



## NSW Fisheries Threatened Species Recovery Planning Program



# ***Eastern (Freshwater) Cod*** ***(Maccullochella ikei)*** **Recovery Plan**

**MAY 2004**

Prepared in accordance with the threatened species provisions (Part 7A)  
of the New South Wales *Fisheries Management Act 1994*



Natural Heritage Trust  
*Helping Communities Helping Australia*

**Approved New South Wales Recovery Plan**

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Cover photograph: eastern cod (*Maccullochella ikei*) by John Matthews

## A message from the Minister

This document constitutes the formal National and New South Wales State Recovery Plan for the eastern cod, *Maccullochella ikei*. It considers the conservation requirements of the species across its known range, identifies the future actions to be taken to ensure the long-term viability of the eastern cod in nature and the parties who will carry these out.

The eastern cod is listed as 'endangered' under both the (Australian Government) *Environment Protection and Biodiversity Conservation Act 1999* and the (NSW) *Fisheries Management Act 1994*.

The overall objective of this plan is to ensure the recovery and natural viability of eastern cod populations in their former range in the Clarence and Richmond Rivers. The plan provides detailed recovery actions intended to be implemented over a ten year period.

It is important for everyone to play their part in the conservation of our state's magnificent natural resources for future generations to enjoy. This recovery plan provides an opportunity for the whole community, including NSW Government agencies, councils and universities to work towards a common, worthwhile goal.

I am pleased to approve this recovery plan and look forward to the day when eastern cod once again abound in the Clarence and Richmond Rivers.



22 June 2004

**Hon Ian Macdonald MLC**  
**NSW Minister for Primary Industries**



# 1 Acknowledgments

This plan has been prepared with the assistance of many people. In particular:

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## 2 Overview

### Introduction

The eastern cod has been listed as 'endangered' under both the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* and the (NSW) *Fisheries Management Act 1994*.

Eastern cod are a large, predatory, freshwater fish native to only the Clarence and Richmond Rivers in northern New South Wales, where they were once abundant. Although similar to the Murray cod, they are a separate species. Populations of eastern cod apparently collapsed in the 1920s and 1930s and continued to decline until the 1980s, when the species was protected. Wild eastern cod are now thought to be found only in the Mann and Nymboida river systems, tributaries of the Clarence River. Small scale surveys and anecdotal information suggests that eastern cod numbers are being maintained, and may be recovering, but there has been no rigorous scientific assessment of their abundance.

While eastern cod have been successfully bred in captivity for some time, little is known about its abundance, natural life history, habitat requirements or population dynamics. The historical decline of eastern cod has generally been attributed to over-harvesting and habitat degradation (especially sedimentation). Existing and potential threats to the species include a combination of habitat modifiers, including sedimentation, snag removal, flow modification, water pollution and barriers to migration plus illegal fishing and fish introductions leading to genetic degradation, disease and direct competition.

Various activities, which should assist the recovery of the eastern cod, have been undertaken by community and government stakeholders in the past. Some activities, such as stocking, have been directly aimed at eastern cod protection and recovery, while broader strategies, such as land and river habitat rehabilitation, have made an indirect contribution.

This recovery plan has been developed to assist the recovery of the species through the implementation of a range of strategies. The plan describes our current state of knowledge of eastern cod and the gaps that still remain in our understanding in their ecology, abundance, natural life history, genetics and population dynamics. It also discusses the major threats and issues affecting their conservation and management. The plan then identifies the actions required to improve this knowledge and reduce major threats to ensure the ongoing viability of eastern cod in the wild.

### Recovery objectives

The overall objective of this plan is to ensure the recovery and natural viability of eastern cod populations in their former range in the Clarence and Richmond rivers. This requires their genetic diversity and structure to be maintained, and population numbers to increase.

The activities in the plan specifically aim to:

- ensure the security of existing eastern cod populations in the Mann and Nymboida rivers by maintaining and enhancing, where necessary, the aquatic habitat values in that locality, and through statutory protection mechanisms
- establish and protect additional reproducing populations of eastern cod at selected locations in its former range
- gain a greater understanding of the size, distribution, ecological requirements, historical and existing genetic status of the population of eastern cod

## Approved Recovery Plan

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- gain a better understanding of the threats to the survival of eastern cod, and initiate management actions to reduce identified threats
- co-ordinate and initiate new community awareness and education programs relating to eastern cod
- coordinate and support appropriate actions by the community and government to provide a strategic, regional approach to eastern cod survival and effective threat management
- establish an ongoing monitoring program to document the status of eastern cod populations and habitat and evaluate the effectiveness of past and present recovery actions.

### Recovery criteria

The plan will be judged a long-term success if it leads to:

- the status of eastern cod is revised from 'endangered' to 'vulnerable' and its eventual removal from lists under *Fisheries Management Act and Environment Protection and Biodiversity Conservation Act* schedules.

Specific recovery criteria, based on biological information including abundance and population trends, will be developed as the necessary data becomes available through research actions.

### Recovery actions

The recovery actions in this plan are classified into six primary result areas, being:

- habitat protection and restoration
- minimising the risks of impacts from introduced fish
- reducing the impacts of fishing
- establishing new populations through stocking
- research and monitoring
- increasing community awareness, involvement and support.

### Implementation and costs

NSW Fisheries will coordinate and lead the implementation of the recovery plan, with support from relevant NSW government agencies, councils, universities and the community. The implementation of some recovery actions will be subject to securing additional funding from grant programs (such as the Natural Heritage Trust) or other sources.

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### 3. Introduction

Eastern cod (*Maccullochella ikei*) are a large, predatory, freshwater fish native to only the Clarence and Richmond Rivers in northern New South Wales, where they were once abundant. Although similar to the Murray cod, they are a separate species. Populations of eastern cod apparently collapsed in the 1920s and 1930s and continued to decline until the 1980s, when the species was protected. Wild eastern cod are now thought to be found only in the Mann and Nymboida river systems, tributaries of the Clarence River.

While eastern cod have been successfully bred in captivity for some time, little is known about its natural life history, genetics, habitat requirements or population dynamics. Also, the reason(s) for the decline have not been rigorously assessed, although the major causes are suspected to be habitat degradation (especially sedimentation) and over-harvesting.

Both NSW Fisheries and the Fisheries Scientific Committee (NSW) have identified the eastern cod from the list of endangered species in NSW a priority for the development of a recovery plan.

#### 3.1 Objectives

The objective of this recovery plan is to provide a comprehensive list of actions and strategies to facilitate the recovery and natural viability of eastern cod populations. As part of the plan, public and government support and action will be focussed on effectively reducing threats and thereby providing security to the existing wild population, gaining a greater understanding of the biology of the species, monitoring the results of recovery actions and establishing additional, secure breeding populations at selected locations.

#### 3.2 Legislative context

In NSW, the *Fisheries Management Act 1994* (*Fisheries Management Act*) provides the legislative framework for the protection and recovery of threatened species, populations and communities of fish, aquatic invertebrates and marine plants.

Eastern cod, *Maccullochella ikei*, are listed as an endangered species under both the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* and the (NSW) *Fisheries Management Act 1994*.

Under the *Fisheries Management Act*, the Director of Fisheries has certain responsibilities, including the preparation of recovery plans for listed threatened aquatic species, populations and ecological communities (See Appendix 2 for details).

#### 3.3 Recovery plan preparation

This Recovery Plan has been developed in accordance with the requirements of the *Fisheries Management Act*, the *Environment Protection and Biodiversity Conservation Act 1999*, and with the "Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities" prepared by Environment Australia in 2000. As eastern cod occur only in NSW waters, this plan has been prepared in consultation with Environment Australia to be adopted as the National Recovery Plan for the species.

This plan has been prepared by NSW Fisheries' Threatened Species Unit in consultation with an eastern cod working group. This working group was established to discuss and resolve issues relating to the management of the species and actions required for its recovery. The group included staff representatives from NSW Fisheries and Environment Australia, which have responsibility for implementing the state and national plans respectively. The working group included representatives from the government agencies that will cooperate in implementing the plan. Other members were included on the basis of their scientific expertise, expertise in eastern cod conservation, prior involvement or as representatives of major stakeholder groups.

### 3.4 Recovery plan implementation

NSW Fisheries is the lead management agency responsible for the implementation of this recovery plan. However, the success of the plan and the long term recovery of eastern cod would require action by many other organisations and individuals who either have an interest in the conservation of the species or whose actions and decisions have the potential to affect its survival.

Under the *Fisheries Management Act*, public authorities must not undertake actions inconsistent with a recovery plan. Departure from this must not occur without consulting with NSW Fisheries. The NSW Government agencies relevant to this plan are NSW Fisheries, Department of Infrastructure, Planning and Natural Resources, Department of Environment and Conservation (formally National Parks and Wildlife Service and Environment Protection Authority), State Forests of NSW, NSW Agriculture and relevant local councils.

The *Fisheries Management Act* requires that public authorities (other than local councils) identified in a recovery plan as responsible for the implementation measures included in the plan, must report on actions that have been implemented in their annual report to Parliament. Local councils must report on recovery plan actions in their annual reports on the state of the environment in their area.

## 4. Biology and ecology

### 4.1 Names

Common: eastern cod

Other names: eastern freshwater cod, Clarence River cod

Scientific: *Maccullochella ikei* (Rowland)

### 4.2 Systematic position

The eastern cod is not a relative of the true (mainly marine) codfish family, but a member of the order Perciformes (perch-like fishes) and family Percichthyidae (southern hemisphere freshwater basses). Its nearest relatives are the Murray cod (*M. peeli peeli*) and the trout cod (*M. macquariensis*), both from the inland Murray-Darling River system, and the Mary River cod (*M. peeli mariensis*) from the coastal Mary River in southern Queensland.

### 4.3 Description<sup>[13]</sup>

A large, elongate, deep-bodied fish with relatively small eyes and a short, rounded, depressed snout with a distinctly concave profile; lower jaw protrudes. Mouth large, extending to below posterior eye margin. Dorsal fin (X-XII, 13-16) has spines shorter than rays, 5<sup>th</sup> -6<sup>th</sup> spines longest. Pelvic fins have 1<sup>st</sup> ray elongated into 2 filaments, the 2<sup>nd</sup> long, tapering into a fine tip, fin inserted anterior to rounded pectoral fins (16-19 rays). Caudal peduncle short, tail rounded. Anal fin rounded (III, 11-12). Cheeks and opercula scaled, snout naked; scales mainly ctenoid. Lateral line scales 65-82. Operculum with fleshy margin and two spines, the lower largest. Vertebrae 35, 15 precaudal; gill rakers 18-20. Otolith length 3.2-3.5 per cent of total length. Eastern cod are yellow green to golden, with black to very dark green, heavily reticulated mottling dorsally and laterally, extending onto ventral surface in some fish; ventral surface otherwise grey, becoming grey-white in turbid water. Dorsal, pectoral, caudal and anal fins clearish to dark grey-green, with mottling on fin bases, pale grey to whitish margins on these fins (rayed portion of dorsal). Pelvic fins colourless, filaments white. Eastern cod have been recorded to 41 kg but are mainly less than 5 kg and 660 mm since the 1960s.

The eastern cod is similar to the Murray cod (*Maccullochella peeli peelii*) and is often confused with this species. It also closely resembles the Mary River cod (*Maccullochella peelii mariensis*).

### 4.4 Life history

Research into the life history of the eastern cod has been extremely limited. The following data is from Rowland<sup>[15]</sup> and Rowland (personal communication).

#### 4.4.1 Growth

Eastern cod can be aged from opercular bones and otoliths using the techniques developed for Murray cod. Mean length and weight at ages 3 to 8 are: 3 – 357 mm, 0.96 kg; 4 - 418 mm, 0.98 kg; 5 – 445 mm, 1.34 kg; 6 – 440 mm, 1.44 kg; 7 – 581 mm, 3.43 kg; 8 – 640 mm. The eastern cod is a slow-growing species, and individuals are significantly smaller than same-age Murray cod. The length-weight relationship for eastern cod is:  $W = 2.79 \times 10^{-9}L^{3.2592}$ , where  $W$  = whole weight in kg;  $L$  = total length in mm.

#### 4.4.2 Reproduction

Eastern cod sexually mature at 4 or 5 years old, when 0.7 kg to 1.5 kg. The breeding season is in spring and spawning starts when water temperatures rise above 16 °C. Broodfish are territorial and aggressive. Cod lay large (3 mm) strongly adhesive eggs onto hard surfaces, probably rocks and logs in the wild. Fecundity is expected to be relatively low, similar to Murray cod (3.2 - 7.6 eggs/gram). Hatching commences at 8 days, and is complete 12 days after fertilisation at 17 - 20 °C. Larvae commence feeding on zooplankton 12 days after hatching.

#### 4.4.3 Movement

The eastern cod is thought to be a territorial fish that does not undergo distinct upstream or downstream migrations. However, limited movement may occur before and during the breeding season.

### 4.5 Diseases and parasites

Several diseases have been recorded in captivity under hatchery conditions. Infestations by the protozoan parasite *Chilodonella hexasticha* (which causes the disease chilodonelliasis) and *Ichthyophthirius multifiliis* (white spot) can cause disease and death if left untreated. The fungal infection, *Saprolegnia* sp. can develop if cod are roughly handled. The ecto-parasite anchor worm *Lernaea* sp. has been recorded on wild eastern cod.

### 4.6 Distribution, abundance and habitat

#### 4.6.1 Historical distribution and abundance

Historical reports from the 1800s and early 1900s indicate large populations of cod once existed in the Clarence and Richmond River systems, downstream of tablelands waterfalls (Fig. 1).

When Europeans first settled in the Clarence Valley in the 1830s, cod were plentiful in all the freshwater reaches of the Clarence River and its tributaries<sup>[1]</sup>. Many of the early settlers “lived off the land” and caught cod and other fish and native animals for food<sup>[18]</sup>. Fish up to 27 kg were frequently caught in the Clarence and Orara Rivers<sup>[17]</sup>. In a letter dated 10 May 1866, the distinguished naturalist John MacGillivray wrote of catching 25 cod up to 23 kg during a trip to the Wymboida [sic] River<sup>[2]</sup>. Early settlers, who were mainly cedar cutters, found that cod up to 27.3 kg were plentiful in the Richmond River and many of its tributaries<sup>[3]</sup> (S. King, R. Russ, personal communications).

Eastern cod apparently declined in the Richmond River from about 1926. The last authenticated capture of a wild cod from the Richmond River system was in 1971 (J. Bell, personal communication).

Similarly, cod disappeared from much of the Clarence River system during the late 1920s and the 1930s.

### 4.6.2 Present distribution and abundance

There are no scientific estimates of past or present population sizes and few areas where indications of relative abundance have been determined. Existing information about eastern cod distribution and abundance is primarily based on anecdotal reports from recreational fishing groups and from aquaculturists sourcing wild broodstock for conservation stocking programs. These sources indicate the eastern cod may be found in greater numbers in a wider area since 1984, when the species received protection from harvesting.

#### 4.6.2.1 Distribution of the natural population

Rowland<sup>[16]</sup> stated that 'Cod are now considered extinct in the Richmond River system, and very rare or absent in the major northern tributaries of the Clarence River system (the Clarence, Rocky and Cataract Rivers) and they are no longer found in the Orara River, where they were once very common<sup>[17]</sup>. Since the late 1960s, only small numbers of cod (*usually* less than 5 kg) have been caught and only from tributaries such as the Nymboida, Little Nymboida, Guy Fawkes, Boyd and Mann Rivers (Fig.1), where some pristine habitat still exists. The cod in these rivers are considered to comprise one population.'

Since 1993, angler reports indicate that eastern cod numbers have increased to the point where they are now regularly caught within a wider area of the Clarence River system. However, this information is yet to be confirmed using scientific sampling methods.

It is unclear whether the habitat within the known range of the species is critical to its survival. Over the next few years, survey and research activities included in this recovery plan should help to clarify this issue and lead to the implementation of appropriate habitat protection measures. (see section 11.1.2).

#### 4.6.2.2 Distribution of stocked fish

Re-stocking with artificially bred juveniles was undertaken during the 1988/89 season (approximately 29,000) and each year since 1997 (a total of approximately 190,000 to 2002), meaning that approximately 210,000 juvenile cod have been released to date. These stockings took place in numerous locations throughout the Clarence and Richmond River systems, including impoundments.

Since the stocking program began, there has been no large scale survey of cod distribution, although small scale surveys and anecdotal information indicate that the stocked fish survived at many locations, particularly the Rocky Creek and Emigrant Creek sub-catchments of the Richmond River and in the Orara River in the Clarence River catchment.

### 4.6.3 Habitat

Little is known about the habitat requirements of eastern cod, but they probably resemble related species. Cod are typically found in clear flowing rivers with rocky substrate and large amounts of in-stream cover. Recent research indicates eastern cod are typically associated with deeper parts of the river near cover, especially around rocky islands and large boulders in fast-flowing water.

## 4.7 Conservation status

*M. ikei* is listed as follows:

- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) - Endangered
- *Fisheries Management Act 1994* (NSW) - Endangered
- Australian Society for Fish Biology (ASFB) - Endangered
- Australian and New Zealand Environment and Conservation Council (ANZECC) - Endangered
- International Union for Conservation of Nature and Natural Resources (IUCN) (now the World Conservation Union) - Critically endangered.

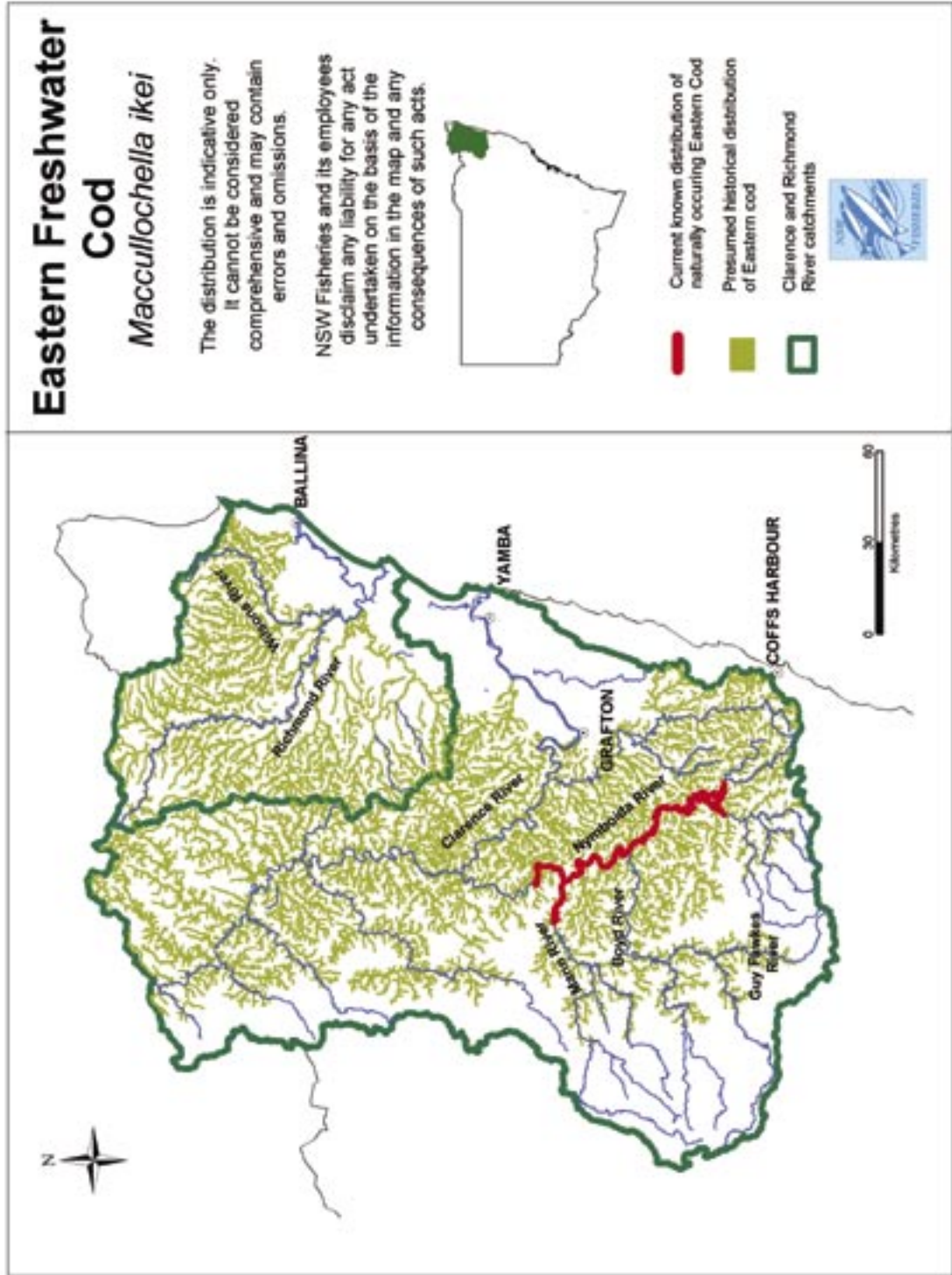


Figure 1 Distribution of Eastern cod

## 5. Reasons for decline and current threats

### 5.1 Historical decline<sup>[16]</sup>

There was a marked decline of cod in the Richmond River after the north coast railway, which closely follows the river, was constructed north of Casino in 1926. Elderly local residents claim the river was extensively dynamited during the railway's construction, and this, plus a number of large fish kills involving many cod in heavy floods during the 1920s and 1930s were probably the major reasons for the cod's decline in this system.

Cod disappeared from much of the Clarence system after a number of massive fish kills during the late 1920s and the 1930s. Long dry periods, followed by extensive bushfires and then heavy summer rains were reported before some of the fish kills. These conditions can cause water quality to deteriorate by depleting dissolved oxygen and increasing including a marked turbidity, concentrations of suspended solids, electrical conductivity and nutrient levels in some Australian rivers<sup>[4]</sup>. Contaminated water released from mining dams are also thought to have caused the death of cod and other freshwater fish in parts of the Clarence system.

Part of north coast railway route also follows the Orara River from Coffs Harbour to Grafton and associated illegal fishing using dynamite may also have caused the rapid decline of cod in this river.

For both rivers, agricultural development in parts of the catchment area could also have contributed to a loss of cod habitat.

The eastern cod, like other species of *Maccullochella*, is a large, long-lived, slow-growing species, which produces relatively few eggs and has a long generation period<sup>[15]</sup>. An extended age distribution in such fishes represents an evolutionary adaptation by which potentially high larval mortality in unfavourable breeding seasons is compensated for by repeated annual spawnings over the life span of individuals<sup>[9][12]</sup>.

It is possible that eastern cod populations have lost this advantage, and that its intrinsic biology as a species has prevented its recovery from the low population levels caused by fish kills and other factors. Small, isolated populations are extremely susceptible to extinction<sup>[8]</sup>.

### 5.2 Habitat loss and degradation

Most areas of the Clarence and Richmond River systems are now highly modified compared with their natural state at the time of European settlement.

Riverine fish species, like the eastern cod, need a complex, interconnected array of microenvironments for spawning, feeding, nursery and resting or refuge to survive<sup>[5]</sup>.

River features that provide such environments include instream rocks and woody debris (snags), undercut banks, riparian vegetation, diverse water velocities, pool-riffle sequences, river substrates suitable for invertebrate production, and aquatic vegetation. The connectivity of these habitats is also an important feature.

Stream dwelling species usually undergo complex cycles of dispersion and migration. While adult eastern cod are typically found in deep, fast-flowing parts of the river near cover, other habitats may also be critically important.

Interactions between the river channel and its adjacent environment are a major influence on riverine habitat structure, and there are many human activities within river drainage areas that directly and indirectly impact on the river systems and fish habitat.

The following sections discuss these impacts in detail.

### 5.2.1 Sedimentation

Increases in suspended and deposited solids occur in rivers as a result of activities like agriculture, forestry, mining and civil construction works. Turbidity due to suspended solids can physically block out light from the water. This reduces the ability of plants to photosynthesise and levels of primary production in the river. The settling of waterborne solids is likely to have even greater significance. Apart from the immediate effects of the infilling of deep pools, the deposited sediment may be redistributed and transported for many years. This settling can repeatedly degrade the riverine ecosystem as it smothers or damages aquatic vegetation, gravel beds deep holes and pools.

### 5.2.2 Large woody debris (snag) removal

River “improvement” works often involve removing snags to improve navigation or increase the water flow. These woody structures provide shelter for eastern cod and could also be important as spawning sites.

### 5.2.3 River flows

River flows in the Clarence and Richmond catchments are subject to a number of consumptive uses including town water supplies, irrigation, power generation and stock and domestic use. While little accurate information exists about the amount of water extracted or its impact on river health, it is clear that present extraction levels have significantly affected river health, causing stress in several areas.

Increased demand for agricultural and urban water supplies have the potential to cause further damage to river health and habitats for eastern cod

On the north coast of NSW, higher flows generally occur in summer and autumn and lower flows in winter and spring. However, flow conditions are also greatly affected by climatic cycles such as floods and droughts. Native aquatic flora and fauna have adapted to such highly variable flow conditions. Seasonal rises and falls in water level and water temperature are two major cues for spawning and migration for many aquatic organisms. The maintenance of these environmental cues is critical to protecting and restoring the breeding conditions for eastern cod populations.

Under the *Water Management Act 2000*, water management plans including Water Sharing Plans are being prepared for sections of these rivers/subcatchments during the term of this recovery plan.

The principles of the NSW River Flow Objectives and Water Quality Objectives must be addressed in the environmental flow rules for these Water Sharing Plans. While the River Flow Objectives aim to address the flow requirements of aquatic ecosystems, and not a particular species, it is important to ensure the rules are not detrimental to the conservation of particular species.

Water management plans must be consistent with the State Water Management Outcomes Plan (SWMOP) and Water Policy Advice No.12 (Conservation of Biodiversity and Threatened Species Management). The SWMOP and the Advice both state that the flow requirements of threatened species and their habitat be considered (where known) and incorporated into water management plans. Water management plans must also be consistent with the objectives and recommendations of gazetted recovery plans.

Larger fish species, such as eastern cod, are at the top of the aquatic food chain and are often the most vulnerable to changes in natural flow variability and habitat condition. These fish can be considered an “icon” species as they typically have greater, or higher flow requirements to complete their life cycle. By including the flow needs of bigger fish into the environmental flow rules the flow needs of smaller species will also be met and protected.

Eastern cod are mainly found in rivers where water flow is unregulated. These rivers generally follow natural flow patterns and when water is extracted during low flow and drought periods, the changes in water volume and movement can increase stress on species and habitats. Environmental flow rules applied within the range of eastern cod should aim to reduce stress during low and no-flow periods, while avoiding increasing stress on medium and high flows to create a more natural flow pattern.

A further cause for concern in the Nymboida-Mann River system is the alienation of catchment in higher reaches of the system. The construction of many small to medium sized farm dams on the Dorrigo plateau, especially those built on-stream, means that rainfall is intercepted and stored before it can enter the main channels and hence does not contribute to flows. This factor is particularly notable during small rainfall/runoff events, but it is such events that are thought to be significant in creating diverse habitats and introducing potential food sources. Even when dams overflow during rainfall events, their filling time introduces a delay in the runoff event which alters (smooths out) the hydrological profile of the in-stream flow.

### 5.2.4 Barriers to fish migration

Barriers such as weirs and dams built across watercourses can prevent fish reaching spawning and feeding areas as well as interrupting gene flow and causing fish populations to fragment. Unless suitable fish passage facilities are provided, breeding opportunities for many native fish will be reduced and potentially vast areas of habitat may become inaccessible.

In the Clarence River system, Nymboida Weir is a major barrier for eastern cod in an important part of the habitat range of the remnant natural population. The Nymboida River, from the Little Nymboida junction upstream of the weir to the Mann River junction, is one of the best remaining habitat areas for the species in the Clarence River. A fish passage structure at the weir would give eastern cod complete access to this habitat in the vast majority of flow conditions.

As part of the Clarence Valley and Coffs Harbour Regional Water Supply project, the Lower Clarence County Council has agreed to fund a fish passage structure at Nymboida Weir. NSW Fisheries will work with the Lower Clarence County Council to develop the most appropriate fish passage structure design.

The Richmond River has a number of significant barriers to fish migration, including the Casino Weirs<sup>[6]</sup>. It is appropriate to fit artificial fish passage structures to these barriers in areas close to habitat suitable for establishing new populations or where habitat restorations are carried out. Weir inspections and negotiations to decommission redundant weirs and install fish passage structures (where appropriate) are continuing under the NSW weir review.

### 5.2.5 Riparian vegetation

The state of riparian vegetation has a direct influence on river health through factors such as bank stability, soil conservation, water quality and the availability of food and shelter for many terrestrial and aquatic plants and animals.

Clearing native riparian and floodplain vegetation to provide land for grazing, tillage crops and forestry plantations has caused extensive in filling of pools throughout the Richmond River system. While parts of the Clarence River catchment are reserved as national parks and state forests, many parts of the upper catchment area have lost significant amounts of riverside vegetation. In the Clarence system, soil erosion from agricultural areas around Dorrigo has been identified as a major contributor to the deterioration of ecosystems along the Nymboida River<sup>[10]</sup>.

### 5.2.6 Water pollution

Water pollution can take many forms including changes to water temperature, turbidity, pH, biological oxygen demand (BOD), nutrients and heavy metals, and the introduction of toxic man-made or natural materials. Pollution can severely affect aquatic health, and there are many point sources of pollution in the Richmond and Clarence River systems.

These sources include aquaculture and agriculture practices using agro-chemicals such as pesticides and fertilisers as well as intensive animal husbandry wastes. Forestry activities can introduce chemical pollutants and acid run-off in some areas. Mining activities can introduce toxic heavy metal salts and acid drainage. Industrial processes such as brewing and food processing can introduce high biological oxygen demand and these and other industries may introduce toxic chemicals. Bushfires and fire management activities can also introduce high biological oxygen demand and induce siltation.



## 5.3 Impacts from fish introductions

### 5.3.1 Risks from stocking Murray cod

Translocation of fish, particularly related cod species, pose a significant threat to eastern cod. Eastern cod are closely related to Murray cod and it would be fairly likely that eastern cod would hybridise if Murray cod were stocked into the range of eastern cod.

Small numbers of Murray cod have been stocked into the Clarence and Richmond River systems in the past. However, due to the risk of hybridisation, it is now illegal to possess, sell or stock Murray cod within the range of eastern cod. There is also the potential for Murray cod to introduce foreign pathogens and parasites to the eastern cod's range.

Aquaculture is an expanding industry and offers diversification to farmers. Currently, silver perch are cultured in the range of eastern cod. Silver perch farms are required, by permit conditions, to release zero effluent. They also have protocols in place to prevent fish escaping as well as pathogens. Some fish farmers have applied to trial Murray cod grow-out for the food-fish trade, however the ban on stocking Murray cod in the Clarence and Richmond rivers includes aquaculture. (also see section 6.2).

Some farmers in the range of eastern cod are keen to stock large predatory fish in their dams for sport and eating. There are unconfirmed reports that Murray cod have been sourced from aquarium shops and stocked in some farm dams.

### 5.3.2 Genetically unsuitable eastern cod

Eastern cod with a poor genetic makeup constitute a threat to the wild eastern cod population. Strict controls govern the current breeding and stocking program for eastern cod with permit conditions that include genetic protocols (Appendix 3). Uncontrolled eastern cod breeding and stocking in the range of wild eastern cod could have serious genetic consequences.

### 5.3.3 Introduced species

The tropical banded grunter (*Amniataba percooides*) has been introduced into the Clarence River catchment and poses a significant threat to eastern cod. This species was probably accidentally introduced with other stocked fish. It can breed and recruit in very large numbers and may induce similar impacts relating to competition and predation, to that of the introduced species redfin.

There are other introduced species, such as gambusia and goldfish, in the Clarence and Richmond rivers with unknown effects on eastern cod.

## 5.4 Illegal fishing

Despite the protected status of eastern cod, reports and evidence indicate that illegal cod fishing and harvesting are taking place. There is some indication that indiscriminate methods, such as explosives and gill nets, are occasionally used. The extent of this illegal activity is unknown, nor can the impact of such activities be accurately assessed. However, from the reports it clear that eastern cod continue to be illegally removed. Any illegal activity that reduces eastern cod numbers is considered harmful to the viability of the population.

The key habitat of the existing population of eastern cod is generally in rugged, sparsely populated country where it is difficult to detect and respond to illegal activities. Many reaches of the Nymboida-Mann river system are inaccessible by road, so routine patrols of the area demand a considerable investment in time and resources.

NSW Fisheries officers and staff from several other State agencies (eg. DEC (Parks Services Division), State Forests) routinely visit parts of the key habitat. DEC (Parks Services Division) rangers, in particular, have a regulatory role within National Parks, and may be able to play a supplementary role in controlling illegal cod fishing.

Some members of the public have raised concerns over an apparent lack of response to reports of suspected illegal activity. Decisions of what enforcement action, if any, is warranted in any particular case remains the province of NSW Fisheries. However, improved feedback to the public on law enforcement responses to reports of illegal activities may encourage community members to provide more detailed and timely information.

## 6. Social, economic and cultural issues

### 6.1 Fishing tourism

It is widely known among the recreational fishing community that eastern cod are protected from harvesting or harm, and that deliberately fishing for them is illegal. Despite this, eastern cod are regularly caught and released by anglers who fish for eastern cod or other species such as Australian bass and freshwater catfish.

While the impact of this fishing activity on eastern cod populations is unclear, research into other species indicates that some cryptic mortality probably does occur. There is a closed season for fishing for the two cod species mainly found in the Murray River, the Murray cod and the endangered trout cod. This closure extends over their breeding season, when they are highly susceptible to being caught. There is also concern that catching and releasing cod could interrupt their reproductive cycle before or during breeding, or when they are guarding their nest. Similar concerns are held for eastern cod.

Although there are concerns about the impact on eastern cod of incidental capture and subsequent release, an alternative and widely held view among anglers is that the presence of *conservation aware* sports-fishers has a positive influence on cod populations. Their presence is thought to reduce the use of illegal fishing gear and the likelihood of cod being killed after capture while increasing the reporting of illegal cod fishing. The interest that sport-fishers have shown has also led to considerable financial and in-kind support for eastern cod recovery actions.

The existence of this unique fishery has led to specialist fishing charters and the development of fishing-based tourism in the area, which has had a positive economic effect. From this, it is clear that the eastern cod's recovery and possible future legalisation of catch-and-release fishing or controlled harvest fishing for cod could lead to the growth of fishing-based tourism and greater economic and social benefits for the area.

### 6.2 Environmental flows

A primary action of eastern cod recovery identified under this plan is to protect and enhance habitat values. This will require the delivery of adequate flows in all streams in the natural range of eastern cod. This plan allocates responsibility to all agencies involved in the water reform process to encourage the adoption, review and modification of flow rules conducive to the survival of eastern cod and to maintain a suitable aquatic ecosystem within the cod's natural range.

As noted in section 5.2.3, a large bodied species such as eastern cod will typically have greater, or higher flow requirements to complete their life cycle than smaller species.

While the creation of tailor-made flows for each fish is not an objective, it is important to consider the flow requirements of individual species to ensure it is not detrimental to their life cycle.

However, determining what flows are 'ecologically adequate' and the statutory processes for achieving such flows are complex.

NSW Fisheries, in consultation with aquatic ecologists, will develop guidelines and principles to help determine adequate flow levels.

Regional Water Management Committees, established under the Water Management Act 2000, are developing the statutory process for flow management through Water Sharing Plans.

Water sharing plans incorporating Bulk Access Regimes (BAR), must be prepared for each water source, which are generally at a subcatchment level in unregulated rivers in NSW. The water sharing plans will define environmental flows within the BAR for the 10 year tenure of the plans. If the BAR is adjusted during this term, the state government may be liable to pay compensation unless provisions for adjustment are incorporated in the water sharing plans.

The decision-making process for the establishment of the water sharing plans includes a requirement to undertake a socio-economic assessment of the impact of the plan. In most cases, flow modelling and water use information is limited. The assessments are generally qualitative, focusing on the possible scale and magnitude of the most important potential impacts and their trade-offs in each region by using demographic and economic information to indicate the effect on each region's extractive and non-extractive use of water.

### 6.3 Commercialisation of hatchery produced cod

There is a growing industry based around the aquaculture of native, freshwater fish. Silver perch have proven a highly suitable farm-fish and a number of silver perch farms now operate in the Clarence and Richmond river areas. Some of these farmers have expressed an interest in trialing cod species as they command high market prices. Small tonnages of Murray cod are being grown-out for the food-fish market in some areas, although farmers have not been allowed to culture Murray cod in the Richmond and Clarence drainage areas because of the risk they pose to the survival of eastern cod. A fish hatchery named Booma Fisheries has been permitted to produce eastern cod for conservation stocking and trial fish farming purposes.

It is unknown if eastern cod will be a commercially feasible species for aquaculture. If it is successful, there are obvious environmental and economic advantages for local silver perch farmers to produce native species that may achieve high market prices. Allowing eastern cod to be sold to stock farm dams may prevent farmers illegally stocking Murray cod in the Clarence and Richmond river areas and will help minimise this threat to eastern cod.

Commercial aquaculture of eastern cod could also assist recovery of the species by providing extra funds to meet the costs of developing efficient techniques for conservation stocking programs or promoting community awareness of eastern cod issues. These funds could be drawn from the sale of excess fingerlings for farm dam stock or a direct levy on commercial sales of cultivated cod.

In recent years, landholders have shown increasing interest in stocking farm dams with eastern cod and in their commercial production through aquaculture.

Consideration of all commercial proposals were delayed until all potential impacts, positive and negative, could be evaluated in preparation for this recovery plan. Reasons for this policy include concerns over possible excessive demands for wild broodstock, the potential genetic impacts of farmed fish in the wild and the capacity of NSW Fisheries to enforce protective legislation once eastern cod are in public ownership. Also, there were concerns about the appropriateness of using a threatened species as food.

The potential benefits of eastern cod recovery were featured in the exhibition of the draft recovery plan, which attracted submissions on this issue. Following consideration of these submissions, NSW Fisheries has revised its policy to allow commercial production of eastern cod.

NSW Fisheries will only approve the aquaculture of eastern cod where the facility:

- only uses fingerlings in excess to those fish required for conservation stocking or the progeny of such fish
- makes appropriate financial or in-kind contributions towards recovery actions
- uses appropriate measures to prevent the escape of fish pathogens or effluent.

Only fingerlings in excess of those bred for the conservation stocking program can be sold and only properties within the Clarence and Richmond catchments will be permitted to stock eastern cod.

### 6.4 Indigenous cultural issues

During research for this plan and via direct consultation with all Local Area Land Councils within the historical range of the eastern cod, no evidence has been found to indicate that the cod represents any totemic or other cultural significance to indigenous people. However, there is little doubt that eastern cod were a significant food resource for aboriginal people within the Clarence and Richmond catchments.

A significant aboriginal population lives in the Clarence and Richmond catchments and a large number live close to waterways that could or do support eastern cod. These people are a valuable resource in relation to the recovery of the eastern cod, particularly in terms of monitoring river health and illegal fishing activities.

NSW Fisheries has developed an Indigenous Fishing Strategy and implementation plan. A primary goal of the strategy is to “encourage and support the involvement of indigenous communities in the management of the state’s fisheries resources” and a key implementation approach is to “acknowledge and address indigenous issues in preparing every fishery management strategy”, which includes this recovery plan.

Hence, while no specific indigenous issues in relation to eastern cod were identified during the preparation of this plan, there is both a strategic and policy imperative for ensuring that the role and interests of indigenous people are taken into account in eastern cod recovery.

Recovery activities should specifically seek to encourage participation of local indigenous people, and proposals that may affect indigenous culture (such as fishing closures or declaration of an aquatic reserve) will require specific and direct consultation with local indigenous groups.

### 6.5 Implementation of this recovery plan

There are many existing community and government actions currently focused on matters that will aid in the recovery of eastern cod. Implementing this recovery plan will require the coordination of many of these activities and the identification of future actions. Funding options, including the use of innovative funding mechanisms, need to be examined along with the level of existing financial support in the community for recovery actions. The economic impacts on local communities which fund recovery activities should also be considered and, where possible, minimised. It will be particularly important to fund the conservation stocking program and associated research work that is at the core of this recovery plan. Actual or potential sources of funding for recovery actions include:

- Commonwealth government environmental programs, such as the Natural Heritage Trust
- Financial contributions or levies from commercial aquaculture operations trialing eastern cod
- Contributions from water supply authorities or other agencies, authorities, councils or private interests where priority works or activities may adversely impact on eastern cod or its habitat
- Contributions from the NSW Recreational Fishing (Freshwater) Trust Fund
- Contributions in the form of money, resources, expertise and/or time from individuals and community groups.

## **7. Ability to recover**

The decline of eastern cod has been well documented as occurring since European settlement in the Clarence and Richmond River catchments. Rowland (1993) attributed the species decline largely to poor land management practices and massive overfishing and/or catastrophic events early this century. Many of these practices are historical and no longer occur. Other practices, particularly land management techniques and illegal fishing, still pose some threat. However, positive community attitudes and sympathetic management approaches should prevent a repeat of catastrophic declines of eastern cod populations in future.

Part of the remnant eastern cod key habitat is contained within National Park areas. While National Parks cannot directly protect the species, park management practices act to minimise habitat disturbance in the area.

In areas outside National Parks, there are several activities which, through adequate coordination and support, should result in the restoration of suitable eastern cod habitat.

There is no impediment to species recovery while the identified threats are human induced and possible to manage, or while significant areas of key habitat remain in a relatively natural state and the likelihood of effective rehabilitation for other habitat areas remains.

## **8. Biodiversity benefits**

The decline of the eastern cod highlights the importance of habitat conservation and the role of effective fisheries management in conserving biodiversity. The conservation and study of the eastern cod will also benefit other species that share the same habitat.

Increased awareness in the community about eastern cod helps raise the profile of all threatened species. This leads to more opportunities and support for the conservation of threatened species and the increased protection of aquatic biodiversity.

Recovering and protecting eastern cod in its former range will have the additional benefit of reintroducing or maintaining the largest, top-order aquatic predator in these two river ecosystems. This will maintain natural selection pressures on prey species.

## **9. Previous recovery actions**

### **9.1 Survey and monitoring**

Some previous population survey work has been conducted <sup>[7]</sup>.

The surveys conducted for the above report were completed in 1993 and further surveys for eastern cod commenced in 2000.

## 9.2 Captive breeding and stocking programs

Captive breeding techniques for eastern cod were developed by NSW Fisheries between 1988-1990 at the Grafton Research Centre and initial stockings of 30,000 eastern cod were made into the Clarence and Richmond river catchments at that time.

Further work carried out by Mike Gilbert of Booma Fisheries, Dorrigo from 1994 was done in consultation with NSW Fisheries. The permit was based on the provision that strict genetic management protocols were followed (see Appendix 2) and all fish were to be used for conservation purposes. Booma Fisheries stocked 660 fingerlings in 1996 and 30,000 in 1997.

The community group, Project Big Fish, is a non-profit organisation that began promoting the conservation of eastern cod in December 1997. A primary aim of Project Big Fish is to raise funds for eastern cod stocking. Funds raised by Project Big Fish, with major contributions from Coffs Harbour City Council and NSW Fisheries, have permitted a substantial conservation stocking program to be implemented since 1998. Annual total release numbers have ranged from 30,000 to 60,000 per year during this time.

NSW Fisheries has prepared a comprehensive fishery management strategy covering freshwater fish stocking in NSW. The strategy evaluates the various environmental, social and economic risks associated with stocking activities, and sets out management requirements which address those risks to ensure that stocking activities proceed in a sustainable manner. The strategy addresses both 'harvest' stocking (enhancement of recreational fisheries) and conservation stocking.

All future stocking of eastern cod will be in compliance with the fishery management strategy.

## 9.3 Community education

NSW Fisheries has undertaken various activities targeted at increasing public awareness of eastern cod issues. These activities include:

- advisory signage
- media releases and magazine articles
- brochures
- field day displays
- internet articles.

The efforts of Project Big Fish Inc have been recognised by a Gold River Care 2000 award in 1998 and a Gold NSW Land Care Award in 1999. Project Big Fish's activities to spread community awareness about eastern cod issues include:

- displays at shows, field days, shopping centres and environmental expos
- an internet site
- open days at Booma hatchery
- restocking workshops
- brochures and newsletters
- presentations to schools, community groups, fishing clubs and local government
- public releases of fingerlings involving local schools, ABC documentary and video units
- media releases and interviews.

Booma Fisheries has also been active in raising the awareness of eastern cod issues and has established the Eastern Freshwater Cod Museum. School groups regularly visit this museum.

## 9.4 Threat abatement and habitat protection

Eastern cod have been protected under NSW legislation since 1984. Fisheries officers regularly patrol eastern cod habitat areas in order to check compliance with protective provisions.

There have been many community and government actions aimed at protecting and restoring river habitats. While these have been implemented in many areas of the Richmond and Clarence catchments, they were not effectively coordinated or focused on eastern cod habitat protection.

## 10. Overall recovery objective

This plan aims to ensure the recovery and natural viability of eastern cod populations within their former range in the Clarence and Richmond river drainage areas. By engaging public and government support to effectively manage threats to the wild populations of the species, this can be achieved.

This recovery plan will be subject to review within ten (10) years from the date of publication.

Short-term objectives should be met within that period, while long-term objectives are considered to be fundamental to species recovery but only achievable over a longer period of time.

It is desirable that the objectives of the plan express performance criteria in numeric or other measurable terms. For example, factors such as the number of mature individuals, viable populations or occupied habitat areas can be used to measure the rate of the cod's recovery and viability. This is especially necessary when the successful recovery of eastern cod populations would lead to a status revision from "threatened" to a lower level of concern.

However, in the case of eastern cod, it is not considered possible or practical for the plan's long term criteria to be measured in numbers for two reasons:

- Insufficient objective information is available on the current eastern cod population. No confident measure exists for values such as; number of mature (or total) individuals, biomass, extent of distribution, population structure or density. This means no baseline figures can be determined against which to measure long term performance criteria or population viability.
- Ecological response of populations is rarely simple. A good understanding of the species in question and its environment is essential before predictions can be made with any confidence. This is especially true of species where population density is limited by factors other than availability of resources, such as predation (fishing pressure), habitat fragmentation or poor habitat quality. When the threat is removed, the population may rapidly expand, only to plateau or decline when food, nest sites, refuge areas or other resources become limited. This means simple extrapolations of population growth or distribution rarely indicate "population performance"<sup>[1]</sup>. This complexity is exacerbated in species, like eastern cod, that live relatively long lives compared to other members in their ecological community, because response to changes may only be evident after several generations.

It is expected that the research and monitoring program implemented under this recovery plan will provide enough information to develop long term recovery criteria that is more specific and measurable for inclusion in the recovery plan before, or during, the first major review.

## 10.1 Short term objectives

- Ensure the security of existing eastern cod populations in the Mann and Nymboida rivers by maintaining and enhancing, where necessary, the aquatic habitat values in that locality, and through statutory protection mechanisms.
- Establish and protect additional reproducing populations of eastern cod at selected locations in its former range.
- Gain a greater understanding of the size, distribution, ecological requirements, historical and existing genetic status of the population of eastern cod.
- Gain a better understanding of the threats to the survival of eastern cod, and initiate management actions to reduce identified threats.
- Coordinate and initiate new community awareness and education programs relating to eastern cod.
- Coordinate and support appropriate actions by the community and government to provide a strategic, regional approach to eastern cod survival and effective threat management.
- Monitor the outcomes of past and present recovery actions and the species' ongoing conservation status.

### Performance criteria

- Threats to existing population minimised.
- A minimum of two additional naturally reproducing eastern cod populations established in each of the Clarence and Richmond River catchments.
- Research undertaken and results publicised.
- Threats identified, management actions initiated.
- Comprehensive community education program in place.
- Community actions identified, assessed, supported and integrated into recovery plan.
- Effective monitoring program established.

## 10.2 Long-term objectives

- Promote the recovery of eastern cod to secure the ongoing natural viability of the species.
- Periodically assess species ongoing conservation status.

### Performance criteria

- Status of eastern cod revised from 'Endangered' to 'Vulnerable' and eventually removed from lists under the *Fisheries Management Act* and *Environment Protection and Biodiversity Conservation Act* schedules.
- Long term monitoring program established.



## 11. Recovery actions

### 11.1 Habitat protection/restoration

#### [Refer section 5.2]

Only one wild naturally reproducing population of eastern cod is known to exist in the Mann-Nymboida sub-catchment of the Clarence River. This area is mostly within National Parks and forestry areas and is relatively undisturbed. This is in stark contrast to areas in the previous range of eastern cod where natural populations no longer exist. Activities such as farming, urban development and mining activities have significantly altered the landscape within these river systems. It is likely that some of the least degraded areas will need some habitat restoration to allow eastern cod populations to re-establish. Other more severely degraded areas are unlikely to become suitable cod habitat in future.

<b>11.1.1 Prepare strategic habitat protection/restoration plan</b>	
<ul style="list-style-type: none"> <li>Prepare a strategic plan for the protection of key eastern cod habitats in the Mann-Nymboida River sub-catchment and identify, restore and protect potential habitats to re-establish additional viable populations:</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries</i>
<i>Performance criteria:</i>	<i>Strategic plan prepared</i>

<b>11.1.2 Ensure the security of the existing population of eastern cod</b>	
<p>The identification and protection of key eastern cod habitat in the Mann-Nymboida River sub-catchment area and the long-term viability of the existing wild population are the highest priorities of this recovery plan. The following actions must be completed to reach these plan objectives:</p>	
<i>Responsibility:</i>	<i>NSW Fisheries</i>
<i>Performance criteria:</i>	<i>Strategic plan prepared</i>

<b>11.1.2.1 Survey existing habitat in the Mann-Nymboida River sub-catchment and determine the key habitat requirements for eastern cod.</b>	
<ul style="list-style-type: none"> <li>Complete a distributional survey of eastern cod using electro-fishing, angling, netting/trapping and snorkelling techniques and investigate aquatic habitat associations. Assess stream reaches using a standardised regime for habitat descriptors. (Refer section 11.5: Research and Monitoring)</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, Project Big Fish.</i>
<i>Performance criteria:</i>	<i>Key habitat determined, surveyed, characterised and mapped.</i>

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### 11.1.2.2 Ensure that the risk of degradation of existing eastern cod habitat is minimised.

- Investigate the use of critical habitat protection as a means of protecting key Eastern Cod habitats.
- Encourage land use activities in the upper catchment (eg. agriculture, forestry, industry, mining, municipal) that minimise the risk of pollution, sedimentation and other adverse impacts on the Nymboida-Mann system by:
  - identifying, assessing and negotiating, where necessary, mitigating measures for pollution point sources
  - assessing, and modifying where appropriate, land and water management policies and practices which may contribute to reduced stream flows, catchment alienation, loss of riparian vegetation or excessive soil loss
  - incorporating aquatic habitat protection mechanisms into plans of management for adjacent National Parks
  - including harm reduction measures in Bush Fire Hazard Reduction Plans, particularly those managed by State Forests and DEC. For example, burning operations can be scheduled to minimise the risk of ash run-off during eastern cod breeding season.
- Incorporate NSW Fisheries' eastern cod environmental flow recommendations as part of the water management planning process.
- Ensure the construction of an effective fish passage structure on the Nymboida weir.

*Responsibility:*

*NSW Fisheries, DIPNR, State Forests, DEC, NSW Agriculture, local councils, water management committees, catchment management authorities.*

*Performance criteria:*

- *Statutory habitat protection measures in place.*
- *Impacts of land and water management practices assessed and mitigated.*
- *Compliance with water sharing arrangements and environmental flow rules*
- *Nymboida Weir effective fish passage structure in place.*

### 11.1.3 Identify, protect and enhance potential habitats in other areas within the previous natural range of eastern cod with a view to re-establishing viable populations.

Even with protection measures established for the existing wild population, its limited geographic range makes it vulnerable to a range of natural or human induced catastrophic events. For the species to be viable, it is essential to establish other naturally reproducing populations in locations separate to the Mann-Nymboida river system.

The restoration of degraded aquatic habitats demands time and resources. It requires comprehensive and professional planning and the coordinated activity of many agencies and community groups. Many activities in sub-catchments of the Clarence and Richmond rivers are addressing aspects of habitat rehabilitation (by Landcare and Rivercare groups etc.). This recovery plan, and the subsequent strategic habitat plan (see Section 11.1.1), will build on habitat restoration assessments and current activities to provide direction and impetus for future programs.

The following actions must be completed to reach these recovery plan objectives:

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<b>11.1.3.1 Identify suitable sites to re-establish eastern cod populations.</b>	
<ul style="list-style-type: none"> <li>Identify suitable sites by considering information describing stream characteristics collected by government agencies and community groups. Characterisation of selected localities using a standardised regime for habitat descriptors will be undertaken. (see Section 11.5: Research and monitoring). Selection will also have regard to habitat protection or restoration activities either completed or in progress, as well as previous stocking history in the locality.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, DIPNR, Project Big Fish</i>
<i>Performance criteria:</i>	<i>Potential sites selected</i>

<b>11.1.3.2 Protect and enhance identified sites.</b>	
<p>It is proposed to work with resource management agencies and the community to:</p> <ul style="list-style-type: none"> <li>Ensure that the risk of degradation of potential eastern cod habitat is minimised.</li> <li>Initiate direct protection for the habitat through legislative mechanisms.</li> <li>Restore aquatic habitat in identified locations to a state suitable for long term eastern cod survival.</li> <li>Ensure that management approaches are put in place to maintain restored habitats in the long term.</li> <li>Ensure that the risk of pollution, sedimentation and other adverse impacts are minimised.</li> <li>Ensure the retention of remaining snags.</li> <li>Establish linkages with existing conservation groups.</li> <li>Adopt policies and instigate actions aimed at protection of these waterways.</li> <li>Encourage the adoption of NSW Fisheries Policy and Guidelines for Bridges, Roads, causeways, Culverts and Similar Structures 1999.</li> <li>Establish fish passage structures on relevant barriers to fish migration (eg Richmond River 'Norco' weir).</li> <li>Encourage implementation of 'best practice' soil conservation practices within the Clarence and Richmond drainage areas.</li> <li>Investigate the feasibility of resnagging operations or the suitability of creating eastern cod habitats using artificial materials.</li> <li>Encourage land managers to adopt 'best practices' in the protection and regeneration of riparian vegetation.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, DIPNR, State Forests, DEC, NSW Agriculture, local councils, Project Big Fish, catchment management authorities</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li><i>Statutory habitat protection measures in place.</i></li> <li><i>Impacts of land and water management practices assessed and mitigated.</i></li> <li><i>Decreased risk of waterway degradation in the Clarence and Richmond River systems.</i></li> <li><i>Degraded areas of potential eastern cod habitat are rehabilitated.</i></li> </ul>

## 11.2 Minimise impacts from fish introductions

[Refer sections 5.3 and 9.2]

<b>11.2.1 Minimise risk of impact from non-endemic fish introductions</b>	
<ul style="list-style-type: none"> <li>• Ensure that all stocking related activities are conducted according to the requirements set out in NSW Fisheries' "Freshwater Fish Stocking in NSW" strategy.</li> <li>• Maintain prohibition on the possession, sale, stocking and aquaculture of Murray cod in eastern cod's range and increase law enforcement/education activities to maximise compliance.</li> <li>• Conduct surveys to determine the extent and spread of translocated species such as banded grunter, Murray cod, golden perch, gold fish, and silver perch.</li> <li>• Develop and implement a public education program on identifying undesirable species and encourage reporting.</li> <li>• Allow the sale of eastern cod for farm dam stockings.</li> <li>• Encourage farmers who wish to stock dams on their properties to stock appropriate endemic species such as eastern cod and Australian bass.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, Project Big Fish</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Specific additional law enforcement actions carried out.</i></li> <li>• <i>Increased awareness about the potential impacts of stocking Murray cod in the Clarence and Richmond rivers.</i></li> <li>• <i>Translocated species surveys complete.</i></li> <li>• <i>Public education programs implemented.</i></li> <li>• <i>Increased number of eastern cod and Australian bass fingerlings sold for farm dam stocking.</i></li> </ul>

<b>11.2.2 Minimise risk from impact of genetically unsuitable eastern cod</b>	
<ul style="list-style-type: none"> <li>• Maintain strict genetic controls for eastern cod conservation stocking programs.</li> <li>• Increased awareness about the potential impacts of stocking genetically unsuitable eastern cod in the Clarence and Richmond rivers.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, Project Big Fish</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Compliance with genetic controls.</i></li> <li>• <i>Public education programs implemented.</i></li> </ul>

### 11.3 Reduce impacts of fishing

[Refer section 5.4 and 6.1]

<b>11.3.1 Reduce or prevent fishing induced mortality</b>	
<ul style="list-style-type: none"> <li>Assess the effect of catch and release fishing on eastern cod by conducting a study of the closely related Murray cod on post-hooking mortality.</li> <li>Use increased knowledge to modify, if necessary, fishing regulations/activities in known eastern cod distribution eg, lure &amp; fly only (no bait).</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li><i>Post-hooking mortality study complete.</i></li> <li><i>Fishing regulations/activities modified, if necessary.</i></li> </ul>

<b>11.3.2 Reduce impacts of fishing on pre-spawning fish</b>	
<ul style="list-style-type: none"> <li>Review information on seasonal fishing activities and eastern cod spawning times.</li> <li>Assess the need for total fishing closures, seasonal fishing closures and fishing gear restrictions in appropriate areas of the Nymboida-Mann river system.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li><i>Information reviewed.</i></li> <li><i>Fishing closure implemented, if necessary.</i></li> </ul>

<b>11.3.3 Maximise compliance with fishing regulations.</b>	
<ul style="list-style-type: none"> <li>• Increase enforcement capabilities of regional Fisheries Officers.</li> <li>• Increase number of Fisheries Officer angler contacts in the Clarence and Richmond River drainage areas.</li> <li>• Investigate the suitability of providing appropriate Fisheries enforcement powers to DEC (Parks Services Division) rangers.</li> <li>• Investigate the options available to improve procedures for reporting illegal activities and providing feedback on enforcement actions.</li> <li>• Implement a program for volunteer education officers. (Fishcare Volunteers).</li> <li>• Increase public awareness of protected status of eastern cod (see section 11.6).</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, Project Big Fish</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Increased enforcement by NSW Fisheries.</i></li> <li>• <i>Possibility of providing enforcement powers to DEC (Parks Services Division) officers assessed and implemented, if appropriate.</i></li> <li>• <i>Fishcare Volunteer program established.</i></li> <li>• <i>Establishment of effective public reporting and feedback mechanism.</i></li> <li>• <i>Number of actions to increase public awareness of eastern cod protected status.</i></li> </ul>

## **11.4 Establish new populations through stocking**

### **[Refer section 9.2]**

The effective restocking of eastern cod within their former range is fundamental to the success of eastern cod recovery. Restocking streams within the former range of a species with juveniles is widely accepted as a principal component of most fish recovery programs. However, the ensured success of the restocking program requires a coordinated program of research, management and monitoring actions, including a rigorous assessment of potential restocking sites and genetic management requirements.

Potential impacts on other components of the ecosystem will also need to be examined although the limited number of stocking sites within the natural range of the eastern cod is not expected to cause any significant environmental impacts. The survey and research components (see Recovery action 5) will provide valuable information on eastern cod populations to use in assessing the success of the stocking program.

All eastern cod stocking activities will be undertaken in accordance with the requirements of the fishery management strategy for stocking in NSW freshwaters.

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<b>11.4.1 Maintain strict genetic management protocols for the breeding of eastern cod.</b>	
<ul style="list-style-type: none"> <li>• Retain, and monitor adherence to, strict genetic management permit requirements (Appendix 3).</li> <li>• Review and implement appropriate genetic management protocols in the light of genetic study results.</li> <li>• Introduce tagging program for broodstock released from breeding program to prevent repeat use.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Genetic monitoring program established.</i></li> <li>• <i>Compliance with genetic management requirements.</i></li> <li>• <i>Review of genetic management complete and new protocols implemented.</i></li> <li>• <i>Broodstock tagging program implemented.</i></li> </ul>

<b>11.4.2 Optimise strategic conservation stocking program.</b>	
<ul style="list-style-type: none"> <li>• Ensure that all stocking related activities are conducted according to the requirements set out in NSW Fisheries' "Freshwater Fish Stocking in NSW" strategy.</li> <li>• Ensure the most effective use of wild broodstock.</li> <li>• Assess stability of eastern cod numbers at previous stocking sites.</li> <li>• Select potential new stocking sites with reference to existing River Styles and other available studies.</li> <li>• Prioritise stocking sites by undertaking habitat characterisation surveys of potential and previous sites as they relate to site selection criteria.</li> <li>• Identify funding opportunities and secure funds.</li> <li>• Determine optimum stocking levels based on genetic objectives and environmental considerations.</li> <li>• Investigate and implement, if appropriate, methods for chemical tagging of stocked fish.</li> <li>• Determine optimum timing of stock release to minimise environmental stress and maximise dispersal.</li> <li>• Design and implement a long term monitoring program to assess stocked populations.</li> </ul>	
<i>Responsibility:</i>	<i>Booma Fisheries, Project Big Fish, NSW Fisheries</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Number of fish stocked in selected habitats.</i></li> <li>• <i>Stocking program funds secured.</i></li> <li>• <i>Sufficient abundance and recruitment data collected to allow assessment of stocking program success.</i></li> <li>• <i>A minimum of two, new reproducing populations established in each catchment</i></li> </ul>

## 11.5 Research and monitoring

### [Refer section 9.1]

Relatively little is known of the natural history of eastern cod. A major element of the recovery plan will be to undertake appropriate research activities to develop a better understanding of the species. Research efforts will be split into the primary components of ecology/distribution and genetics.

The ecology and distribution research component will be undertaken as a joint venture between NSW Fisheries and Project Big Fish, while genetic research on eastern cod will be conducted by Southern Cross University, with some assistance from NSW Fisheries. Work on both components may be enhanced through potential funding acquisition through the National Heritage Trust

To make the most efficient use of resources, and to minimise impacts on eastern cod and their habitat, the initial research phase will evaluate several techniques to identify the most appropriate techniques.

<b>11.5.1 Biology, ecology, distribution and habitat requirements.</b>	
<b>Phase 1 - evaluation of survey methodology and site selection:</b>	
<ul style="list-style-type: none"> <li>Evaluate in the field the use of electro-fishing, angling, netting/trapping and snorkelling as effective techniques in surveying eastern cod.</li> <li>Simultaneously, evaluate the most suitable sites for regular monitoring, as well as aquatic habitat associations/characterisation of stream reaches using a standardised regime for habitat descriptors.</li> </ul>	
<b>Phase 2 - seasonal surveys:</b>	
<ul style="list-style-type: none"> <li>Undertake at least one monitoring survey per year for the duration of the recovery plan, using the techniques found most appropriate and a minimum of 12 sites per survey. Sites to include both regular (surveyed each year) and a number of previously unsurveyed sites selected on the bases of; stocking history, habitat quality and anecdotal reports of extant cod.</li> <li>Determine population abundance and structure, assess changes in population demographics and habitat preference, as related to seasonal habitat variation or migratory tendencies. It is envisaged that the spring survey will provide information on natural reproductive requirements and habits.</li> <li>Provide detailed information on overall and seasonal distribution and abundance of eastern cod.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, Project Big Fish</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li><i>Most effective survey techniques identified.</i></li> <li><i>Suitable stream habitat characterised.</i></li> <li><i>Regular monitoring sites selected.</i></li> <li><i>Biological/ecological data collected and evaluated.</i></li> </ul>



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<b>11.5.2 Long term monitoring.</b>	
Evaluate the results of phase 1 & 2 in terms of techniques, timing and site selection to develop and implement a long-term program to assess response to recovery actions.	
<i>Responsibility:</i>	<i>NSW Fisheries</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Long-term monitoring program designed and implemented.</i></li> <li>• <i>Response to recovery plan actions assessed.</i></li> </ul>

<b>11.5.3 Evaluate genetic status.</b>	
<p>Little is known of the historical or current genetic diversity and population structure of eastern cod. In order to maintain the long-term genetic diversity of the species, and to maximise genetic variability within the conservation stocking program, a detailed knowledge of eastern cod population genetics is desirable. NSW Fisheries has supported a proposal by Southern Cross University to undertake genetic studies on eastern cod, and will assist the study with specimen procurement during eastern cod survey activities.</p> <p>The study will have the following specific objectives:</p> <ul style="list-style-type: none"> <li>• To determine the historical genetic status of wild populations of eastern cod.</li> <li>• To estimate the current genetic status of wild populations across the species geographic distribution.</li> <li>• To assess the effectiveness of existing captive breeding and restocking programs in maintaining genetic diversity of the wild population(s).</li> <li>• To provide information to captive breeding and restocking groups aimed at conserving genetic resources and enhancing the overall recovery objectives.</li> </ul> <p>An indirect benefit of the study will be to provide a basis for assessing if Murray cod hybridisation has occurred, and if so to what extent and in which areas.</p>	
<i>Responsibility:</i>	<i>Southern Cross University, NSW Fisheries</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li>• <i>Historical and current genetic status adequately determined.</i></li> <li>• <i>Existing programs assessed and modified as required to ensure genetic diversity.</i></li> </ul>

## 11.6 Community awareness, involvement and support

### [Refer section 9.3]

The potential to recover eastern cod populations will be greatly improved if there is widespread community understanding of the problems faced by eastern cod and the recovery actions required. It is also essential that there is community support and involvement in the implementation of this plan.

<b>11.6.1 Enhance advisory activities.</b>	
<ul style="list-style-type: none"> <li>Develop education program to increase community awareness of the problems faced by eastern cod.</li> <li>Investigate the feasibility of an educational kit for use in schools.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, DEC (Parks Services Division), Project Big Fish</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li><i>Education program developed and implemented.</i></li> <li><i>Number of displays, meetings, publications, signage at appropriate access points, interpretive displays.</i></li> </ul>

<b>11.6.2 Encourage community involvement in the implementation of the recovery plan.</b>	
<ul style="list-style-type: none"> <li>Advertise and widely distribute information on the recovery plan and what the community can do to assist with recovery actions.</li> <li>Support activities of Project Big Fish and other local organisations.</li> <li>Encourage participation of local indigenous people through direct consultation and targeted advisory activities.</li> <li>Encourage the reporting of incidental eastern cod captures and reporting of suspected illegal activities.</li> <li>Promote responsible fishing practices in eastern cod areas.</li> </ul>	
<i>Responsibility:</i>	<i>NSW Fisheries, Project Big Fish</i>
<i>Performance criteria:</i>	<ul style="list-style-type: none"> <li><i>Number of publications and advertisements promoting the recovery plan.</i></li> <li><i>Publications developed and number distributed.</i></li> <li><i>Ongoing involvement of Project Big Fish and other local organisations.</i></li> <li><i>Awareness of and support for eastern cod recovery activities within local indigenous communities.</i></li> <li><i>Number of eastern cod records on the Threatened, Protected and Pest Public Reporting Program.</i></li> <li><i>Responsible fishing advisory material developed and distributed.</i></li> </ul>

## 12. Implementation

Part 7A of the *Fisheries Management Act 1994* requires that a government agency must take any appropriate action available to them to implement the measures included in a recovery plan and not undertake actions inconsistent with a recovery plan.

The *Fisheries Management Act* threatened species amendments to the environmental assessment provisions of the *Environmental Planning and Assessment Act 1979* (EP&A Act) require that consent and determining authorities consider relevant recovery plans when exercising a decision making function under parts 4 & 5 of the EP&A Act. Such authorities, when considering an activity in an area of potential habitat or known historical record of eastern cod that may affect the species, must consider the conservation strategy outlined in this plan.

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies and non-government bodies for the period of the recovery plan. A budget for plan implementation can be found in Section 14.

**Table 1:** Implementation schedule

Section	Recovery action	Responsibility for implementation	Timeframe	Priority
<b>11.1</b>	<b><u>Habitat protection/restoration</u></b>			
11.1.1	Prepare strategic habitat protection/ restoration plan.	NSW Fisheries	2005	high
11.1.2	Ensure the security of the existing population of eastern cod by:			
11.1.2.1	Survey existing habitat in the Mann-Nymboida River sub-catchment and determine the key habitat requirements for eastern cod.	NSW Fisheries, Project Big Fish.	2004-2008	high
11.1.2.2	Ensuring that the risk of degradation of existing habitat is minimised.	NSW Fisheries, DIPNR, State Forests, DEC, NSW Agriculture, local councils	ongoing	very high
11.1.3	Identify, protect and enhance potential habitats in other areas within the previous natural range of eastern cod to re-establishing viable populations by:	NSW Fisheries, DIPNR, Project Big Fish	2004-2008	high
11.1.3.1	Identifying suitable sites to re-establish eastern cod populations.	NSW Fisheries, DIPNR, Project Big Fish	ongoing	medium
11.1.3.2	Protecting and enhance identified sites.	NSW Fisheries, DIPNR, State Forests, DEC, NSW Agriculture, local councils, Project Big Fish	ongoing	medium

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Section	Recovery action	Responsibility for implementation	Timeframe	Priority
<b>11.2</b>	<b><u>Minimise impacts from fish introductions</u></b>			
11.2.1	Minimise risk of impact from non-endemic fish introductions	NSW Fisheries, Project Big Fish	ongoing	very high
11.2.2	Minimise risk of impact from genetically unsuitable eastern cod	NSW Fisheries, Booma Fisheries	ongoing	ongoing
<b>11.3</b>	<b><u>Reduce impacts of fishing</u></b>			
11.3.1	Reduce or prevent fishing induced mortality	NSW Fisheries	ongoing	high
11.3.2	Reduce impacts of fishing on pre-spawning fish	NSW Fisheries	ongoing	high
11.3.3	Maximise compliance with fishing regulations	NSW Fisheries, Project Big Fish	ongoing	very high
<b>11.4</b>	<b><u>Establish new populations through stocking</u></b>			
11.4.1	Maintain strict genetic management protocols for the breeding of eastern cod.	NSW Fisheries, Booma Fisheries	ongoing	high
11.4.2	Optimise strategic conservation stocking program	NSW Fisheries, Booma Fisheries, Project Big Fish	ongoing	high
<b>11.5</b>	<b><u>Research and monitoring</u></b>			
11.5.1	Biology, ecology, distribution and habitat requirements	NSW Fisheries, Project Big Fish	2004-2007	high
11.5.2	Long term monitoring	NSW Fisheries	ongoing	high
11.5.3	Evaluate genetic status	Southern Cross University, NSW Fisheries	2004-2005	medium
<b>11.6</b>	<b><u>Community awareness, involvement and support</u></b>			
11.6.1	Enhance advisory activities	NSW Fisheries, DEC (Parks Services Division), Project Big Fish	ongoing	high
11.6.2	Encourage community involvement in the implementation of the recovery plan.	NSW Fisheries, Project Big Fish	ongoing	high

## 13. Preparation and review

This recovery plan was prepared by NSW Fisheries Threatened Species Unit in consultation with the eastern cod recovery working group and stakeholder groups.

The progress of the recovery plan will be annually evaluated and reported. The report will be made available to all parties contributing to the implementation of the plan, and summary information will be included in the Annual Report of NSW Fisheries.

This recovery plan will be reviewed within ten (10) years from the date of publication.

## 14. Budget for implementation

See Table 2, over page.

**Table 2:** Costing table. Estimated costs of implementing the actions identified in the eastern (freshwater) cod recovery plan

Action No:	Action Title	Estimated Cost/ Year in \$ Thousands										Priority	Total Cost	Responsibility		
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10					
0	Recovery plan coordination	18	14	10	8	8	8	8	8	8	10	1	100	NSWF		
11.1	<b>1 - Habitat protection/restoration</b>															
11.1.1	Prepare strategic habitat protection/ restoration plan	25													25	NSWF
11.1.2.1	Survey existing habitat in the Mann-Nyboidea River sub-catchment and determine the key habitat requirements for eastern cod	*	*	*	*										*	NSWF Project Big Fish
11.1.2.2	Ensure that the risk of degradation of existing habitat is minimised	**	**	**	**	**	**	**	**	**	**	**	**	**	**	NSWF, DIPNR, State Forests, DEC NSW Ag, Local Councils WMCs, RMCs, CMBs

Action No:	Action Title	Estimated Cost/ Year in \$ Thousands										Priority	Total Cost	Responsibility
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10			
11.1.3.2	Protect and enhance identified sites	5	3	3	3	1	1	1	1	1	1	2	20	NSWF, DIPNR, State Forests, DEC NSW Ag., Local Councils Project Big Fish, CMBS
<b>11.2</b>	<b>2 – Minimise risks of impacts from introduced fish.</b>													
11.2.1	Minimise risk of impact from non-endemic fish introductions	4	3	3	3	3	3	3	3	3	3	1	31	NSWF Project Big Fish
11.2.2	Minimise risk from impact of genetically unsuitable eastern cod	1	1	1	1	1	1	1	1	1	1	1	10	NSWF Project Big Fish
<b>11.3</b>	<b>3 – Reduce impacts of fishing</b>													
11.3.1	Reduce or prevent fishing induced mortality	3	2									1	5	NSWF
11.3.2	Reduce impacts of fishing on pre-spawning fish	2	2									1	4	NSWF

Action No:	Action Title	Estimated Cost/ Year in \$ Thousands										Priority	Total Cost	Responsibility		
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10					
<b>11.4</b>	<b>4 – Establish new populations through stocking</b>															
11.4.1	Maintain strict genetic management protocols for the breeding of eastern cod	1	1	1	1	1	1	1	1	1	1	1	1	1	10	NSWF
11.4.2	Optimise strategic conservation stocking program	25	15	15	10										65	NSWF Booma Fisheries Project Big Fish
<b>11.5</b>	<b>5 - Research and monitoring</b>															
11.5.1	Biology, ecology, distribution and habitat requirements	49	35	35											119	NSWF Project Big Fish
11.5.2	Long term monitoring	20	10	10	10	10	10	10	10	10	10	10	10	10	110	NSWF
11.5.3	Evaluate genetic status	30	7												37	NSWF Southern Cross University



Action No:	Action Title	Estimated Cost/ Year in \$ Thousands										Total Cost	Priority	Responsibility		
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10					
<b>11.6</b>	<b>6 - Community awareness, involvement and support</b>															
11.6.1	Enhance advisory activities	5	4	3	3	2	2	2	2	2	2	2	2	2	27	NSWF DEC (Parks Services Division) Project Big Fish
11.6.2	Encourage community involvement in the implementation of the recovery plan	2	2	2	2	2	2	2	2	2	2	2	2	2	20	NSWF, DEC Project Big Fish
	<b>TOTALS</b>	<b>195</b>	<b>104</b>	<b>88</b>	<b>46</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>35</b>	<b>633</b>	

**Priority ratings:** 1 - Action critical to meeting plan objectives, 2 - Action contributing to meeting plan objectives, 3 - Desirable, but not essential to plan.

**Recovery Plan Coordination** includes all actions associated with 'in-kind' administration and general implementation of the recovery plan.

\* Costs of this action are covered as part of Action 11.5.1

\*\* No direct costs are estimated, however, action must be considered by relevant authorities.

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## Appendix 1

### Eastern cod taxonomy and systematics<sup>[16]</sup>

Diagnosis. A species of freshwater cod, *Maccullochella*, differing from *M. p. peelii* by having longer pelvic fins, larger orbit length, larger and morphologically distinct sagittal otoliths, and distinctive colouration, from *M. p. mariensis* by the combination of a narrower caudal peduncle, shorter post-orbital head length, larger orbit, shorter inter-orbital width, more scale rows below the lateral line, longer fifth/sixth dorsal spine, and greater extension of the first anal pterygiophore towards the vertebral column, and from *M. macquariensis* by having a concave head profile, protruding lower jaw, 15 precaudal vertebrae, greater extension of the first anal pterygiophore towards the vertebral column and distinctive colouration.

Dorsal fin XII, 14 (X-XII, 13-16); anal fin III, 12 (III, 11-12); pectoral fin rays 17 (16-19); pelvic fin I, 5; caudal fin rays 18 (17-19); predorsal bones 2 (2-3); precaudal vertebrae 15 (15); caudal vertebrae 20 (20).

Large, elongate, deep-bodied fish; slightly compressed. Depth from dorsal origin to base pelvic fin 28.3 (26.0-30.3)% SL. Body dorsal profile convex, highest above pectoral base. Caudal peduncle elongated, 19.8 (19.8-24.8)% SL.

Head broad, width 62.1 (46.0-66.2)% HL; moderately compressed; profile distinctly concave. Lower jaw protruding beyond upper; mouth large, gape extending to posterior border of eye. Eyes moderately large, dorsolateral; orbit length 14.3 (12.0-19.0)% HL. Irregular rows of villiform, curved teeth in jaws, on vomer and palatines. Operculum with fleshy margin; 2 spines, lower spine largest. Edge of preoperculum smooth.

Lateral line distinct, following dorsal profile, extending to base of caudal fin; 70 (65-82) scales in lateral line. Body covered by small scales, mostly ctenoid; cheeks and opercular scaled, snout naked.

Pelvic fin inserted in advance of pectoral base; first ray elongated into 2 filaments, second long, tapering to fine tip; pelvic fin 17.9 (16.6-21.0)% SL. Pectoral fin large, 16.7 (14.2-19.0)% SL; upper rays longest. Dorsal fin origin posterior to pectoral and pelvic bases. Dorsal spines strong, fifth-sixth longest 10.8 (8.5-13.0)% SL; soft dorsal fin rounded. Anal fin opposite soft dorsal, rounded; second spine largest. Caudal fin large, rounded.

Species can attain a large size and cod of 22.7 to 27.3 kg were frequently caught in the Clarence system<sup>[17]</sup>; largest specimen reported 41 kg from Koreelah Creek in 1921 (K. Murphy, personal communication).

Colour in life and in alcohol. In life yellow-green to golden with black to very dark green, heavily reticulated mottling on dorsal surface, head and sides, extending onto ventral surface in some specimens. Ventral surface of head and body dark grey; becoming grey-white when in turbid water. Dorsal, pectoral, caudal and anal fins clearish to very dark grey-green with mottling on their bases. Thin pale-grey to whitish margins sometimes present on soft dorsal, anal and caudal fins. Pelvic fin colourless, translucent; filaments white.

In alcohol, grey dorsally with black to dark grey heavily reticulated mottling on dorsal surface, head and sides; ventral surface grey and brownish. Fins dark to grey; pelvic fin white.

## Appendix 2

### Extract from *Fisheries Management Act 1994*

#### 220ZN Contents of recovery or threat abatement plans.

##### Recovery plans

Recovery plans must:

- (a) identify the threatened species, population or ecological community to which it applies, and
- (b) identify any critical habitat declared in relation to the threatened species, population or ecological community, and
- (c) identify any threatening process or processes threatening the threatened species, population or ecological community, and
- (d) identify methods by which adverse social and economic consequences of the making of the plan can be minimised, and
- (e) state what must be done to ensure the recovery of the threatened species, population or ecological community, and
- (f) state what must be done to protect the critical habitat (if any) identified in the plan, and
- (g) state, with reference to the objects of [Part 7A of the *Fisheries Management Act*]:
  - (i) the way in which those objects are to be implemented or promoted for the benefit of the threatened species, population or ecological community, and
  - (ii) the method by which progress towards achieving those objects is to be assessed, and
- (h) identify the persons or public authorities who are responsible for the implementation of the measures included in the plan, and
- (i) state the date by which the recovery plan should be subject to review by the Director.

## Appendix 3

### Genetic guidelines for the conservation stocking program

MINIMUM of 25 pairs of broodfish to be used within five (5) consecutive breeding seasons as shown in Table 1. This number of pairs per generation should prevent loss of fitness through inbreeding depression and will result in an approximate loss of one per cent of genetic variation.

- Progeny from AT LEAST 5 pairs to be stocked at each site.
- This requires that eggs from each pair be incubated separately
- Stock the larvae from 5 pairs into each pond, or
- Pool fry from 5 pairs after harvest.

As far as is practically possible, the same number of offspring from each pair should be stocked into the wild. Equalising family sizes effectively doubles the available genetic variation in the recovering population. It would be beneficial for us to adapt a strategy that equalised family sizes. This would require that offspring from all pairs be kept independently throughout the entire breeding process. The same number (roughly) of offspring from each pair could then be stocked at each re-introduction site. However to incorporate equalised family sizes into the recovery plan is logistically difficult.

Ideally use single cross matings (1 Female x 1 Male). (*Easier to manage*)

**or**

Cross every female with every male. DO NOT mix eggs from several females or milt from several males. Each female's eggs must be divided into the same number of portions as the number of males in the breeding program. Each portion of eggs should be the same size. Do the same with males (quantities of milt not important, as eggs are the limiting factor). Fertilise each portion of eggs from individual females with milt from each of the males. (*Genetically more beneficial but very hard to achieve*).

If males do not produce enough milt for fertilisation they should not be used that season. If they again fail to produce sufficient milt the following season they should not be used in the program. Therefore a few excess males may be required as backups.

Ideally NO individuals will be bred from more than once in the program. Therefore all broodstock should be replaced each year (assuming no recapture of broodfish). However, as a minimum, AT LEAST some broodfish should NOT have been used in a previous season. This number depends on the length of the breeding program. The minimum number to be replaced each year is given in Table 1.

Collect broodfish from 3 or more sites (eg. Cod hole, junction of Nymboida's, Buccarumbi). As far as possible, set up pairs with individuals from different locations. Collect broodfish before May.

Do not use larger females (> 10kg). Use broodfish 2-5kg.

**Table 1:** Minimum number of new breeding pairs required per season based on the number of seasons *Booma Fisheries* is permitted to continue with the breeding-restocking program.

Breeding seasons	Minimum new breeding pairs / season.
1	25
2	13
3	9
4	7
5	5