic plants, and also prey on macro-invertebrates that serve as food for native fish. Increased incidence of disease among native fish has also been found to be associated with high carp densities, and parasites such as the introduced broad fish tapeworm have recently been recorded from native fish in rivers inhabited by carp (Dove *et al*., 1997).

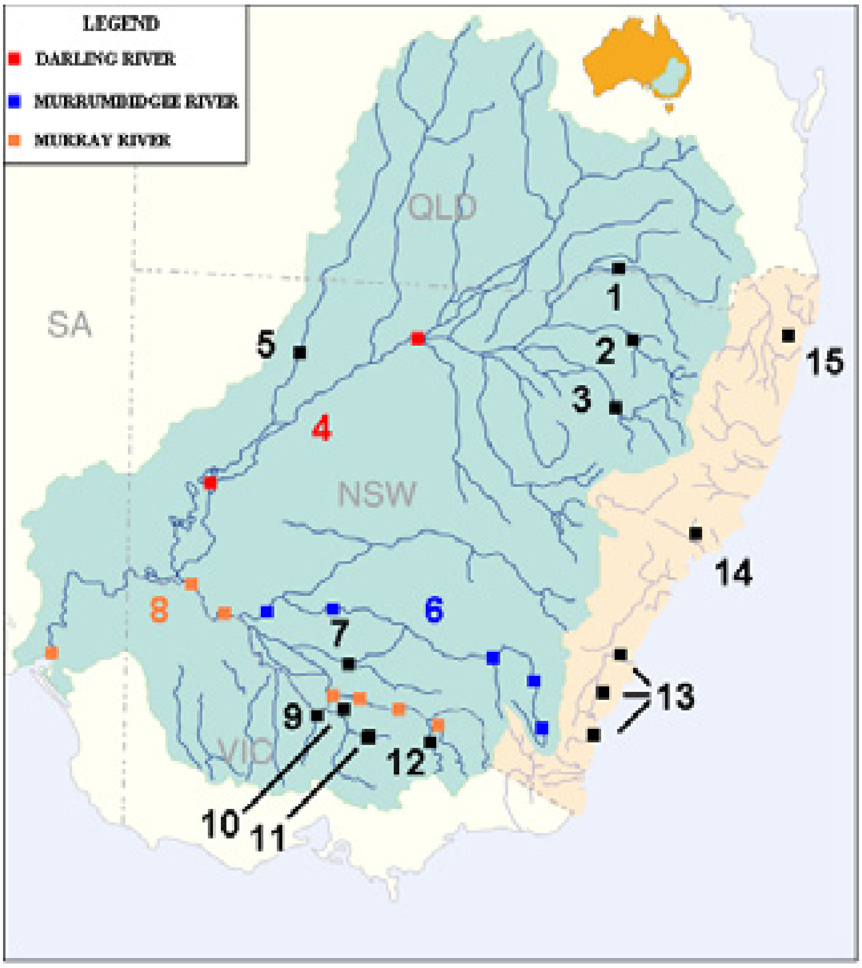
Stocking is often perceived as a rapid solution to declining fish populations. However, this is rarely the case in natural environments where fish numbers have fallen because of habitat degradation. Injudicious and unplanned stocking can cause a loss of genetic variability within natural populations, introduce disease, reduce prey abundance, and may increase mortality of wildspawned fish without providing any ultimate increase in population size. Stocking fish that cannot readily be identified as hatchery stock can result in misleading fishery assessments if large numbers of small fish are wrongly interpreted as indicating a healthy breeding population.

5.3. Diversity Hotspots

For the purposes of this report, areas of high threatened freshwater fish diversity were considered to be those locations where populations of several different species of threatened and/or potentially threatened freshwater fish are known to still occur. Such hotspots of threatened freshwater fish diversity in the waters of coastal New South Wales and the Murray-Darling Basin were identified using a combination of catch data from the NSW Rivers Survey, Australian Museum records from 1990 onwards, and less extensive river surveys also conducted from 1990 to the present. These hotspots may be either sites known to be inhabited by threatened and potentially threatened fishes, or sites located in areas that would most benefit the species covered in the synopses.

It should be noted that although this project utilised information from as many different fish surveys as possible, it is very likely that there are other areas of high threatened fish diversity in the regions studied that have yet to be identified. Location data based on stocked and translocated populations was not used in this analysis.

Figure 2: Areas of high threatened freshwater fish diversity in the river systems of coastal New South Wales and the Murray-Darling Basin (numbers on this map correspond to site numbers for localities listed in section 6.1.).



6. RECOMMENDATIONS

6.1. Suggested Community Projects and Recommended Engineering Solutions

6.1.1. MacIntyre River

SITE	SPECIES	THREATS	ACTIONS
Goondiwindi Weir Fishway (NSW/ Qld Border)	- Murray cod - freshwater catfish - silver perch	- Fish cannot locate the entrance to the fishway at various flow levels, and especially high rates of flow.	- A permanent guiding wall, level with the fishway entrance, should be constructed to prevent fish swimming upstream past the opening, OR - A flat section should be added at the top of the rock-ramp before the slope starts; this would allow flexibility to adjust the upper section of the rock-ramp after construction without increasing the slope.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Costs of modifications to this site were estimated at approximately $0.5M	S.Fairfull, pers. comm. 2000; B.Lynch, pers.comm. 1998; Mallen-Cooper, 2000; Thorncraft & Harris, 1996;

Recommended actions of the Murray-Darling Basin Fish Management Strategy include developing a program to modify the non-working fishway at Boggabilla located less than 20km upstream of Goondiwindi Weir. This site is considered a high priority objective of the strategy.

6.1.2. Gwydir River

SITE	SPECIES	THREATS	ACTIONS
Downstream of Copeton Dam – Gwydir Wetlands	- silver perch - freshwater catfish - crimson-spotted rainbowfish - spangled perch - Murray cod - purple-spotted gudgeon - non-speckled hardyhead	- Cold water pollution from bottom offtakes on Copeton Dam. - Highly regulated downstream flows. - Agricultural practices associated with bankside grazing and the production of cotton. - Culverts and causeways that infringe upon fish passage. - Floodplain developments that infringe upon wetland rehabilitation.	- Construction of thermal mitigation devices on Copeton Dam. - Flow regimes should also be modified to be within biological and environmental requirements. - Initiate communications with local landholders in this area to help mitigate effects of agricultural practices.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
N/A	Department of Public Works, NSW.

The middle and upper Gwydir River and the Horton River harbour a large and diverse fish fauna. These actions will protect riparian vegetation and ensure that the biological and environmental requirements of the native fish fauna are maintained and incorporated into water management plans and strategies. NSW Fisheries also recommends the construction of a variable level offtake tower on Copeton Dam. This would be one of the most viable actions for the management of these fish populations.

6.1.3. Namoi River

SITE	SPECIES	THREATS	ACTIONS
Upper Namoi River	- freshwater catfish - Murray cod - crimson-spotted rainbowfish - spangled perch - river blackfish - golden perch - silver perch	- Limited public knowledge of the need to protect the diverse fish fauna present. - Predation and/or competition with brown and rainbow trout.	- Installation of appropriate information signs. - Discontinue stocking of brown and rainbow trout in areas supporting threatened species.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
\$300 approx. per sign	N/A

This part of the Namoi River system, between Narrabri and Manilla, is known to be inhabited by a diverse fish fauna. NSW Fisheries suggests that WWF and the IRN illustrate the diversity of not only the fish fauna but other aquatic fauna and flora present in this region via appropriate information signage. Signs could be placed at sites which would best depict the need to preserve the species present to as wide an audience as possible. Examples might include rest or recreation areas near both main roads and rivers, such as at Lake Keepit on the Oxley Highway.

6.1.4. Darling River

SITE	SPECIES	THREATS	ACTIONS
Bourke Weir	- spangled perch - golden perch - Murray cod - freshwater catfish - silver perch - crimson-spotted rainbowfish - olive perchlet	- Poor fish passage.	- Installation of a suitable vertical slot fishway at Bourke. - Removal of weirs or construction of fishways on the Darling River and its tributaries.
Menindee Weir	- crimson-spotted rainbowfish - silver perch - spangled perch	- Poor fish passage. - Changes to quantity and variability of river flows.	- Installation of an effective fishway. - Alter weir operations to improve flow management.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
- Costs of modifications to Brewarrina Weir were estimated at approximately $0.5M. - Costs of modifications to Bourke Weir were estimated at approximately $0.5M.	Harris *et al.* 1992; C.Lay, pers. comm. 2000; B.Lynch, pers. comm. 1998.
Costs of modifications to Menindee Weir were estimated at approximately $1.5M.	B.Lynch, pers. comm. 1998; M.Mallen-Cooper, pers. comm. 2000.

Bourke Weir on the Darling River is known to affect fish communities in various ways, primarily as a major obstruction to fish passage. Brewarrina Weir is located approximately 100km upstream of Bourke Weir. There are tentative management plans to alleviate the accumulation of threatened and potentially threatened native fishes below this barrier. NSW Fisheries recommends improvements to fish passage at Bourke Weir to complement management plans at Brewarrina Weir.

Modifications to these two weirs should significantly improve fish diversity and abundance not only along this reach of the Darling River, but also in other smaller river sections diverting north, south and east from this location. These actions are perceived as a priority modification for effective fish passage in this area.

6.1.5. Paroo River

SITE	SPECIES	THREATS	ACTIONS
Paroo River system	- silver perch - spangled perch - rainbowfish - golden perch	- Widespread use of pesticides and herbicides if proposed irrigation scheme proceeds. - Changes to quantity and variability of river flows. - Degradation caused by feral animals and plants.	- Initiate communications with local landholders to reduce impacts of weirs, levees and farm dams on flow volumes and patterns. - A community project to identify and initiate the protection of riparian and wetland areas through stock exclusion where necessary. - This report recommends the Paroo River as the first site to be declared an aquatic reserve under the NSW Fisheries Management Act 1994 (1997 amendments)

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
N/A	Kingsford, 1999.

These actions will serve to protect riparian vegetation and ensure that the biological and environmental requirements of the native fish fauna are maintained and incorporated into water management plans and strategies.

6.1.6. Murrumbidgee River

SITE	SPECIES	THREATS	ACTIONS
Balranald Weir, Redbank Weir	- silver perch - Murray cod - crimson-spotted rainbowfish - freshwater catfish	- Poor fish passage. - Changes to quantity and variability of river flows.	- Investigate removal of Balranald Weir, OR - Insert a Deelder fish lock at Balranald Weir. - Installation of vertical slot fishways at all other sites. - Alter weir operations to improve flow management.
Golgedrie Weir, Yanco Weir, Hay Weir, Maude Weir, Berembed Weir	- Murray cod - trout cod - Murray hardyhead - river blackfish - Murray jollytail - Freshwater catfish - silver perch	- Ineffective fishways on Golgedrie and Yanco Weirs. - Poor fish passage at Hay Weir. - Loss of riparian vegetation. - Loss of instream cover. - Loss of instream flow variability and overbank flooding.	- Insert a Deelder fish lock or Denil fishway at Golgedrie and Yanco Weirs. - Insert a Deelder lock at Hay Weir. - Reintroduce woody debris (snag piles). - Community based project to restore bankside vegetation. - Increase floodplain inundation.
Upper Murrumbidgee River, Junction with Tumut River	- Macquarie perch - Murray cod - silver perch - two-spined blackfish - mountain galaxias	- Cold water pollution from Burrinjuck and Blowering Dams. - Loss of riparian vegetation. - Loss of instream cover. - Predation and/or competition with brown and rainbow trout. - Invasion by willows.	- Construction of thermal mitigation devices on Burrinjuck and Blowering Dams. - A community based project to reintroduce woody debris (snag piles). - A community based project to fence sections of the river bank to control grazing pressure and promote regeneration of native riparian plant species. - Discontinue stocking of brown trout and rainbow trout in areas supporting threatened species. - A community-based project to remove pest plant species such as willows.

Queanbeyan River, Upstream of Googong Dam	- Remnant population of Macquarie perch	- Sedimentation resulting from catchments, streambank erosion, and invasion of pest plants such as willows. - Macquarie perch population confined to short reach of river by waterfall.	- A community-based project to address erosion sites and control pest plant species such as willows. - Support scientifically monitored and controlled translocation of fish from below waterfall to expand species distribution.
Murrumbidgee River at Cooma	- trout cod - Macquarie perch	- Riparian vegetation community decline caused by uncontrolled stock access and willow invasion. - Accidental capture of threatened species by anglers causing injury or death.	- A community based project to fence sections of the river bank to control grazing pressure and promote regeneration of native riparian plant species. - A community-based project to remove pest plant species such as willows. - Creation of an aquatic reserve to prevent accidental capture and protect local habitat.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Costs of modifications to Hay and Golgeldrie Weirs were estimated at approximately $0.5M each.	Harris & Thorncraft, 2000; C.Lay, pers. comm. 2000; Lintermans, 2000; A.Lugg, pers.comm. 2000; B.Lynch, pers. comm. 1998; MCMC, 1994; MDBC, 2000.

Golgeldrie Weir is approximately 20km downstream of Yanco Weir and Hay Weir is approximately 130 km downstream of Golgeldrie Weir. Both sites have barriers that would significantly benefit from an effective fishway, and in turn have positive influences on recruitment and migratory life-history phases of various fish species in the Murrumbidgee River system.

The northern and southern banks of the Murrumbidgee River from Hay Weir to approximately Darlington Point have been identified as a medium priority for revegetation (MDBC, 2000). The reach extending from Balranald Weir to the junction of the Murray River, as well as the area at the junction of the Tumut and Murrumbidgee Rivers, have also been identified as high priorities for bank revegetation. The reintroduction of woody debris (snag piles) and the restoration of bankside vegetation are management actions that could be coordinated through relevant community level organisations. The benefits to both large predatory fish and smaller fish species would be significant.

Balranald Weir on the Murrumbidgee River and Redbank Weir on the Lachlan River would benefit significantly from the installation of effective fishways to help expand isolated fish populations and the general distribution and abundance of species found to occur in this area. Where Murray cod are present and the passage of this species is considered a priority, then the vertical slot design is the only fishway that should be used, until such time as research indicates that other designs are appropriate. Reviews of weirs are conducted from time to time to identify weirs that can be removed. NSW Fisheries plans to evaluate a Deelder fish lock at Balranald Weir if a current review justifies its continued existence.

6.1.7. Edward River

SITE	SPECIES	THREATS	ACTIONS
Stephens Weir	- Murray cod - silver perch - crimson-spotted rainbowfish	- Poor fish passage. - Loss of instream flow variability and overbank flooding.	- Increase floodplain inundation.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Costs of modifications to this site were estimated at approximately $1.0M.	A.Lugg, pers. comm. 2000; B.Lynch, pers. comm. 1998; M.Mallen-Cooper, pers. comm. 2000.

Stephens Weir on the Edward River has been identified as a major barrier and is a priority modification for effective fish passage in this area. The Murray Wetland Working Group has recently received funding to build a fishway at this site (A.Lugg, pers. comm. 2000).

6.1.8. Murray River

SITE	SPECIES	THREATS	ACTIONS
Upper Billabong Creek near Holbrook and Coppabella Creek near Jingellic	- southern pygmy perch - river blackfish	- Sedimentation resulting from catchments, streambank erosion, and invasion of pest plants such as willows. - Predation and/or competition with brown and rainbow trout.	- A community-based project to address erosion sites and control pest plant species (willows). - Discontinue stocking brown and rainbow trout in areas supporting threatened species.
Below Hume Dam	- silver perch - Murray cod - trout cod - Murray jollytail - southern pygmy perch	- Cold water pollution resulting from bottom offtakes on Hume Dam and Dartmouth Dam. - Loss of natural flow regime.	- Construction of thermal mitigation devices on Dartmouth and/or Hume Dams. - Restore natural flow regimes, particularly flooding, into river management strategies to help facilitate fish recruitment.
Murray River near Torrumbarry	- silver perch	- Limited preservation of one of the few remaining viable populations of silver perch.	- A community-based project to enhance the physical habitat conditions via resnagging and restoration of riparian vegetation. - A community-based project to remove pest plant species (willows).

Murray River downstream of Yarrawonga Weir (sections of private property which are interspersed with state forest)	- trout cod - Murray cod - golden perch	- Invasion of pest plant species (willows) and loss of riparian vegetation. - Loss of natural flow regime, particularly unseasonal flooding and erosion from irrigation flows.	- A community-based project to enhance the physical habitat conditions via resnagging and restoration of riparian vegetation. - A community-based project to remove pest plant species (willows). - Restore natural flow regimes, particularly flooding, into river management strategies to help facilitate fish recruitment.
Lock 15	- silver perch - Murray cod - crimson-spotted rainbowfish - freshwater catfish	- Poor fish passage. - Changes to quantity and variability of river flows.	- Investigate removal of Euston Weir (Lock 15). - Alter weir operations to improve flow management.
Lock 10 & Mildura Weir	- Murray cod - crimson-spotted rainbowfish. - silver perch	- Poor fish passage. - Loss of instream flow variability and overbank flooding.	- Install fishways at both of these sites. - Increase floodplain inundation.
Lock 1 & Barrages	- Likely to benefit many fish species; i.e. all of those (estuarine, marine and freshwater species) entering freshwater from coastal waters in this region.	- Poor fish passage. - Creation of lake environment within river channel.	- Construction of appropriate fishways, OR - Modify operating procedures to improve fish passage. - Investigate removal of barrages. - Routine manipulation of weir levels to restore natural flow variability.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Costs of modifications to Lock 15 were estimated at approximately $1.0M. Costs of modifications to Lock 10 were estimated at approximately $0.6M. Costs of modifications to Lock 1 were estimated at approximately $0.6m, while modifications to remotely operated radial gates located at the Barrages were estimated at $2.0m.	A.Lugg, pers. comm. 2000; B.Lynch, pers.comm. 1998; C.Lay, pers. comm. 2000; B.Lynch, pers. comm. 1998; Mallen-Cooper, 2000; S.Fairfull, pers. comm. 2000.

The native fish community on the Victorian side of the Murray River at these sites is currently under consideration for listing as a vulnerable ecological community under Schedule 2 of the Victorian Flora and Fauna Guarantee Act 1988. This fish community is known to be under threat from cold water pollution resulting from bottom offtakes on Hume Dam and Dartmouth Dam, as well as ineffective fish passage at Yarrawonga Weir. Therefore, the fish found here would significantly benefit from removing this threat which is likely to result in the local extinction of these species as listed under Schedule 3 of the Victorian Flora and Fauna Guarantee Act 1988.

Recommended actions of the Murray-Darling Basin Fish Management Strategy include the design and construction of suitable fish passage at Mildura Weir and Lock 1 near Blanchetown, as well as modification of the ineffective fishway at Mulwala. These sites are considered to be a high priority objective of the Strategy and are termed as being capable of being carried out with "moderate ease". Species that would benefit from fish passage at the Barrages include congolli, pouched lamprey, climbing galaxias, mountain galaxias and common galaxias.

6.1.9. Loddon River, Victoria

SITE	SPECIES	THREATS	ACTIONS
Loddon Fishway	- freshwater catfish - trout cod	- Poor fish passage.	- Restore fish passage via the installation of effective fishways and removal of obsolete structures.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Unavailable	Douglas *et al.*, 1994; S.Fairfull, pers. comm. 2000; Koehn & Clunie, 2000.

The Murray-Darling Basin Fish Management Strategy identified Loddon Fishway as a recently built, ineffective fish passage. Developing programs to improve fish passage at this site is considered as one of the high priority objectives of the Murray-Darling Basin Fish Management Strategy. The Loddon River flows into the Little Murray River, and is known to be inhabited by freshwater catfish and a single natural sub-population of trout cod in the Murray River from Mulwala to Tocumwal. As such, any improvement to fish passage at Mulwala would effectively abate one threat likely to result in the local extinction of these species as listed under Schedule 3 of the Victorian Flora and Fauna Guarantee Act 1988.

6.1.10. Broken Creek, Victoria

SITE	SPECIES	THREATS	ACTIONS
Rices Weir	- Murray cod - golden perch	- Poor fish passage.	- This site requires work to maintain tailwater levels at the base of the vertical slot fishway as well as modification to the operating rules for the trash rack.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Costs of modifications to this site were estimated at approximately $1.0M.	B.Lynch, pers. comm. 1998; T.O'Brien, pers. comm. 2000.

An immediate threat to recruitment and migration at this site is the inability of fish to find the entrance to the fishway. At present this is governed by Murray River water levels. It is recommended that, together with the involvement of local community groups, modifications are initiated to the existing fishway in order to return fish passage to this region.

6.1.11. Broken River, Victoria

SITE	SPECIES	THREATS	ACTIONS
Gowangardie Weir	- Murray cod - golden perch	- Poor condition of fishway.	- Improve fish passage or possible removal of structure.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Costs of modifications to Gowangardie Weir were estimated at approximately $1M.	A.Baxter, pers. comm. 2000; B.Lynch, pers. comm. 1998; T.O'Brien, pers. comm. 2000.

This 4.3m high weir is in poor condition and management options are still being explored. It is located downstream of two weirs that have new vertical slot fishways. Improvements to Gowangardie Weir would serve to enhance fish passage both at this site and in Broken River as a whole by complementing fish passage improvements further upstream. This would effectively abate one threat likely to result in the local extinction of these species as listed under Schedule 3 of the Victorian Flora and Fauna Guarantee Act 1988.

Remnant, translocated Macquarie perch populations still exist in Hughes and Seven Creeks, both of which flow into the Goulburn River. The Broken River also flows into the Goulburn River and it is possible that Macquarie perch and a single re-stocked sub-population of trout cod may also benefit from improvements to fish passage at Gowangardie Weir.

6.1.12. Ovens River, Victoria

SITE	SPECIES	THREATS	ACTIONS
Ovens River Weir near Wangaratta	- Murray cod - golden perch	- Poor fish passage.	- Construction of appropriate fishways, OR - Investigate removal of weir.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Cost of modifications to this site was estimated at approximately $0.5M.	Brown *et al.*, 1998; B.Lynch, pers. comm. 1998.

Extending the existing range of the Murray River trout cod population to include self-maintaining stocks in the Ovens River is considered a medium to long term objective of the Trout Cod Recovery Plan, and as such any improvement to fish passage at this site would significantly benefit this species. This would effectively abate one threat likely to result in the local extinction of these species as listed under Schedule 3 of the Victorian Flora and Fauna Guarantee Act 1988.

6.1.13. South Coast

SITE	SPECIES	THREATS	ACTIONS
Kangaroo River near Nowra & Mongarlowe River near Braidwood	- Macquarie perch - short-finned eel - Australian grayling - climbing galaxias - congolli	- Sedimentation resulting from catchments, streambank erosion, and invasion of pest plants such as willows. - Obstruction to fish passage at Tallowa Dam.	- A community-based project to address erosion sites and control pest plant species such as willows and privet. - Construction of effective high-level fishway on Tallowa Dam.

Bega River near Bega & Moruya River near Moruya.	- *Mordacia* spp. - Australian grayling - congolli - short-finned eel - common galaxias	- Barriers to fish passage. - Sedimentation resulting from catchments, streambank erosion, and invasion of pest plants such as willows.	- Restore fish passage via the installation of an appropriate fishway structure at this site, OR - by the removal of temporary barrages. - A community-based project to address erosion sites and control pest plant species such as willows.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
N/A	A.Lugg, pers. comm. 2000; Gehrke *et al*., 2001.

The Bega River near Bega has two barriers that prevent fish passage to the majority of the streams and rivers found in the Bega River basin. One of these is a temporary salt-water barrage constructed from sand to allow upstream water users access to freshwater. Repeated earthworks within the river channel to maintain this barrier can damage the habitat and prevent fish migrations. A permanent alternative freshwater supply upstream would allow this barrier to be removed permanently, stabilising the riverbed and allowing unobstructed fish passage. Installation of fishways at other sites would significantly improve the likelihood of the local freshwater fish fauna successfully migrating and recruiting into this system.

6.1.14. Central Coast

SITE	SPECIES	THREATS	ACTIONS
Hunter River	- freshwater herring - freshwater catfish (upstream) - short-finned eel	- Poor fishway design. - An eroded weir crest on Jerry's Plains Weir.	- Modify existing fishway - OR investigate removal of fishway and/or weir.
Williams River	- freshwater herring - freshwater catfish (upstream) - short-finned eel	- Extensive de-snagging of the Williams River and other tributaries of the Hunter River has simplified available habitats.	- Re-snag river reaches to restore habitat diversity.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
Re-snagging experiments in the Williams River have cost around $50,000 per kilometre	Andrew Brooks, Macquarie University; Brooks *et al.,* 2000; Mallen-Cooper, 2000; T.O'Brien, pers. comm. 2000.

Bishop (1997) reported that Jerry's Plains fishway became a spillway at higher headwater levels, which severely compromised fish passage. Also, at this site an eroded weir crest releases water away from the fishway and attracts fish to other parts of the weir. There is potential to refine the recessed rock-ramp design to accommodate a wider range of headwater levels. This could be achieved by using rock-groynes on the sides of the ramp, or by having different floor levels in the ramp to allow for high and low flows. Recent experience in Victoria has also confirmed that the large boulders in rock-ramp fishways should not be underwater for the efficient passage of small native fish.

There is also the question of results indicating the poor passage of larger, non-fish fauna in rock-ramp fishways. Long-armed prawns, other moderately large sized crustaceans (> approx. 100mm), and freshwater turtles are not effectively passing through the Jerry's Plains rock ramp fishway. This may indicate that larger migratory aquatic fauna in general may not be able to use this type of fishway.

Macquarie University (Andrew Brooks), NSW Fisheries (Peter Gehrke) and the Department of Land and Water Conservation (Hugh Jones) are investigating changes in the river bed, habitats, fish communities and freshwater mussels following extensive re-snagging of the Williams River, a tributary of the Hunter. Apart from its local application, this project will have implications for other habitat rehabilitation programs elsewhere in the study area.

6.1.15. North Coast

SITE	SPECIES	THREATS	ACTIONS
Streams near Broadwater National Park	- Oxleyan pygmy perch - ornate rainbowfish	- Small creeks near Broadwater National Park containing these species were cleared of vegetation for the construction of drains. - Predation and competition by *Gambusia holbrooki* - Fire management practices by NPWS - Urban development - Barriers to fish passage	- Recovery actions could involve rehabilitation of these degraded creeks via re-planting of riparian vegetation, and the reconstruction of stream morphology and channel characteristics. - Control and or eradication of the alien pest species *Gambusia holbrooki*. - Education amongst local government and NPWS staff on the presence of this species and its current conservation status. - Investigate possible methods to address poor fish passage.
Clarence River	- eastern cod - olive perchlet - freshwater herring - freshwater catfish - ornate rainbowfish	- Overfishing. - Loss of aquatic vegetation. - Habitat degradation. - Removal of instream cover.	- Prevent the removal of any and all types of natural instream and bankside cover for purposes outside the preservation of the species known to occur here.

COST ESTIMATES	CONTACT INFORMATION/ REFERENCES
N/A	J.Knight, pers. comm. 2000.

Populations of Oxleyan pygmy perch and ornate rainbowfish have been located in small creeks near Broadwater National Park which were cleared for the construction of drains. Recovery actions could involve the rehabilitation of these creeks via re-planting of riparian vegetation and erosion prevention measures along affected areas. The control and or eradication of the alien pest fish species *Gambusia holbrooki* is considered a major step in the protection of Oxleyan pygmy perch and ornate rainbowfish in this area.

6.2. Discussion of Key Threats and General Recommendations to Improve the Conservation Status of Threatened Freshwater Fishes

6.2.1. Altered flow regimes

The extraction of water from rivers and streams in a catchment reduces both instream flows and the volume of water present downstream. Water resource developments for irrigation, town water supply and hydroelectric power generation have led to the alteration of natural flow regimes in many Australian rivers. River regulation, the process by which flows are altered, generally reduces the flow of water downstream and reduces the frequency and magnitude of natural flooding (Walker, 1985). Water release patterns from storages also generally result in a reversal of the natural flow regime, causing increased flows in summer and reduced flows in winter and spring (e.g. in the Murray River downstream of Albury; EPA, 1997). Pumping of water directly from waterways, especially during summer low-flow periods, exacerbates the effects of such lowered flows.

Altered flow regimes thus affect riverine biota in a number of ways, including by:
- reducing instream flows;
- altering the seasonality and natural variability of flows;
- reducing the frequency, duration and magnitude of flood events; and
- altering natural river levels and increasing the rate of fall of river levels (Cadwallader & Lawrence, 1990).

Reduced flows during summer can limit the amount of habitat available for biota, threatening the survival of some species and possibly contributing to a decrease in biodiversity. Instream habitat may also dry up more quickly, before some animals, particularly macroinvertebrates, are able to complete their lifecycles. It is not just very low flows that are of environmental concern. Reduced high flows may also fail to adequately provide for a range of important ecological functions; for example, linkages between rivers, floodplains and wetlands have been shown to be important for a range of ecological functions, and reduced high flows can restrict this interaction (Robertson *et al.,* 1999). Careful consideration of Environmental Stream Flows needs to be given in maintaining or rehabilitating drought-refuge habitat for aquatic organisms. Two types of flow events are probably of particular importance. Firstly, small flows or local run-off events are likely of be important in maintaining the availability of surface water during extended periods of little or no rainfall. In many areas, weirs and low-flow threshold water harvesting may hamper the passage of these small stream flows, and poor water quality may result from low levels of ground cover during drought. These flows should be maintained to provide a natural degree of 'topping-up' with high quality water, without artificially reducing the frequency of drying. Secondly, drought-breaking floods may be of critical importance during the drought-recovery process by providing pathways for the dispersal of aquatic organisms that have survived the drought. These pathways are essential to the drought recovery and recolonisation process, and provisions should be made to ensure the movement of aquatic organisms upstream, downstream and across floodplains (Moffatt *et al.,* 1997).

State Government initiated water reforms have resulted in the preparation of management plans for many river basins around Australia. The continued support and implementation of these programs should be a priority for all States and the Commonwealth Government.

Recommendations for mitigating the effects of altered flow regimes include the following:
- all States should develop policies that allow for the establishment of or increase in environmental water allocations and contingency allocations to 'top up' small scale natural floods;

- all States should adopt storage operational procedures based on flow translucency principles which allow a level of natural variation to be incorporated into flow releases and weir operations;
- all States should provide for the protection of natural flows within remaining unregulated rivers, sections of rivers and tributaries to provide a level of natural variation;
- water authorities in each State should adopt operational procedures for the release of water at ecologically appropriate times;
- the installation of regulators to enable the re-establishment of more natural wet/dry cycles in wetlands;
- the restoration of key instream flow variability and overbank flooding through environmental flow releases and restrictions on extraction of floodwaters;
- the removal of block-bank structures and levees that prevent natural inundation of floodplain habitats, and re-connection between rivers and wetlands, during medium to high flow events;
- the establishment and implementation of environmental contingency allocations in all catchments to permit the creation of floods or augmentation of natural flows; and
- environmentally harmful modifications to flow regimes should be listed as a Threatening Process under State and Commonwealth threatened species legislation.

There is the opportunity to incorporate a range of threatening processes related to altered flows, unsuitable water temperatures and barriers to stream passage into a single Threat Abatement Plan targeted at addressing the broad range of threats associated with river regulation. Several priority case-study sites could also be established where a range of threatened species and communities exist and where the implementation of such a Threat Abatement Plan would be effective in ameliorating a range of such threats.

6.2.2. Barriers to fish passage

Artificial structures such as dams, weirs, culverts, causeways, erosion control structures and tidal barriers can all prevent the passage of aquatic biota. The passage of aquatic organisms, particularly fish, is important in providing access to suitable habitat, for spawning migrations and for maintaining the genetic diversity of populations.

Identification and assessment of barriers to fish migration have been conducted in Victoria (McGuckin & Bennett, 1999), and such barriers have been prioritised for remedial works that provide for the passage of native fish at those barriers identified as significantly restricting fish passage. Identification of such barriers to fish passage is also progressing in New South Wales and Queensland (Jackson & Jenkins, 1996; Pethebridge *et al.,* 1998).

It is necessary to note, however, that the removal of certain barriers to fish passage in some areas may lead to an invasion of alien fish species from downstream locations into areas previously dominated by native fish species (Lintermans, 2000).

Recommendations for mitigating the effects barriers to fish passage include the following:
- all Governments should develop a framework for the identification of barriers and the prioritisation and implementation of appropriate remedial actions;
- all States should require Environmental Impact Assessments for any new structures that have the potential to create barriers (e.g. weirs, road and rail crossings, farm dams, etc.) in order to evaluate and mitigate their impacts on fish passage;
- best management guidelines are required for the design of any new structures that have the potential to create barriers (e.g. weirs, road and rail crossings, farm dams, etc.) to ensure that appropriate fish passage is maintained;
- the prevention of the passage of aquatic biota should be listed as a Threatening Process under relevant State and Commonwealth threatened species legislation;

- cross-compliance programs with State and Local Government agencies attached to the funding for roadworks and other infrastructure would also be an effective way of targeting State and Commonwealth funds at river restoration works;
- the provision of Commonwealth funds for new infrastructure and the maintenance of existing infrastructure should be assessed through the COAG water reform process whereby funds are dependent upon the provision of fishways and on setting environmental standards for new and replacement infrastructure;
- the Commonwealth Government should seek to prevent or mitigate threats to the passage of aquatic biota through conditions applied to developments relying on water supplies or proposing new infrastructure;
- the New South Wales and Victorian Governments should continue to fund programs to enable the removal of obsolete or particularly environmentally damaging structures, such as weirs, levees, blocked banks, floodgates, culverts and causeways;
- the New South Wales and Victorian Governments should continue to fund programs to enable the installation of effective fishways on all remaining major weirs;
- the New South Wales and Victorian Governments should fund programs to enable the manipulation of weirs and other barriers to flow and fish passage to create more natural flow patterns; and
- the removal of barriers to fish passage must take into account the possible invasion of alien fish species from downstream locations.

6.2.3. Loss of riparian vegetation

Sediment inputs to streams and rivers occur from a variety of sources, both natural and anthropogenic, and the effects of such sediment increases on a range of aquatic and semi-aquatic organisms is well documented.

Various stream ecologists and environmental managers (e.g. Smith & Pollard, 2000) have recommended fenced buffer strips along riverbanks to protect riparian vegetation and reduce erosion and runoff. Recommended buffer widths are expressed as multiples of channel width, and may vary from three times the channel width for third or higher order streams, to equal to the stream width for first order streams. Under this system, a river 200m wide in its lowland reaches should have a 200m wide buffer zone along each bank, whilst a small fourth order stream 5m wide should have a 15m wide buffer zone along each bank. Commonly recommended buffer widths of 20-30m may be unnecessarily conservative for many small streams on private property, whilst offering only a small percentage of the riparian protection needed for larger rivers. Cross-compliance with industry assistance, such as in the document being prepared for the sugar industry packages ($700 million, July 2000) and for retrofitting of irrigation schemes under MD2001, should be considered. Such cross-compliance measures could focus on:

- protection of riparian zones,
- revegetation strategies,
- installation of sediment traps,
- public and landowner education,
- stormwater management,
- construction guidelines,
- best practice forestry management,
- improved agricultural practices,
- improved dam operation and construction procedures,
- prevention of stock access to stream frontages,
- erosion management,
- management of mining activities (including instream gravel extraction), and
- sustainable river management works.

There is a great opportunity for the sediment Threat Abatement Plan to be integrated with the Threat Abatement Plans for other threatening processes, such as degradation of riparian vegetation, and also Recovery Plans for various threatened riparian ecological communities that are likely to be listed under the Environment Protection and Biodiversity Conservation Act, 1999.

Recommendations for protecting and managing riparian vegetation include the following:

- stock access should be carefully managed and where necessary removed or restricted in riparian buffer strips, with off-stream watering being provided, though occasional managed stock access to buffer strips may be required for the management of weeds in specific instances; and
- the degradation of riparian vegetation should be listed as a Threatening Process under relevant State and Commonwealth threatened species legislation.

6.2.4. Loss of instream cover

The removal of instream cover not only impacts directly on fish through loss of habitat, but also on invertebrates and other organisms that colonise the surfaces of such material and on associated ecological processes that are essential for ecosystem health. Further loss of instream and bankside vegetation cover will contribute to a continued decline in many native freshwater fish species and a general deterioration of river health.

Recommendations for the protection of instream cover include the following:

- the prevention of the removal of any and all types of natural instream and bankside cover for purposes outside the preservation of the species known to occur there (this would include snags and instream aquatic and riparian vegetation);
- the removal of snags and instream aquatic and riparian vegetation should be listed as a Threatening Process under State and Commonwealth legislation;
- the re-introduction of snags into river reaches that have previously been desnagged to create habitat heterogeneity and support a broader diversity of aquatic species; and
- the prevention or restriction of motorboat and jetski activity in key areas to preserve aquatic and riparian vegetation.

6.2.5. Thermal pollution

Cold water pollution occurs below dams whenever water is released from outlets located near the bottom of the dam. This depression of river temperatures, compared to natural conditions, can leave a cold water "legacy" extending many hundreds of kilometres downstream (Cadwallader, 1978). For example, following the construction of Dartmouth Dam, downstream temperatures in the Mitta Mitta River were reduced by up to 10°C (Koehn, 1996). Unnaturally low water temperatures impact on a broad range of biological and chemical processes by slowing the metabolic processes of organisms ranging from phytoplankton to benthic invertebrates and fish. Cold water pollution is known to interfere with the feeding, growth, survival and reproduction of many Australian native freshwater fishes (Koehn & O'Connor, 1990).

Recommendations for mitigating the effects of decreased water temperature include the following:

- the artificial destratification of dams by mechanical mixing of the water column within reservoirs;
- the release of surface waters instead of bottom waters;
- the placement of 'curtains' that force water entering outlets to originate from above the curtains (Sherman, 2000);
- the issue of licenses (under the Protection of Environment Operations Act) to operate dams which specify conditions concerning the temperature of water discharges; and
- thermal pollution should be listed as a Threatening Process under State and Commonwealth legislation.

While retrofitting existing dams with variable level off-takes is expensive, new dams should be designed with such off-takes so as to minimise the release of cold water downstream. Government legislation can be used to apply conditions to new developments that ensure thermal pollution mitigating techniques are used.

Priority water storages for thermal pollution mitigation identified in New South Wales include Wyangla, Blowering, Burrendong, Hume, Copeton, Keepit and Carcoar Reservoirs (NSW Department of Public Works and Services, 1996).

6.2.6. Chemical pollution

The use of agricultural chemicals in broad acre farming is widespread. The nature and degree of impacts of pollution upon aquatic ecosystems depend on a number of factors, including the type of pollutant, the volume and frequency with which it is discharged, and the resilience of the waterway. The impact also depends on the life-cycle stage which comes into contact with the polluted water. Eggs and larval fish are generally more susceptible than adults (Smith & Pollard, 2000).

Recommendations for mitigating the effects of chemical pollution include the following:
- the creation of riparian buffer zones using local native plant species in areas of high pesticide usage;
- the prevention of new broad-acre farming of such crops as cotton and rice within 500 metres of river banks; and
- chemical pollution should be listed as a Threatening Process under State and Commonwealth legislation.

6.2.7. Alien, translocated and stocked fish species

Problems arising from the introduction to an area of live fish outside their natural ranges may arise through the introduction of both native and exotic species. Fish have in the past been introduced from outside their natural ranges both deliberately to establish new fisheries and for biological pest control, and accidentally from ornamental or aquarium sources. Once such species have been introduced into new catchments, their spread often continues through natural range expansion and population growth.

There have been deliberate introductions of at least eight species into Australian inland waters that have resulted in the establishment of self-sustaining populations. These species are brown trout *Salmo trutta*, rainbow trout *Oncorhynchus mykiss*, European perch *Perca fluviatilis*, carp *Cyprinus carpio*, goldfish *Carassius auratus*, tench *Tinca tinca*, roach *Rutilus rutilus*, and gambusia *Gambusia holbrooki*. At least a further three species have established self-sustaining populations as a result of accidental releases of aquarium and ornamental fish, including oriental weatherloach *Misgurnus anguillicaudatus*, tilapia *Oreochromis mossambicus* and guppy *Poecilia reticulata*.

Currently NSW Fisheries will not allow the stocking of alien fish species in areas known to be inhabited by listed threatened fish species.

Recommendations for the management of pest fish species include the following:
- the cessation of stocking of introduced species into specific rivers and streams to protect listed threatened species and ecological communities – Macquarie perch, silver perch, various galaxiids and southern pygmy perch in particular are known to be threatened by competition, predation and diseases spread by exotic fish species;
- the initiation of full Environmental Impact Assessments into all fish stocking practices to assess disease, genetic, predation and other ecological and biological risks to wild riverine fish communities and threatened fish species;

- the accidental introduction of live fish outside their natural ranges should be listed as a Threatening Process under relevant State and Commonwealth threatened species legislation;
- the prohibition of introducing live fish outside their natural ranges under relevant State and Commonwealth threatened species legislation;
- the establishment of a registry to identify and track trade in exotic species, and to thus facilitate the elimination of any potentially invasive species that may arrive via the aquaculture and aquarium trades;
- the initiation of programs to remove or control pest species such as carp, redfin and gambusia from native fish habitats (local communities can join in this activity);
- the initiation of strategic frameworks allowing community and local government groups to understand the problems caused by pest species, set realistic objectives, implement appropriate management actions, and evaluate the effectiveness of their actions; and
- the initiation of programs to increase community awareness of the impacts of introduced species and the implications of the further spread of such species through recreational fishing activities – as many of these species are spread through deliberate stocking programs, the negative implications of these programs should also be acknowledged and managed.

6.2.8. Aquatic Reserves and Threatened Communities

The creation of aquatic reserves in key river reaches and wetlands for the protection of fish and fish habitats, particularly for threatened species and ecological communities, should be considered under the relevant legislation in each state. (e.g. Section 194 of the New South Wales Fisheries Management Act 1994, Section 88 of the Victorian Fisheries Act 1995, Section 120 of the Queensland Fisheries Act 1994 (1997 amendments.), and Section 47 of the South Australian Fisheries Act 1982).

Recommendations for the implementation of aquatic reserves in freshwater areas should include:
- parts of the Paroo River in New South Wales.

Recommendations for the implementation of threatened communities include the following:
- parts of the Murray River Basin in New South Wales and Victoria; and
- the Goulburn River Catchment in Victoria.

The NSW Fisheries Scientific Committee has recently recommended that the native freshwater fish community in the Murray Darling Basin qualifies under Schedule 4 of the Fisheries Management Act 1994 (1997 amendments) as an Endangered Ecological Community. This report complements this recommendation with special regard to the following areas:
- between Torrumbarry and Euston Weirs on the Murray River;
- the Upper Murrumbidgee, at the junction with the Tumut River; and
- the Murray River below Hume Dam.

The Production of habitat protection plans aimed at conserving any identified critical freshwater fish habitats should also be considered (e.g. see section 192 of the New South Wales Fisheries Management Act 1994, 1997 amendments). Specific characteristics of habitats required by Oxleyan pygmy perch outlined in Knight (2000) could be considered as the first habitat type to be declared under the above legislation as well as under the Queensland Fisheries Act 1994 (1997 amendments).

6.2.9. Community education

Community education programs targeting land and water managers, landholders, irrigators, campers, and recreational anglers regarding the protection of fish habitat and threatened fish species should be initiated. This may include the erection of appropriate signs at camping and fishing grounds.

Table 3: Recommended additions to international and national conservation listings concerning the conservation of threatened and potentially threatened freshwater fish from the waters of coastal New South Wales and the Murray-Darling Basin.

CATEGORY	IUCN	ASFB	EPBCA
Threatening Processes	No Provision	No Provision	- Altered flow regimes - Barriers to fish passage - Loss of riparian vegetation - Loss of instream cover - Thermal pollution - Chemical pollution - Alien fish species
Critical Habitats	No Provision	No Provision	No Provision
Threatened Communities	No Provision	No Provision	Native freshwater fish communities in the Murray River – between Yarrawonga and Tocumwal (Vulnerable); Native freshwater fish communities in Paroo River (Vulnerable); Native freshwater fish communities in the Upper Murrumbidgee River (Vulnerable).

Table 4: Recommended additions to Australian state and territory conservation listings concerning the conservation of threatened and potentially threatened freshwater fish from the waters of coastal New South Wales and the Murray-Darling Basin.

CATEGORY	NSW	VIC	ACT	SA	QLD
Critical Habitats	Coastal Wallum Heathland waterbodies	No Provision	No Provision	No Provision	Coastal Wallum Heathland waterbodies
Threatened Communities	Murray River Basin	Goulburn River Catchment	-	No Provision	No Provision
Aquatic Reserves	Paroo River	No Provision	No Provision	-	No Provision
Threatening Processes	- Altered flow regimes - Barriers to fish passage - Thermal pollution - Chemical pollution - Alien fish species	-	- Altered flow regimes - Barriers to fish passage - Loss of riparian vegetation - Loss of instream cover - Thermal pollution - Chemical pollution - Alien fish species	- Altered flow regimes - Barriers to fish passage - Loss of riparian vegetation - Loss of instream cover - Thermal pollution - Chemical pollution - Alien fish species	- Altered flow regimes - Barriers to fish passage - Loss of riparian vegetation - Loss of instream cover - Thermal pollution - Chemical pollution - Alien fish species

6.3. Current Conservation Status Listings and the Recommended Changes to them.

Table 5: Current international and national conservation status listings of threatened and potentially threatened freshwater fish from the waters of coastal New South Wales and the Murray-Darling Basin (species arranged in phylogenetic order), together with recommended changes to these listings (in bold font).

SPECIES NAME	COMMON NAME	IUCN	ASFB	EPBCA
Mordacia praecox	Non-parasitic lamprey	Vulnerable **No Change**	Vulnerable **No Change**	Not Listed **Vulnerable**
Anguilla australis	Short-finned eel	Not Listed **Lower Risk (Least Concern)**	Not Listed -	Not Listed -
Potamalosa richmondia	Freshwater herring	Not Listed **Lower Risk (Least Concern)**	Not Listed -	Not Listed -
Galaxias brevipinnis	Climbing galaxias	Not Listed **Data Deficient**	Not Listed -	Not Listed -
Galaxias fuscus	Barred galaxias	Critically Endangered **No Change**	Critically Endangered **No Change**	Endangered **No Change**
Galaxias maculatus	Common galaxias	Not Listed **Lower Risk (Least Concern)**	Not Listed -	Not Listed -
Galaxias olidus	Mountain galaxias	Not Listed **Lower Risk (Least Concern)**	Not Listed -	Not Listed -
Galaxias rostratus	Murray jollytail	Vulnerable **No Change**	Vulnerable **No Change**	Not Listed **Vulnerable**
Prototroctes maraena	Australian grayling	Vulnerable **No Change**	Vulnerable **No Change**	Vulnerable **No Change**
Tandanus tandanus	Freshwater catfish Inland / Coastal	Not Listed / Not Listed **Vulnerable / Lower Risk (Least Concern)**	Not Listed / Not Listed **Vulnerable / Lower Risk (Least Concern)**	Not Listed / Not Listed **Vulnerable / Lower Risk (Least Concern)**
Craterocephalus amniculus	Darling hardyhead	Vulnerable **No Change**	Vulnerable **No Change**	Not Listed **Vulnerable**
Craterocephalus fluviatilis	Murray hardyhead	Endangered **No Change**	Endangered **No Change**	Vulnerable **Endangered**
Craterocephalus stercusmuscarum var. *fulvus*	Non-speckled hardyhead	Not Listed **Data Deficient**	Not Listed -	Not Listed -
Melanotaenia fluviatilis	Crimson-spotted rainbowfish	Not Listed **Lower Risk (Least Concern)**	Not Listed **Lower Risk (Least Concern)**	Not Listed -
Rhadinocentrus ornatus	Ornate rainbowfish	Not Listed **Data Deficient**	Not Listed **Data Deficient**	Not Listed **Near Threatened**
Ambassis agassizii	Olive perchlet Inland / Coastal	Not Listed / Not Listed **Lower Risk (Least Concern)**	Not Listed / Not Listed **Lower Risk (Least Concern)**	Not Listed / Not Listed -
Maccullochella ikei	Eastern cod	Endangered **No Change**	Endangered **No Change**	Endangered **No Change**

Maccullochella macquariensis	Trout cod	Endangered **Critically Endangered**	Endangered **Critically Endangered**	Critically Endangered **No Change**
Maccullochella peelii	Murray cod	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Near Threatened**
Macquaria ambigua	Golden perch	Not Listed **Lower Risk (Least Concern)**	Not Listed **Lower Risk (Least Concern)**	Not Listed **-**
Macquaria australasica	Macquarie perch	Endangered **No Change**	Endangered **No Change**	Endangered **No Change**
Bidyanus bidyanus	Silver perch	Vulnerable **Endangered**	Vulnerable **Endangered**	Not Listed **Endangered**
Bidyanus welchi	Welch's grunter	Not Listed **Lower Risk (Least Concern)**	Not Listed **Lower Risk (Least Concern)**	Not Listed **-**
Leiopotherapon unicolor	Spangled perch	Not Listed **Lower Risk (Least Concern)**	Not Listed **Lower Risk (Least Concern)**	Not Listed **-**
Nannoperca australis	Southern pygmy perch	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Near Threatened**
Nannoperca oxleyana	Oxleyan pygmy perch	Endangered **No Change**	Endangered **No Change**	Endangered **No Change**
Gadopsis bispinosus	Two-spined blackfish	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Near Threatened**
Gadopsis marmoratus	River blackfish	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Lower Risk (Near Threatened)**	Not Listed **Near Threatened**
Pseudaphritis urvillii	Congolli	Lower Risk **Lower Risk (Least Concern)**	Not Listed **Lower Risk (Least Concern)**	Not Listed **-**
Mogurnda adspersa	Southern purple-spotted gudgeon Inland / Coastal	Lower Risk (Least Concern) / Not Listed **Endangered / Lower Risk (Least Concern)**	Lower Risk (Least Concern) / Not Listed **Endangered / Lower Risk (Least Concern)**	Not Listed / Not Listed **Endangered / No Change**

Table 6: Current Australian state and territory conservation status listings of threatened and potentially threatened freshwater fish from the waters of coastal New South Wales and the Murray-Darling Basin (species arranged in phylogenetic order), together with recommended changes to these listings (in bold font).

SPECIES NAME	COMMON NAME	NSW	VIC*	ACT	SA	QLD
Mordacia praecox	Non-parasitic lamprey	Not Listed **Vulnerable**	Not Listed -	N/A	N/A	N/A
Anguilla australis	Short-finned eel	Not Listed -	Not Listed -	N/A	N/A	Not Listed -
Potamalosa richmondia	Freshwater herring	Not Listed -	Data Deficient **No Change**	N/A	N/A	Not Listed -
Galaxias brevipinnis	Climbing galaxias	Not Listed -	Not Listed -	N/A	Not Listed **Protected**	Not Listed -
Galaxias fuscus	Barred galaxias	N/A	Critically Endangered **No Change**	N/A	N/A	N/A
Galaxias maculatus	Common galaxias	Not Listed -	Not Listed -	N/A	Not Listed -	Not Listed -
Galaxias olidus	Mountain galaxias	Not Listed -	Not Listed -	Not Listed -	Not Listed -	Not Listed -
Galaxias rostratus	Murray jollytail	Not Listed **Vulnerable**	Not Listed **Data Deficient**	N/A	Not Listed **Protected**	N/A
Prototroctes maraena	Australian grayling	Not Listed **No Change**	Vulnerable **No Change**	N/A	N/A	N/A
Tandanus tandanus	Freshwater catfish Inland / Coastal	Not Listed / Not Listed **Vulnerable / No Change**	Vulnerable / N/A **No Change / N/A**	N/A	Protected / N/A **No Change / N/A**	Not Listed / Not Listed **Common / Common**
Craterocephalus amniculus	Darling hardyhead	Not Listed **Vulnerable**	N/A	N/A	N/A	Not Listed **Rare**
Craterocephalus fluviatilis	Murray hardyhead	Endangered **No Change**	Endangered **No Change**	N/A	Not Listed **Protected**	N/A
Craterocephalus stercusmuscarum var. *fulvus*	Non-speckled hardyhead	Not Listed **Vulnerable**	Not Listed **Vulnerable**	N/A	Not Listed **Protected**	Not Listed **Common**
Melanotaenia fluviatilis	Crimson-spotted rainbowfish	Not Listed -	Data Deficient **No Change**	N/A	Not Listed **Protected**	Not Listed **Common**
Rhadinocentrus ornatus	Ornate rainbowfish	Not Listed -	N/A	N/A	N/A	Not Listed **Rare**
Ambassis agassizii	Olive perchlet Inland / Coastal	Endangered population / Not Listed **No Change / No Change**	Extinct / N/A **No Change / N/A**	N/A	Protected / N/A **No Change / N/A**	Not Listed / Not Listed **Common / Common**
Maccullochella ikei	Eastern cod	Endangered **No Change**	N/A	N/A	N/A	N/A
Maccullochella macquariensis	Trout cod	Endangered **No Change**	Critically Endangered **No Change**	Endangered **No Change**	Protected **No Change**	N/A
Maccullochella peelii	Murray cod	Not Listed -	Vulnerable **No Change**	Not Listed **Vulnerable**	Not Listed **Protected**	Not Listed **Rare**

Macquaria ambigua	Golden perch	Not Listed -	Not Listed -	Not Listed -	Not Listed -	Not Listed -
Macquaria australasica	Macquarie perch	Vulnerable **No Change**	Endangered **No Change**	Endangered **No Change**	N/A	N/A
Bidyanus bidyanus	Silver perch	Vulnerable **No Change**	Critically Endangered **No Change**	Not Listed **Endangered**	Protected **No Change**	Not Listed **Rare**
Bidyanus welchi	Welch's grunter	Not Listed -	N/A	N/A	Not Listed **Protected**	Not Listed **Rare**
Leiopotherapon unicolor	Spangled perch	Not Listed -	N/A	N/A	Not Listed -	Not Listed -
Nannoperca australis	Southern pygmy perch	Vulnerable **Endangered**	Not Listed -	N/A	Protected **No Change**	N/A
Nannoperca oxleyana	Oxleyan pygmy perch	Endangered **No Change**	N/A	N/A	N/A	Vulnerable **No Change**
Gadopsis bispinosus	Two-spined blackfish	Not Listed -	Not Listed -	Vulnerable **No Change**	N/A	N/A
Gadopsis marmoratus	River blackfish	Not Listed -	Not Listed -	N/A	Protected **No Change**	Not Listed **Rare**
Pseudaphritis urvillii	Congolli	Not Listed -	Not Listed -	N/A	Not Listed -	N/A
Mogurnda adspersa	Southern purple-spotted gudgeon Inland / Coastal	Endangered Population / Not Listed **No Change / No Change**	Critically Endangered / N/A **No Change / N/A**	N/A	Protected / N/A **No Change / N/A**	Not Listed / Not Listed **Rare / No Change**

* Although the Victorian Fauna and Flora Guarantee Act, 1988 (see Appendix 3) has no separate conservation sub-categories, these are allocated to all species classified as Threatened under this Act by the Department of Natural Resources and Environment according to the standard IUCN Red List criteria.

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GLOSSARY

ACF - Australian Conservation Foundation
ACT - Australian Capital Territory
AFFA - Agriculture, Fisheries & Forestry Australia
ANGFA - Australian and New Guinea Fishes Association
ASFB - Australian Society for Fish Biology
ASU - Arizona State University
COAG - Council of Australian Governments
CRC - Cooperative Research Centre
EPA - Environment Protection Authority (NSW)
EPBCA - Environment Protection and Biodiversity Conservation Act 1999
FAP - Fisheries Action Program
IBI - Index of Biotic Integrity
IRN - Inland Rivers Network
IUCN - International Union for the Conservation of Nature
MCMC - Murrumbidgee Catchment Management Committee
MDB - Murray-Darling Basin
MDBC - Murray-Darling Basin Commission
NCC - Nature Conservation Council (NSW)
NPWS - National Parks and Wildlife Service (NSW)
NRE - Natural Resources and Environment (Victoria)
NSW - New South Wales
QLD - Queensland
SA - South Australia
SCU - Southern Cross University
VIC - Victoria
WWF - World Wide Fund for Nature

APPENDIX 1: AUTHORITIES CONSULTED

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Environment Australia, Canberra
Environment ACT, Canberra
Fisheries Victoria, Melbourne
Fishway Consulting Services, Sydney
Griffith University, Brisbane
Inland Fisheries Commission, Hobart
Inland Rivers Network, Sydney
Marine and Freshwater Research Institute, Geelong
Macquarie University, Sydney
Monash University, Melbourne
Murdoch University, Perth
Murray-Darling Basin Commission, Canberra
Murray-Darling Freshwater Research Centre, Canberra
National Institute of Water and Atmospheric Research, New Zealand
Nature Conservation Council, Sydney
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Northern Territory Museum, Darwin
Queensland Museum, Brisbane
Raintree Aquatics Pty Ltd, Cairns
South Australian Research and Development Institute, Adelaide
Southern Cross University, Lismore
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Ian Wooden (NSW Fisheries)

APPENDIX 3: AUSTRALIAN COMMONWEALTH, STATE AND TERRITORY LEGISLATION PERTAINING TO THREATENED FRESHWATER FISH IN THE WATERS OF COASTAL NEW SOUTH WALES AND THE MURRAY-DARLING BASIN

	National	NSW	ACT	Vic	Qld	SA
Principal Legislation	*Environment Protection and Biodiversity Conservation Act 1999* (replaces the *Endangered Species Protection Act 1992*)	*Fisheries Management Act 1994;1997 amendments*	*Nature Conservation Act 1984*	*Flora and Fauna Guarantee Act 1988* & the *Victorian Fisheries Act 1995*	*Nature Conservation Act 1992* & the *Queensland Fisheries Act 1994* (1997 amendments.)	*Fisheries Act 1982*
Agency Responsible	Environment Australia	NSW Fisheries	Environment ACT	Department of Natural Resources and Environment	Department of Environment	Department of Primary Industry - SA Fisheries
Area Covered	Terrestrial, aquatic	Aquatic (marine, estuarine and freshwater)	Terrestrial, aquatic	Terrestrial, aquatic	Terrestrial, aquatic	Aquatic
Groups Covered	All non-human 'biological entities' Native species which are 'nationally threatened'	'fish' = non-tetrapod aquatic animals at any stage of their life history (whether alive or dead); marine vegetation	Vertebrates, invertebrates, vascular and non-vascular plants	Vertebrates, invertebrates, vascular and non-vascular plants	Vertebrates, invertebrates, vascular and non-vascular plants, protista, procaryotes, viruses	Fish defined as aquatic organisms of any species
Threat Categories	Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Conservation Dependent Species (including sub-species or populations); Critically	Protected Species, Endangered Species, Endangered Populations, Endangered Ecological Communities, Species Presumed Extinct, Vulnerable	Endangered Species, Vulnerable Species, Endangered Communities, Threatening Processes.	Threatened Taxa, Threatened Communities, Potentially Threatening Processes	Presumed Extinct, Endangered, Vulnerable, Rare, Common Species & Aquatic Reserves	Protected Species, Aquatic Reserves

	Endangered, Endangered , and Vulnerable Communities; Key Threatening Processes	Species, Key Threatening Processes, Critical Habitats					
Other Categories						International Wildlife, Prohibited Wildlife, Critical Habitats, Threatening Processes (populations being considered)	

(after Hutchings & Ponder, 1999; Ponder *et al*., in prep; & Pogonoski *et al*., 2001)

APPENDIX 4: SUMMARY OF LISTED TAXA BY FAMILY

FAMILY NAME	SPECIES NAME	COMMON NAME
Ambassidae	*Ambassis agassizii*	Olive perchlet
Anguillidae	*Anguilla australis*	Short-finned eel
Atherinidae	*Craterocephalus amniculus*	Darling hardyhead
	Craterocephalus fluviatilis	Murray hardyhead
	Craterocephalus stercusmuscarum var. *fulvus*	Non-speckled hardyhead
Bovichthyidae	*Pseudaphritis urvillii*	Congolli
Clupeidae	*Potamalosa richmondia*	Freshwater herring
Gobiidae	*Mogurnda adspersa*	Southern purple-spotted gudgeon
Gadopsidae	*Gadopsis bispinosus*	Two-spined blackfish
	Gadopsis marmoratus	River blackfish
Galaxiidae	*Galaxias brevipinnis*	Climbing galaxias
	Galaxias maculatus	Common galaxias
	Galaxias olidus	Mountain galaxias
	Galaxias rostratus	Murray jollytail
Melanotaeniidae	*Melanotaenia fluviatilis*	Crimson-spotted rainbowfish
	Rhadinocentrus ornatus	Ornate rainbowfish
Mordaciidae	*Mordacia praecox*	Non-parasitic lamprey
Nannopercidae	*Nannoperca australis*	Southern pygmy perch
	Nannoperca oxleyana	Oxleyan pygmy perch
Percichthyidae	*Macquaria ambigua*	Golden perch
	Macquaria australasica	Macquarie perch
	Maccullochella ikei	Eastern cod
	Maccullochella macquariensis	Trout cod
	Maccullochella peelii	Murray cod
Plotosidae	*Tandanus tandanus*	Freshwater catfish
Prototroctidae	*Prototroctes maraena*	Australian grayling
Terapontidae	*Leiopotherapon unicolor*	Spangled perch
	Bidyanus bidyanus	Silver perch
	Bidyanus welchi	Welch's grunter

APPENDIX 5: IUCN 2000 RED LIST OF THREATENED FRESHWATER FISH SPECIES PRESENT IN THE WATERS OF COASTAL NEW SOUTH WALES AND THE MURRAY-DARLING BASIN

SPECIES NAME	COMMON NAME	IUCN STATUS
Bidyanus bidyanus	Silver perch	Critically Endangered
Craterocephalus fluviatilis	Murray hardyhead	Endangered
Maccullochella ikei	Eastern cod	Endangered
Maccullochella macquariensis	Trout cod	Endangered
Macquaria australasica	Macquarie perch	Endangered
Mogurnda adspersa	Southern purple-spotted gudgeon	Endangered
Nannoperca oxleyana	Oxleyan pygmy perch	Endangered
Craterocephalus amniculus	Darling hardyhead	Vulnerable
Galaxias rostratus	Murray jollytail	Vulnerable
Mordacia praecox	Non-parasitic lamprey	Vulnerable
Prototroctes maraena	Australian grayling	Vulnerable
Pseudaphritis urvillii	Congolli	Lower Risk

APPENDIX 6: COMMONWEALTH (ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT) LIST OF THREATENED FRESHWATER FISH SPECIES PRESENT IN THE WATERS OF COASTAL NEW SOUTH WALES AND THE MURRAY-DARLING BASIN

SPECIES NAME	COMMON NAME	EPBCA STATUS
Maccullochella macquariensis	Trout cod	Critically Endangered
Galaxias fuscus	Barred galaxias	Endangered
Maccullochella ikei	Eastern cod	Endangered
Macquaria australasica	Macquarie perch	Endangered
Nannoperca oxleyana	Oxleyan pygmy perch	Endangered
Craterocephalus fluviatilis	Murray hardyhead	Vulnerable
Prototroctes maraena	Australian grayling	Vulnerable

APPENDIX 7: SUMMARY OF IUCN CATEGORIES AND CRITERIA

The following table outlines the IUCN Red List categories and criteria. This table is provided as a conceptual framework only and should not be used in isolation from pages 16-22 of the IUCN Red List Categories (IUCN, 1998).

Use any of the A-E criteria	**Critically Endangered**	**Endangered**	**Vulnerable**
A. Declining Population population decline rate at least:	80% in 10 years or 3 generations	50% in 10 years or 3 generations	20% in 10 years or 3 generations
using either: 1. population reduction observed, estimated, inferred or suspected in the past, or 2. population decline projected or suspected in the future based on any of the following: a. direct observation b. an index of abundance appropriate for the taxon c. a decline in area of occupancy, extent of occurrence and/or quality of habitat d. actual or potential levels of exploitation e. the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites			
B. Small Distribution and Decline or Fluctuation In either extent of occurrence: or in area of occupancy:	< 100 km^2 < 10 km^2	< 5,000 km^2 < 500 km^2	< 20,000 km^2 < 2,000km^2
and 2 of the following 3: 1. severely fragmented (isolated subpopulations with a reduced probability of recolonisation, if once extinct) or known to exist at a number of locations	= 1	< or equal to 5	< or equal to 10
2. continuing decline in any of the following: a. extent of occurrence b. area of occupancy c. area, extent and/or quality of habitat d. number of locations or subpopulations e. number of mature individuals	any rate	any rate	any rate
3. extreme fluctuations in any of the following: a. extent of occurrence b. area of occupancy c. number of locations or subpopulations d. number of mature individuals	> 1 order of mag.	> 1 order of mag.	> 1 order of mag.

C. Small Population Size and Decline Number of mature individuals: and 1 of the following 2: 1. rapid rate of decline, or 2. continuing decline and either: a. fragmented, or b. all individuals in a single subpopulation	< 250 25% in 3 years or 1 generation any rate all sub-pops < or equal to 50	< 2,500 20% in 5 years or 2 generations any rate all sub-pops < or equal to 250	< 10,000 10% in 10 years or 3 generations any rate all sub-pops < or equal to 1000
D. Very Small or Restricted Population Either: 1. number of mature individuals, or 2. population is susceptible	< 50 (not applicable)	< 250 (not applicable)	< 1000 area of occupancy <100km^2 or number of locations <5
E. Quantitative Analysis Indicating the probability of extinction in the wild to be at least:	50% in 10 years or 3 generations	20% in 20 years or 5 generations	10% in 100 years

APPENDIX 8: IUCN CATEGORIES, CRITERIA & DEFINITIONS

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, and annual) throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and form.

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) on pages 16 and 17 of the IUCN Red List Categories handbook (1998).

ENDANGERED (EN)

A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the near future, as defined by any of the criteria (A to E) on pages 18 and 19 of the IUCN Red List Categories handbook (1998).

VULNERABLE (VU)

A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to D) on pages 20, 21 and 22 of the IUCN Red List Categories handbook (1998).

LOWER RISK (LR)

A taxon is Lower Risk when it has been evaluated as not satisfying the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. Conservation Dependent (cd). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. Near Threatened (nt). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. Least Concern (lc). Taxa which do not qualify for Conservation Dependent or Near Threatened.

DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on its abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that a threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, or if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it has not yet been assessed against the criteria.

IUCN DEFINITIONS

1. Population

Population is defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life forms, population numbers are expressed as numbers of mature individuals only. In the case of taxa obligatory dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used.

2. Subpopulations

Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little exchange (typically one successful migrant individual or gamete per year or less).

3. Mature individuals

The number of mature individuals is defined as the number of individuals known, estimated or inferred to be capable of reproduction. When estimating this quantity the following points should be borne in mind: Where the population is characterised by natural fluctuations the minimum number should be used. This measure is intended to count individuals capable of reproduction and should therefore exclude individuals that are environmentally, behaviourally or otherwise reproductively suppressed in the wild. In the case of populations with biased adult or breeding sex ratios it is appropriate to use lower estimates for the number of mature individuals which take this into account (e.g. the estimated effective population size). Reproducing units within a clone should be counted as individuals, except where such units are unable to survive alone (e.g. corals). In the case of taxa that naturally lose all or a subset of mature individuals at some point in their life cycle, when mature individuals are available for breeding.

4. Generation

Generation may be measured as the average age of parents in the population. This is greater than the age at first breeding, except in taxa where individuals breed only once.

5. Continuing decline

A continuing decline is a recent, current or projected future decline whose causes are not known or not adequately controlled and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normally count as a continuing decline, but an observed decline should not be considered to be part of a natural fluctuation unless there is evidence for this.

6. Reduction

A reduction (criterion A) is a decline in the number of mature individuals of at least the amount (%) stated over the time period (years) specified, although the decline need not still be continuing. A reduction should not be interpreted as part of a natural fluctuation unless there is good evidence for this. Downward trends that are part of natural fluctuations will not normally count as a reduction.

7. Extreme fluctuations

Extreme fluctuations occur in a number of taxa where population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e. a tenfold increase or decrease).

8. Severely fragmented

Severely fragmented refers to the situation where increased extinction risks to the taxon result from the fact that most individuals within a taxon are found in small and relatively isolated subpopulations. These small subpopulations may go extinct, with a reduced probability of recolonisation.

9. Extent of occurrence

Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary, which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy. This measure may exclude discontinuities or disjunctions within the overall distributions of taxa (e.g. large areas of obviously unsuitable habitat) (but see 'area of occupancy'). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

10. Area of occupancy

Area of occupancy is defined as the area within its 'extent of occurrence' (see definition) which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may, for example, contain unsuitable habitats. The area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. colonial nesting sites, feeding sites for migratory taxa). The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon. The criteria include values in km^2, and thus to avoid errors in classification, the area of occupancy should be measured on grid squares (or equivalents) which are sufficiently small.

11. Location

Location defines a geographically or ecologically distinct area in which a single event (e.g. pollution) will soon affect all individuals of the taxon present. A location usually, but not always, contains all or part of a subpopulation of the taxon, and is typically a small proportion of the taxons total distribution.

12. Quantitative analysis

A quantitative analysis is defined here as the technique of population viability analysis (PVA), or any other quantitative form of analysis, which estimates the extinction probability of a taxon or population based on the known life history and specified management or non-management options. In presenting the results of quantitative analyses the structural equations and the data should be explicit.

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