Oxleyan Pygmy Perch

Nannoperca oxleyana

Background paper

Supporting information to the Oxleyan pygmy perch recovery plan

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Cover photograph by Gunther Schmida

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1. Introduction

The Oxleyan pygmy perch is listed as an endangered species on Schedule 4 of the NSW *Fisheries Management Act 1994*. The species is also listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and as vulnerable under the Queensland *Nature Conservation Act 1992*. The NSW Department of Primary Industries (DPI) in consultation with the Queensland Environmental Protection Agency / Queensland Parks and Wildlife Service has prepared a statutory recovery plan to promote the recovery of pygmy perch to a position of viability in nature.

This recovery statement is a non-statutory document that provides additional information on:

- The legislative context and implications of the plan,
- Biological and ecological information on pygmy perch,
- Current threats to the species survival, and
- Reporting on the implementation of the recovery plan.

The recovery statement will be updated every three years to incorporate the latest information on plan implementation, monitoring, review, and achievements.

2. Legislative context

2.1 Listing of threatened species

Oxleyan pygmy perch are listed as 'threatened' under both State and Commonwealth legislation. Pygmy perch are listed as endangered under the NSW *Fisheries Management Act 1994* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. They are also listed as vulnerable under the Queensland *Nature Conservation Act 1992*.

2.2 Recovery planning

Recovery plans may be prepared by the NSW DPI for species, populations and ecological communities listed as endangered or vulnerable on the schedules of the *Fisheries Management Act 1994*. Approved recovery plans are statutory documents. Ministers and public authorities need to take appropriate actions to implement the measures in the plan for which they are responsible, and to ensure their decisions are not inconsistent with the provisions of the plan without consulting the Minister for Primary Industries. The *Fisheries Management Act 1994* also requires public authorities (other than local councils) with identified responsibilities in a recovery plan to report on implementation actions in their annual report to Parliament. Local councils must report on actions in annual State of the Environment reports.

In Queensland, recovery plans may be prepared for species listed under the *Nature Conservation (Wildlife) Regulation 1994*. Queensland recovery plans state the research and management actions necessary to stop the decline, support the recovery and enhance the chance of long-term survival in the wild, of a stated species or community of protected wildlife.

National recovery plans must also be prepared for threatened species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

2.3 Critical habitat

Both State and Commonwealth legislation allow for the listing of critical habitat. In NSW, the *Fisheries Management Act 1994* requires, wherever possible, the identification and declaration of 'critical habitat' for endangered species, populations and ecological communities. Critical habitat is the whole or any part of the habitat of an endangered species, population or ecological community that is critical to its survival.

In Queensland the *Nature Conservation Act 1992 – Nature Conservation (Wildlife) Regulation 1994* and the *Vegetation Management Act 1999* contain provisions to identify and protect critical habitat or areas of major interest. The *Nature Conservation Act 1992* defines critical habitat as 'habitat that is essential for the conservation of a viable population of protected wildlife or community of native wildlife, whether or not special management considerations and protection are required'.

The Commonwealth Environment Minister may identify and list habitat critical to ensure the survival of threatened species or ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999*. The specific requirements for identifying habitat critical to the survival of nationally threatened species, populations and ecological communities are established by Regulation 7.09 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

There has been no critical habitat declared for Oxleyan pygmy perch. The option of identifying and declaring critical habitat for pygmy perch will be considered as part of the recovery planning process.

2.4 Recovery plan preparation and implementation

This recovery plan was developed by the NSW DPI in accordance with the requirements of the *Fisheries Management Act 1994* (as outlined in section 220ZN; see Appendix 1a) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Appendix 1b), and complies with the Revised Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities 2002 and the Draft Queensland Recovery Plan Procedural Guidelines (draft) 2005.

The NSW DPI has a statutory responsibility to prepare and lead the implementation of this recovery plan within NSW. In Queensland a number of potential contributors are identified as having implementation responsibilities. However, the success of the plan and the long-term recovery of Oxleyan pygmy perch will require action by many 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. For instance, regional natural resource management bodies in NSW and Qld have a role in implementing this recovery plan. In NSW, the *Catchment Management Authorities Act 2003* requires Catchment Management Authorities to have regard to natural resource management plans (including recovery plans) during the development of their catchment action plans.

The estimated costs associated with implementing the actions identified in the Oxleyan pygmy perch recovery plan are included at Appendix 2.

2.5 Linkages with other recovery and threat abatement plans

The wallum heath habitats of Oxleyan pygmy perch support several other threatened species, including the vulnerable honey blue-eye *Pseudomugil mellis*, the vulnerable wallum froglet *Crinia tinnula* and the Olongurra frog or wallum sedge frog *Litoria olongburensis*.

These species are listed under the Queensland *Nature Conservation Act 1992* (administered by the Environment Protection Agency / Queensland Parks and Wildlife Service) and the NSW *Threatened Species Conservation Act 1995* (administered by the Department of Environment and Conservation). Recovery plans for these species have not yet been prepared, but it is likely that recovery activities for these species and Oxleyan pygmy perch will be cross-linked in some areas.

In addition, the predation of several threatened frog species by the plague minnow (*Gambusia holbrooki*) has led to its listing as a key threatening process (Schedule 3) under the NSW *Threatened Species Conservation Act 1995*. The preparation and implementation of a threat abatement plan for Gambusia should benefit the frog species and the recovery of pygmy perch, which also appears to be detrimentally affected by Gambusia.

2.6 Biodiversity benefits

The decline of Oxleyan pygmy perch highlights the importance of habitat conservation for the protection of biodiversity. The coastal wallum heathlands where pygmy perch occur are unique, regionally significant communities that support a diversity of native flora and fauna in a variety of habitat sub-types. The flora includes species from families such as Proteaceae (including the endemic 'wallum banksia' *Banksia aemula*), Epacridaceae (Australian heaths), Myrtaceae, Rutaceae, Fabaceae, Euphorbiaceae, Restionaceae and Cyperaceae.

The terrestrial vertebrate fauna includes birds, skinks, dragons, snakes and a range of small marsupials and bats. The creeks, lakes and swamps support around 30 species of fish [1] [2] [3] [21] [43] [46], at least three species of freshwater turtles [9] [12] [18] [21], numerous frog species [6] [11] [21] [25] and diverse aquatic invertebrate fauna.

Many of these species have a restricted distribution and some are found only in wallum heath ecosystems where they have adapted to habitat characteristics such as nutrient-poor, slightly acidic, sandy soils and acidic waters. Several of these species are rare and because of habitat loss, the survival of some of these species is now under threat.

Aside from Oxleyan pygmy perch, other wallum heath-associated species listed as threatened in NSW include:

	Scientific name	Common name	Status in NSW
Frogs:	*Crinia tinnula*	Wallum froglet	Vulnerable
	Litoria olongburensis	Olongurra frog (or Wallum sedge frog)	Vulnerable
Birds:	*Ephippiorhynchus asiaticus*	Black-necked stork	Endangered
	Ixobrychus flavicollis	Black bittern	Vulnerable
Mammals:	*Pseudomys gracilicaudatus*	Eastern chestnut mouse	Vulnerable
	Syconycteris australis	Common blossom bat	Vulnerable
Plants:	*Phaius australis*	[a swamp orchid]	Endangered
	Phaius tankervilleae	[a swamp orchid]	Endangered
	Allocasuarina defungens	[a she-oak]	Endangered
	Diuris sp. aff. *chrysantha* (Byron Bay)	[an orchid]	Endangered
	Olax angulata		Vulnerable
	Lindsaea fraseri		Endangered
	Lindsaea incisa		Endangered
	Aldrovanda vesiculosa		Endangered
Ecological communities:	Byron Bay Dwarf Graminoid Clay Heath Community		Endangered

Recovery activities to protect and restore the habitats of Oxleyan pygmy perch will also make an important contribution to the conservation of other wallum heath-dependent threatened species.

Wallum heath habitats also have important ecological and hydrological functions, and their conservation should have beneficial effects on adjacent areas. Wallum heath typically occurs on sandy coastal soils in areas of high rainfall, and loss of vegetation cover can lead to rapid erosion of the substrate. Undisturbed wallum heaths also help to maintain water quality in adjacent and downstream areas (including estuarine and inshore marine waters) through filtration of rainwater and regulation of nutrient inputs. In contrast, the impacts of poor water quality from developed parts of the catchment are often compounded and difficult to control.

Pollutants can enter waterways from urban, agricultural, industrial and refuse areas via stormwater and leaching through soils. Consequently, efforts to conserve and restore pygmy perch habitats will also help to maintain ecological integrity and water quality in adjacent and downstream aquatic ecosystems.

Efforts to protect and recover pygmy perch populations will also deliver a range of other biodiversity benefits. For example, increasing community awareness about the plight of pygmy perch should boost the profile of all threatened species and lead to increased opportunities to conserve and protect threatened species and aquatic biodiversity.

3. Biology and ecology

3.1 Names

Common: Oxleyan pygmy perch

Other names: none

Scientific: *Nannoperca oxleyana* Whitley 1940

3.2 Systematic position

The Oxleyan pygmy perch (*Nannoperca oxleyana*) is one of six Australian species of pygmy perch found in the freshwater streams, ponds, lakes and swamps of coastal southern Queensland and all southern states. Oxleyan pygmy perch have the most northerly distribution in this group. The southern pygmy perch (*Nannoperca australis*), Ewen pygmy perch (*Nannoperca variegata*), and Yarra pygmy perch (*Nannoperca obscura*) are endemic to south-eastern Australia. The final two pygmy perch species, *Nannatherina balstoni* and *Nannoperca vittata*, are found only in southwestern Australia.

The classification of these fishes at the species and family level has long been uncertain. At different times, they have been placed in their own family, Nannopercidae, in the family Kuhliidae (with the flagtails, genus Kuhlia) and in the family Percichthyidae (freshwater basses and cods of southern Australia and South America). At a sub-familial level, the group has been variously split into three genera (Edelia, Nannoperca and Nannatherina) or two genera (Nannoperca and Nannatherina, with *E. obscura* and *E. vittata* placed into Nannoperca) [31] [32] [36] [40].

Recent genetic evidence [26] supports the placement of the pygmy perches within the family Percichthyidae, and the recognition of the genera Nannoperca and Nannatherina only.

3.3 Description

Oxleyan pygmy perch are small (max. approx. 60 mm total length, but common to 35 mm) [28] and moderately compressed, with body depth to about 32 per cent in standard length. The mouth is small, reaching to just below the eye; teeth in the lower jaw are enlarged. The preorbital lower edge is hidden by skin. Dorsal fin VI-VIII, 7-9 (usually VII, 8); anal fin III, 7-9 (usually 8); pectoral fin 11-13 (usually 12); gill rakers 2-4 + 6-8, total 9-12. Body covered by ctenoid scales in 26-28 midlateral rows; lateral line lacking. Tail truncated.

Oxleyan pygmy perch are usually light brown to olive in colour (darkest on back, sides paler) and mottled, with three to four patchy, dark brown bars extending from head to tail, and a whitish belly. The opercular flap has a blue iridescence and there is a conspicuous round dark spot with orange margin at the base of the tail. The scales have dusky margins and the fins are mainly clear. There is a blue ring around the eye. During breeding the dorsal, pelvic and anal fins darken and the lateral stripes and tail turn scarlet [5] [32] [42].

Oxleyan pygmy perch are similar in appearance to other pygmy perch species and to juveniles of other perch-like species.

3.4 Distribution

Oxleyan pygmy perch have a restricted and patchy distribution. They are found in the swamps, streams and lakes of coastal lowland wallum heathlands, from Fraser Island and the Tin Can Bay area in south-east Queensland to Corindi (north of Coffs Harbour) in northern NSW. This distribution also includes the sand islands of Moreton and Stradbroke in southeast Queenland [2] [4] [28] [57].

The precise distribution of pygmy perch is difficult to establish. The species may extend further north than recorded, although limited surveys, conducted from Tin Can Bay north to the heathlands of Shoalwater Bay near Byfield, have not established this [3]. However, several species with similar habitat requirements including the honey blue-eye *Pseudomugil mellis* and soft-spined rainbowfish *Rhadinocentris ornatus* have been found in this region [52].

Pygmy perch may also extend further south than presently known but this has not been confirmed. Soft-spined rainbowfish *Rhadinocentrus ornatus*, share their distribution with pygmy perch and these have been found 38 km south of Corindi in Boambee Creek near Coffs Harbour. Suitable areas of habitat appear to occur all the way down the coast to Crowdy Bay National Park or further. However, broad-scale surveys to establish the distributional limits of the species have been unable to locate pygmy perch south of Yuraygir National Park.

In addition, the distribution of pygmy perch on the mainland appears to be disjunct as the species has never been recorded within the 250 km of coastline from Rileys Hill in northern NSW to Deception Bay in south-east Queensland [28] [29].

3.4.1 Queensland distribution

Pygmy perch have been recorded in approximately 20 locations in south-east Queensland. Mainland locations include Searys, Carland and Coondoo/Tinana Creeks (a tributary of the Mary River) in the Tin Can Bay area; the Noosa River and its tributaries; Marcus, Mellum and Blue Gum creeks near the Glasshouse Mountains; [3] and Burpengary Creek, Deception Bay [49].

On Fraser Island, pygmy perch have recently only been recorded in Rocky and Coongul creeks. In the past, they have also been recorded in Woralie and Bogimbah Creeks. On Moreton Island, populations exist in Lake Jabiru, Spitfire Creek, Warrajamba Creek, Blue Lagoon, South Blue Lagoon Creek and North Eagers Creek on the east coast. On the island's west coast, pygmy perch are found in Ben Ewa Swamp and associated streams (including Craven Creek and Tempest Creek). On North Stradbroke Island, small populations of pygmy perch are found in 18 Mile Swamp and Little Canalpin Creek. There have also been unconfirmed reports of pygmy perch from waterbodies in the island's south. [2] [3] [16] [32] [34] [42] [47].

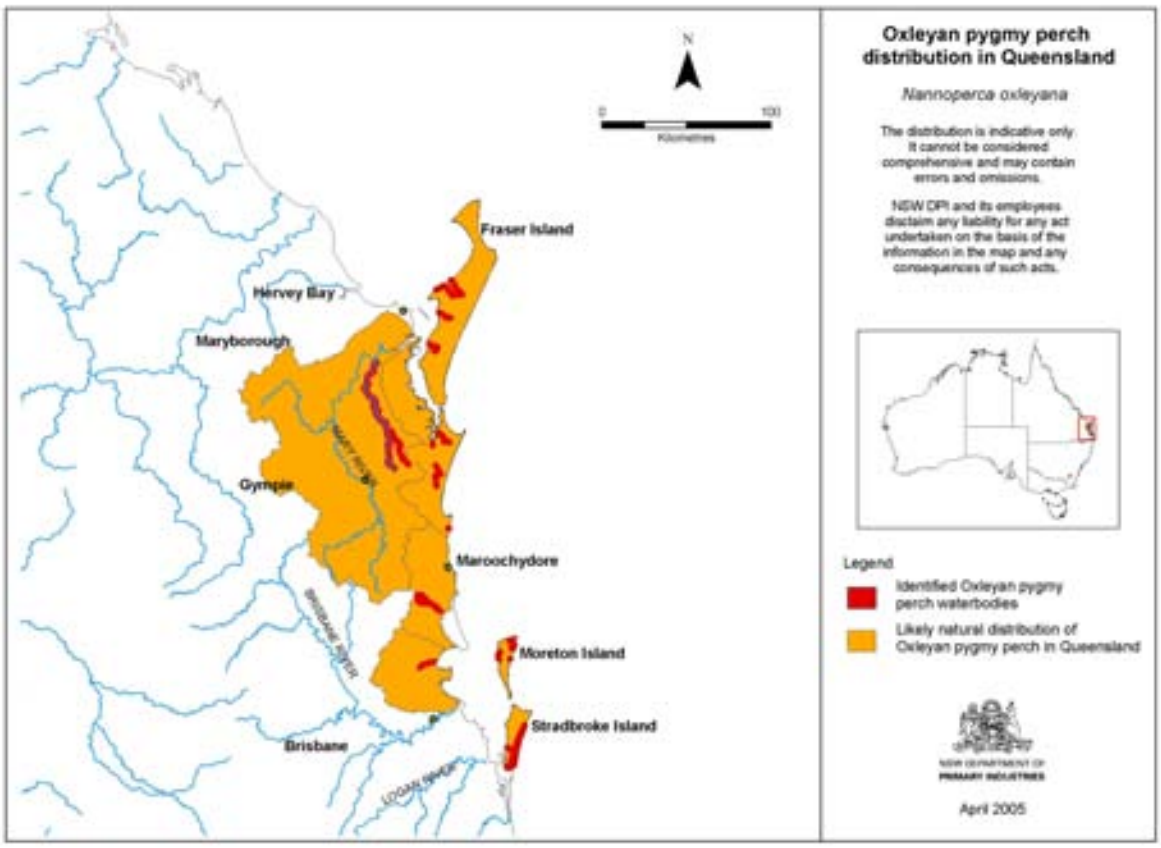

Figure 1: Existing records and likely natural distribution of Oxleyan pygmy perch in Qld

3.4.2 NSW distribution

In NSW, pygmy perch appear restricted to a 114 km stretch of sandy coastal lowlands between Rileys Hill, north of Evans Head, and Corindi [29] [57]. They have never been recorded north of the Richmond River.

The first record of the species in NSW was a specimen in 1929 from the Richmond River (or a small waterbody adjacent to the river), 14 km southwest of Lismore [28] [51]. This is considerably further west than subsequent records. Whether pygmy perch occur today in the Richmond River is unknown, as the river has not been recently surveyed.

Other historical reports of pygmy perch come from the southern end of their known range in the Wooli/Corindi area, including Wooli Creek and Cassons Creek in 1976 and Tick Gate Swamp in 1977. In 1975 and 1977 the species was also found in Lake Hiawatha [36]. However, further surveys of this lake conducted in 1975-79 and again in 1993 failed to locate the species. More recently, pygmy perch have also been recorded in the Wooli area from Lake Minnie Water in 1995 [33], and again in 2001. Furthermore, surveys undertaken by ANGFA and Southern Cross University have located four additional waterbodies containing pygmy perch in the Wooli area, with an additional record from Haleys Creek, near Brooms Head.

Pygmy perch are also known to occur further north of the Wooli area near the township of Evans Head (Figure 1). During a 1993 survey of 33 locations in northern NSW, pygmy perch were found at one site, 'North Range Lake' (in the RAAF bombing range situated within Bundjalung National Park), south of Evans Head [3]. They have since been found in four additional water bodies near North Range Lake and in other areas of Bundjalung National Park including Jerusalem Creek and in a small isolated drain [20] [56].

Closer to the township of Evans Head pygmy perch were found in 1998 and 1999 in a small drain near the Woodburn-Evans Head Road [7] [53]. A more intensive survey of this area in 2000 resulted in the capture of 566 pygmy perch from 25 water bodies in and around Broadwater

National Park [28]. This makes the Evans Head area one of the most important known habitats for the species. Broad-scale distributional surveys undertaken in 2001-02 (Action 7.1.2) led to seven new reports of pygmy perch close to Broadwater and Bundjalung National Park including on private property and Aboriginal land [29].

The apparent absence of the species from the majority of the sub-catchments previously surveyed is an important indicator of the species' distribution, particularly in sub-catchments found north and south of the species' known range. A range of surveys since the 1970s have failed to find pygmy perch in these areas, even in relatively undisturbed tracts of heath vegetation where water bodies meet all the habitat criteria for pygmy perch (eg. [3] [7] [14] [15] [29] [46]).

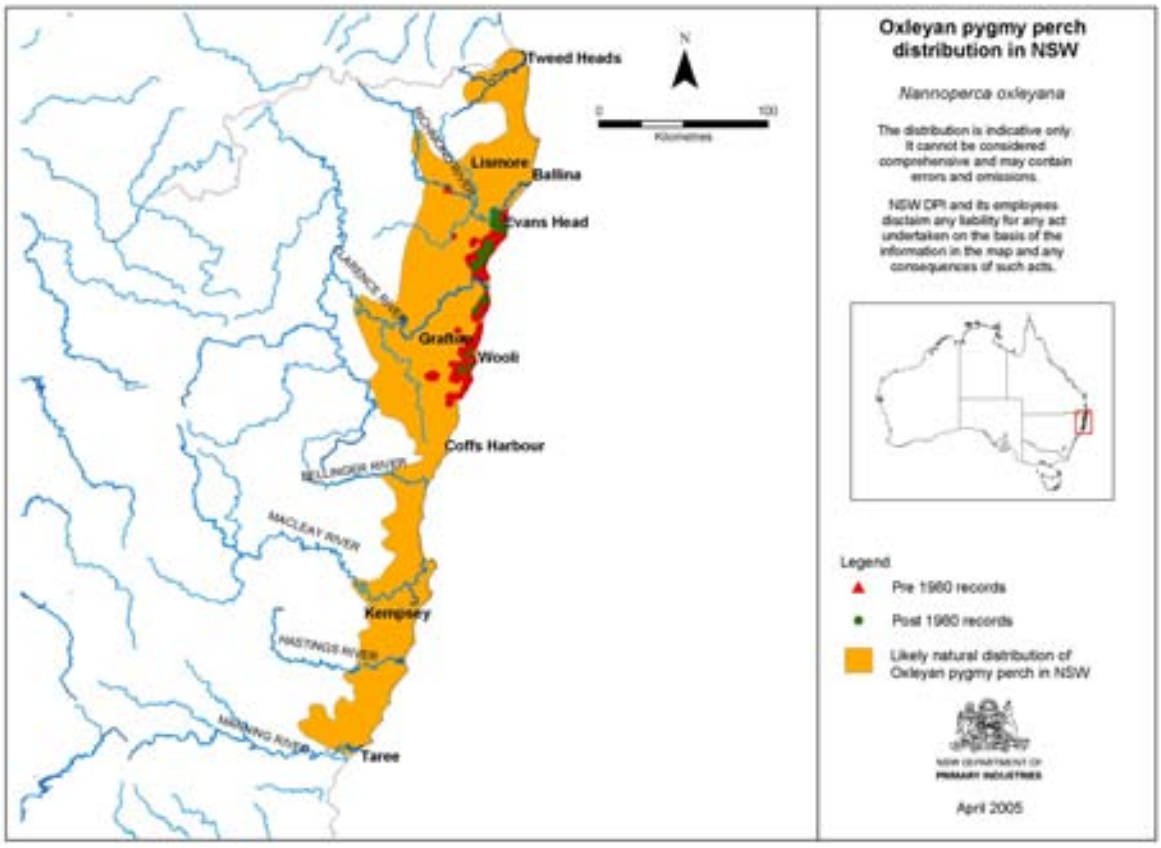

Figure 2: Existing records and likely natural distribution of Oxleyan pygmy perch in NSW

3.5 Limits to current knowledge of the distribution

Until recently, the distribution of pygmy perch in NSW (particularly the northern, southern and western limits of their range) was unknown. Survey work undertaken as part of the draft recovery plan has provided a clearer picture of their distribution by focusing on unsurveyed areas between Myall Lakes National Park and the NSW-Queensland border that may contain pygmy perch habitat [29]. The surveys aimed to identify sub-catchments likely to contain pygmy perch however it is possible that some isolated populations may have been missed. There are many unsurveyed lakes, streams and swamps in Bundjalung and Yuraygir National Parks where pygmy perch may exist. These water bodies will be surveyed as part of the implementation of the recovery plan.

3.6 Abundance

Oxleyan pygmy perch are generally not a prolific species, with low numbers captured at most sites where they occur. However, in a survey of Spitfire, Tempest, Marcus and Coondoo creeks pygmy perch comprised 20 per cent or more of the fish collected [3]. Similarly, another survey

collected 208 fish from 'creek 3b' and 193 from 'lake 9' which accounted for 71 per cent of the total pygmy perch collected in the study [28].

However, local environmental conditions can have a major effect on pygmy perch abundance. For example, when 'creek 3b' was re-surveyed in 2001, no pygmy perch were found [30]. A dirt road crosses the creek and several months after initial sampling the creek had virtually dried up [30].

Population fluctuations may partly explain the variability in records of pygmy perch at particular locations over time. For instance, pygmy perch were recorded in Lake Hiawatha, Tick Gate Swamp and Wooli Creek in the 1970s, and not again in this area until 1995. Similarly, they were recorded in Blue Lagoon on Moreton Island in 1976, then not again until 2000, despite surveys in 1982, 1990 and 1993 [3] [19] [39].

3.7 Habitat

Pygmy perch are generally regarded as restricted to streams, swampy areas and lakes in coastal 'wallum' (Banksia dominated heathlands[10]).

Wallum heath country has a well-distributed annual rainfall (of 1016 to 1778 mm) and freshwater lakes, creeks and wetlands feature prominently throughout the region [3]. Waterbodies in the wallum heath are characterised by very low salinity, low magnesium; calcium hardness and (pH >3 to <7). Habitats range from low conductivity (<250 μs cm-1), clear waters with a pH of 6 to 6.5, to estuarine, darkly stained dystrophic waters of pH 4 to 6, over siliceous sands, aquatic vegetation or plant debris. The generally high organic acid content of these water bodies is derived from leachates from swamps and riparian vegetation, particularly Melaleucas.

Figure 3: Typical pygmy perch habitat, Broadwater National Park (Photo: J. Knight)

However, pygmy perch have also been found in several sites with different habitat characteristics (eg. soil types and vegetation communities), in creeks that run into adjacent areas out of wallum heath. For example, they have been recorded from an intermediate eucalypt forest/heath community over grey acid soils and from littoral rainforest/melaleuca swamp (Jerusalem area, west of Bundjalung National Park [29]), and from among saltrushes in an estuarine creek with conductivity 8860 μs cm^{-1} [20] The water quality parameters recorded at localities supporting pygmy perch in NSW are given in Table 1.

Table 1: Water quality parameters recorded at NSW localities supporting Oxleyan pygmy perch. Figure in parentheses is an outlier. (Source: J. Knight, pers. comm.).

Water quality parameter	Mean (n = 82)	Range
Temperature (deg C.)	17.3	11.7 – 29.7
PH (organic acids)	4.39	3.32 – 6.96
Conductivity (uS.cm)	171	90 – 830 (8860)
Dissolved Oxygen (mg/L)	6.29	2.15 – 10.02
Turbidity	13	0 – 51
Water Colour	N/A	Clear to dark tannin

While wallum heath freshwater bodies are clearly the core habitat, further work may be needed to assess the tolerance and adaptability of pygmy perch to variable habitat and changes in water quality parameters.

Figure 4: Intermediate eucalypt forest / heath community, Jerusalem area (Photo: J. Knight)

Within all these water bodies, pygmy perch are generally found at sites with a high level of in-stream cover (60-80%) and no visible flow or very low flows. Individuals are often found near dense aquatic vegetation, such as stands of emergent and submerged sedges and rushes (eg. *Lepironia articulata*, *Schoenus brevifolius*, *Restio pallens*, *Eleocharis* spp., *Gahnia* sp., *Juncus* sp.), water lilies (*Nymphaea* sp.), bladderworts (*Utricularia* sp.), mosses (e.g. *Sphagnum falcatulum*) and algae (*Chara* sp., *Cladophora* sp., *Batrachospermum* sp.). They are also found in leaf litter beds and occasionally woody debris [3] [4] [28] [42].

Beds of aquatic plants provide a more productive and secure habitat for foraging than open water areas where pygmy perch are at risk from surface predators (birds) and aquatic predators (piscivores such as striped gudgeons and eels). Aquatic plants may also reduce the impact of short periods of high flow that can displace smaller fish some distance downstream [3]. Vertical or undercut banks where fine rootlets of riparian vegetation grow into the water are also important in providing cover in some areas [3] [28].

3.8 Life history and ecology

There is little published information on the biology and ecology of pygmy perch, apart from general information on habitat from field studies and aquarium observations. In the field, studies have looked at the pygmy perch's seasonal spawning period, fecundity, recruitment, dietary preferences, and interactions with other species, while aquarium studies have documented growth rates, size at maturity, courtship and spawning behaviour [3] [4] [28] [34] [47].

3.8.1 Growth

Due to the destructive nature of the standard methods used to estimate growth (scale and otolith analysis) no studies have estimated the growth rate of pygmy perch [3]. However, length-frequency data for fish sampled from Marcus Creek between October 1994 and October 1995 suggested that fish can double their length in a year, with initial samples growing from 14 mm to more than 28 mm over this 12 month period [3]. At all sites, fish achieved better condition in winter than in summer possibly to prepare for reproduction in the spring [3].

3.8.2 Reproduction

Aquarium-bred pygmy perch are sexually mature in four to five months [47], with females breeding at 30 mm and males at 27 mm [32]. The breeding season is extended, beginning in October and continuing as late as April or May, although spawning takes place mainly between October to December. Rising water temperatures are thought to stimulate spawning, which needs a minimum temperature of 20ºC. Males and females at this time display the breeding colours of red lateral stripes, a red tail and black dorsal, anal and pelvic fins.

Courtship and mating occurs when pairs approach each other and quickly shudder to release eggs and milt [47]. Spawning is protracted, with a few eggs laid daily over several days. This serial spawning allows pygmy perch to produce a greater number of eggs in the breeding season than would otherwise be predicted from their body size [28] [53].

The eggs are adhesive and demersal, which means they sink or settle near the bottom, sticking to aquatic vegetation or the substrate depending on where the fish have mated [5] [32] [42] [47]. The dispersal of pygmy perch eggs in sheltered areas probably helps to protect eggs and young fish from aquatic predators and birds and the full force of water movements [3].

During breeding, many hundreds of eggs can accumulate. Young hatch in three to four days and begin to forage over the next two days.

The fecundity of pygmy perch has been reported to be relatively low compared to other species around the same size (225 to 270 eggs per pygmy perch compared to 1000 eggs per *Hypseleotris. compressa*.) [3]. However, this report may be misleading because it was based on a small sample collected near the end of the reproductive season, after most eggs may have been shed. Indeed, the same report noted that despite the apparent low fecundity of pygmy perch, populations could grow to large sizes in suitable environments [3].

3.8.3 Behaviour and movement

Snorkelling observations in Spitfire Creek suggest that pygmy perch are highly mobile. They will forage along the stems of aquatic plants alone or in pairs, while younger fish move in groups of three or four [3]. However, the total extent of pygmy perch foraging movement is unknown [42].

There is no evidence to support distinct upstream or downstream migration in pygmy perch although genetic evidence suggests substantial movement and mixing within individual drainages [24]. Floods and high flow events are suspected of carrying and depositing pygmy perch between bodies of water, but more work is needed to establish whether floods are an important form of "transport" for distributing genetic information [28].

3.8.4 Diet

Published information indicates that pygmy perch are microphagic carnivores. Larvae feed on rotifers and protozoans, while larger fish eat copepods, cladocerans, caridinians and aquatic insects (especially chironomid midges), as well as diatoms, filamentous algae and a few terrestrial insects [32].

The diet for pygmy perch was established by examining the gut contents of 178 fish from the Noosa River and Spitfire Creek on Moreton Island revealing a diet of zooplankton (31%), aquatic insects (23%) and atyid shrimps (22%) terrestrial arthropods (3%) and flying aquatic insects (2%) [3] [4] [42].

3.8.5 Interactions with other native fish species

Pygmy perch share their habitat with other small native species, including firetailed and empire gudgeons (genus Hypseleotris), striped gudgeon (*Gobiomorphus australis*), softspined rainbowfish (*Rhadinocentrus ornatus*) and Duboulay's rainbowfish (*Melanotaenia duboulayi*). The threatened honey blue-eye (*Pseudomugil mellis*) also shares pygmy perch habitat in Queensland but has no record in NSW to date. Studies of the micro-habitat preferences of pygmy perch in Spitfire Creek on Moreton Island found no evidence of aggressive or avoidance behaviour between any of these species[3].

The study also found that the small indigenous species at this site had partitioned their habitat and possibly resources, by occupying different levels of the water column [3]. Even the presence of a large number of species with similar diet and environmental needs such as firetailed gudgeons, did not appear to affect pygmy perch viability or population growth at this site.

3.9 Genetics

The results of a study using allozyme and mitochondrial DNA variation to examine genetic structure in pygmy perch populations in southeast Queensland showed that there was little genetic variation within each population (overall very low allozyme variation) but large variation between populations [24]. This suggests the opportunities for dispersal are limited among the populations that live in small, specific habitats in different drainages. Similar patterns of genetic differentiation have also been found in several other native freshwater fish species in the same area [54].

These results have important implications for the long-term conservation of pygmy perch. They verify the need to maintain as many different populations as possible to preserve genetic diversity. The large genetic differences between populations would also have to be considered if fish taken from other areas or bred in aquaria were used to restock any habitat in future. The limited dispersal abilities and isolated populations of the species suggest that once locally extinct, they are likely to remain so [24].

Alternatively, the low genetic variability in each drainage system, even the extensive systems which flow from Lake Jabiru/Spitfire Creek and the Noosa River, supports the view that fish do move, mix and interbreed within individual drainages [3].

A study by Arthington [3] suggests areas of swamp or lake in the upper catchment may act as a reservoir or refuge for the species and a source of new breeding partners. This means the immigration of fish from these upstream areas could potentially offset any decline in downstream populations. However, the network of fish passageways in each drainage system would need to be maintained for this to occur [3].

No genetic work has been conducted on NSW populations of pygmy perch so patterns of distribution and genetic differences within these populations have not been established.

4. Conservation status

4.1 Listings

Oxleyan pygmy perch are listed/classified as:

- Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
- Endangered under the *Fisheries Management Act 1994* (NSW)
- Vulnerable under the *Nature Conservation Act 1992* (Queensland)
- Endangered by the Australian Society for Fish Biology (ASFB)
- Endangered by the Australian and New Zealand Environment and Conservation Council (ANZECC)
- Endangered by the World Conservation Union (IUCN)

4.2 Reasons for concern

Oxleyan pygmy perch have specific ecological needs. They require waters with low nutrient and pH of the kind associated with coastal heath vegetation [48]. Because of this crucial habitat requirement, they have a limited geographic range that appears to have diminished over time because of habitat loss [32].

The coastal land that stretches from Bundaberg in southern Queensland to Coffs Harbour on the far north coast of NSW was once part of a vast, almost unbroken corridor of coastal heath, interrupted occasionally by open forests, swamps and gallery rainforests on rivers [41]. Since European settlement, this heath has been progressively cleared, disturbed and drained for alluvial and sand mining, cattle grazing, agriculture, forestry and urban development. The history of human impacts on the coastal heathland of south-eastern Queensland via development for forestry, agriculture, urban expansion and tourism is also well-established. Clearing of coastal heathlands and shrublands has seriously reduced the total area of this habitat and increased its fragmentation [3].

From the 1930s onwards, extensive sand mining occurred along the north coast of NSW. The practice was phased out during the 1980s but partially cleared and disturbed areas remain with altered topography and hydrology caused by the removal of sand and the digging of dredge ponds. Cane fields, grazing pastures, pine plantations and rural subdivisions have replaced other areas of wallum heath and their adjacent habitats. Intact heath communities are now largely restricted to protected areas in Broadwater, Bundjalung and Yuraygir National Parks [28] [29].

The limited amount of information recorded about the species and the absence of reliable and frequent survey results make it difficult to identify localised extinctions in recent years. However, there are locations where no pygmy perch have been reported for several decades, including the Richmond River (last recorded 1929) and Lake Hiawatha (last recorded 1977). Even in locations with suitable pygmy perch habitat, population sizes are small and patchily distributed.

The geographical isolation of remaining populations, and the small size of the streams and swamps in which they live increase the risk that one or more of these populations will be lost through habitat disturbance or chance events. Floods may help to distribute pygmy perch although fragmented habitats and other barriers to fish movement will reduce the ability of the species to recolonise areas from which it is lost.

These factors, coupled with the species limited geographic distribution, make pygmy perch particularly vulnerable to threatening processes.

5. Current issues and threats

The primary threats to Oxleyan pygmy perch appear to be habitat degradation and loss, threats to water quality and a lack of information on the distribution and biology of pygmy perch. This section is divided into five parts that discuss these and other major issues relevant to the conservation of pygmy perch.

5.1 Limitations in current understanding

BACKGROUND

Distribution: Prior to the development of the recovery plan there had been very limited sampling effort for the species in NSW and Queensland. The lack of information on the distribution of pygmy perch led the working group to agree that the key priority for initial research was to establish a better indication of the species distribution and limits. The survey work undertaken to date has provided a clearer picture of their distribution [29]. However, many areas that could contain populations of the species remain unsurveyed. In the future it is likely that additional pygmy perch populations will be found through targeted surveys.

Habitat and environmental tolerances: Habitat associations and the water quality parameters associated with pygmy perch habitats have been relatively well documented at most sites where the species has been found. Based on this work, pygmy perch appear to be restricted to water bodies within wallum heath that meet their defined habitat and water quality needs (eg: specific pH, hardness, nutrient levels, presence of aquatic macrophytes etc.). During extensive surveys in southeast Queensland, the species has never been found in areas that do not meet these criteria.

However, in NSW, pygmy perch have been found in several sites with 'atypical' water quality and habitat characteristics[1]. This suggests that the apparent dependence on these needs by pygmy perch requires greater examination. This could involve sampling a wider range of habitat types, including some that do not conform to the habitat characteristics currently thought to be 'optimal' for pygmy perch.

In addition, while the habitat associations for pygmy perch have been well documented little information exists on their tolerance to disturbance, habitat degradation or pollution. More information on tolerance would help to predict the impacts of activities and developments with greater precision.

Life history and genetics: Other significant gaps exist in information about the life history, population dynamics, dispersal patterns and genetics of pygmy perch. For example, little is known about why the species is present or absent at certain sites over time. Floods have been suggested as a dispersal mechanism for pygmy perch [28], but this hypothesis has never been rigorously tested.

More knowledge about the genetic structure of pygmy perch populations and their dispersal mechanisms would help in understanding what effect barriers to their distribution, population fragmentation or changes to topography or hydrology have on the viability of the species.

Genetic studies would also provide data to assist in the conservation of pygmy perch genetic diversity and genetic population structure, which is critical to ensuring their long-term viability. No studies have been done on the degree of genetic variation in NSW populations although work has begun on a pilot study. The study will compare genetic profiles from three populations in

[1] For example, the locality of the original record (Richmond River or a nearby water body) does not fall within the range of 'optimal' habitat as it is currently understood. This locality is well inland of the typical coastal wallum habitat and lacks the distinctive chemical and biological characteristics of the latter, although some features (such as melaleuca swamps and associated low-pH water bodies) are present [28]. Pygmy perch have also recently been found in a number of other sites with atypical habitat parameters ([29]; see section 2.6).

Broadwater National Park. In addition, genetic samples (fin clips) have been collected from all populations in the survey work under this recovery plan for later analysis.

5.2 Community awareness and support

BACKGROUND

One of the major threats to pygmy perch is habitat degradation. This can be caused by a wide range of activities.

While most recent reports have come from national parks, pygmy perch have also been recorded on Commonwealth land (e.g. the RAAF bombing range, south of Evans Head), land owned by local governments, Aboriginal land and private property.

Some landholders are already aware and supportive of conservation efforts for pygmy perch. However, pygmy perch do not have a high profile in the community or among planners and developers. This is partly because they are considered a small, rare fish with no recreational fishing value. In many cases access to accurate information about the species, improved awareness and appropriate planning could avoid many of the impacts on pygmy perch caused by human activities.

There is a need to develop a community education program to increase general awareness about the threats faced by pygmy perch, and the actions required to recover the species. The program should also encourage the community to minimise their impacts on the species and its habitats.

A further need exists for detailed, accurate information that can be used by councils and other public authorities in planning activities to reduce detrimental impacts. The support and involvement of all these groups will be essential to the successful implementation of the recovery plan.

5.3 Habitat degradation and loss

BACKGROUND

The amount of coastal wallum heath has diminished since European settlement. This has been a major factor in the historical decline of pygmy perch and the pressures on remaining areas of suitable pygmy perch habitat continue.

Intact areas of wallum heath are now largely confined to protected areas such as Broadwater, Bundjalung and Yuraygir National Parks in NSW and Cooloola (Great Sandy) and Moreton Island National Parks in Queensland. These areas have played an integral role in the survival of pygmy perch. They have helped preserve large tracts of wallum heath habitat and many of the most recent reports of pygmy perch in NSW have come from water bodies within these parks.

However, even habitats in protected areas can be degraded through a range of recreational, managerial or development activities. Examples include run-off from unsealed roads, herbicide contamination, hazard reduction burning and bushfire fighting efforts and disturbance by recreational users such as four-wheel vehicle drivers or campers. There are also several pygmy perch sites known to exist close to residential areas (or areas zoned for development) and the survival of these populations may be threatened by surface run-off and other activities that degrade habitats.

Some areas of comparatively undisturbed wallum heath still occur on freehold land. However, there is a risk that these areas will be lost because of land demands for housing, agriculture and other developments as populations continue to grow on the NSW north coast. Housing development and road construction projects pose major habitat threats and need to be carefully managed to avoid or minimise impacts.

Direct habitat damage or loss can occur through mining, dredging and excavation work, the removal of riparian vegetation or the interruption of natural flow patterns. Habitats can be indirectly damaged when land clearing causes a deterioration in water quality, changes in nutrient levels or siltation.

The effects of seven processes on habitats are outlined below.

Mining: Sand mining has destroyed some dune lakes in NSW and QLD by rupturing the organic layer underlying the perched aquifer. In each case, this has led to the lake being drained or the intrusion of salt water into freshwater after the dune separating the lake and sea was broken [17] [21] [34] [44] [45]. While sandmining in northern NSW has been phased out, any form of digging activity that alters the aquifer remains a threat to pygmy perch habitats. Sand mining is still carried out within pygmy perch habitat on Stradbroke Island in southern Queensland.

Drainage works: Some areas of pygmy perch habitat have been severely disturbed by the construction and maintenance of drains, especially where natural waterways have been rechannelled. Drains carry water away from roads or low-lying, swampy areas and lowers the water table. Where swamps have been destroyed any remaining pygmy perch and other aquatic fauna may take refuge within the drains to survive. In some areas local councils construct drains and regularly maintain them through excavation. Excavation causes severe disturbance by removing in-stream plant cover and destroying vegetation, which provides sheltered places for pygmy perch to forage. Excavation and dredging may also increase the sediment load (originating from the streambed) which can impair the visual acuity and foraging success of pygmy perch. In places where drainage work has damaged pygmy perch habitat, rehabilitation work may be needed. Pygmy perch have been found in artificial, constructed drains.

Barriers to fish passage: Although there is little information about the dispersal mechanisms of pygmy perch, it is probable that floods or other high flow events play an important role. This is because the temporary watercourses or overflows they create are thought to carry the species between otherwise isolated bodies of water. This has significant implications for local populations of pygmy perch as habitat fragmentation, even on a small scale, and fish barriers such as road crossings, could prevent genetic mixing or the recolonisation of areas where populations have been wiped out or that are used on a seasonal basis.

In addition, poorly designed road crossings (such as dirt tracks across natural waterways) can lead to erosion and infilling of the creek, and deterioration of water quality.

Loss of riparian and other vegetation: Removal of littoral and riparian plants has important effects on bank stability, water quality and the availability of food and shelter. Wallum heath areas may be particularly susceptible to damage, with the removal of vegetation leading to rapid erosion of sandy substrates, bank instability and slumping, infilling of streams and pools, and smothering of submerged aquatic vegetation.

Clearing vegetation elsewhere within the catchment can also contribute to increased turbidity and siltation. Increased turbidity from suspended solids blocks out light from the water column and can reduce the ability of plants to photosynthesize and possibly the ability of fish to hunt by sight [3] [8]. The redistribution and transportation of deposited sediment may continue for many years.

The removal of riparian vegetation has reduced the extent of shelter within habitats and has probably affected the viability of aquatic insects available as a food for pygmy perch.

Pollution: Wallum heath lakes, creeks and swamps can be polluted by a range of urban, agricultural, industrial and recreational activities that cause excess nutrients, toxic substances and silt to affect water quality. Land clearing can also cause sediment to erode and enter waterways.

Other sources of pollution include agricultural pesticides and fertilisers, pharmaceuticals and organic wastes from livestock, sewage, and toxic heavy metal salts from mining. Industrial processes such as brewing, bushfires and fire management activities, road run-off, and all forms

of development which involve disturbance of potential acid sulphate soils (acid run-off) also impact on water quality.

The significance of water pollution as a threat to pygmy perch is unknown, although the presence of extra nutrients in wallum heath water bodies is likely to be an issue because they are naturally nutrient-poor, with phosphorus levels below 10 µg/L.

Fire: Both bushfires and hazard reduction burning activities can affect aquatic biota and their habitats by raising temperatures. They can also change nutrient cycles and the amount of leaf litter and woody debris that accumulates. These changes can induce siltation and high biological oxygen demand (BOD). Other associated impacts include the risk of pollution from fire-fighting chemicals and changes to the volume of water in natural water bodies used as reservoirs to fight bushfires. The management of fire, even within national parks, can be important issue to consider in identifying habitat threats.

Water extraction: Little is known about the impact of water extraction (from surface or groundwater) on pygmy perch. Reduced water flows could potentially lead to salt water intruding into the upper parts of freshwater creeks where pygmy perch live. Saline conditions decrease the area available as habitat to pygmy perch while increasing the upstream presence of larger estuarine predators. Likewise, the extraction of water from watertables that feed wetland areas can diminish or desiccate habitat areas, particularly during droughts.

Due to the importance of water flows and catchment hydrology in transporting fish between locations, recovery efforts should target complete drainage systems, including isolated water bodies.

Options for habitat protection: The loss of habitat is a major threat to Oxleyan pygmy perch because they need specific habitat conditions to survive. To conserve the species, remaining areas of essential habitat must be protected from disturbance. The options for improving protection levels for important habitat areas include:

- Use of statutory mechanisms such as declaring critical habitat, additions to the national park estate, or the identification of key habitat in relevant landuse planning instruments.
- Negotiate with relevant landholders to conserve and manage key habitat areas.

Recovery planning actions will need to be incorporated into relevant natural resource management plans which may impact on pygmy perch habitat. This includes, but is not limited to, catchment action plans, water management plans, vegetation management plans and land management plans such as Crown land assessments and national park management plans.

5.4 Introduced fish species

BACKGROUND

Oxleyan pygmy perch have probably been adversely affected by the presence of introduced species, particularly the plague minnow (or ‘mosquitofish’) *Gambusia holbrooki*, in many parts of their range.

Gambusia are native to rivers draining into the Gulf of Mexico. They were deliberately introduced into Australia and many other countries because of their reputation for eating mosquitos and rapid reproduction [38]. However, they seem to be no more efficient than other small, native fish in controlling mosquitos. As a species, Gambusia is competitive and combines high tolerance with flexible feeding and habitat needs and can compete with native species for food and other resources. Native species could also be affected by their behaviour, which includes chasing and other forms of harassment such as fin nipping which can sever fins [38]. Gambusia has been linked to the worldwide decline of many endemic fish species. They are now regarded as a pest in Australian waters.

Aggressive behaviour by Gambusia towards native fish species in Australia has been widely documented. In a study on the effects of Gambusia attacks on the Pacific blue-eye *Pseudomugil*

signifer the attacks were dependent on the density of the competition [27]. Other experiments in captivity have shown Gambusia to act aggressively towards a variety of species such as: ornate rainbowfish (*Rhadinocentrus ornatus*), Duboulay's rainbowfish (*Melanotaenia duboulayi*) and firetailed gudgeons (*Hypseleotris galii*) [55]. In tank experiments, Gambusia were found to hunt and eat the young of southern blue-eye [22]. The stress caused by such interactions may affect the success of feeding, growth rates and breeding [23] [37].

There is little information about the impacts of Gambusia on pygmy perch. However, their aggression and ability to survive and compete for food in habitats native to pygmy perch, suggest their presence has been detrimental to pygmy perch.

Gambusia is present in at least 20 of the water bodies where pygmy perch have been found. In light of the documented effects of Gambusia on small native fishes, their presence in these water bodies must be considered a local threat. Since Gambusia are distributed by floods or moved by humans for mosquito control, their presence in other creeks in the pygmy perch's geographic range is also an important consideration [3].

Another important consideration is the impact of intentionally introducing native fish species into areas outside their natural range on pygmy perch populations. While this may occur for a number of reasons including for example to enhance recreational fishing opportunities, it has the potential to have similar outcomes for pygmy perch as introducing non-native species such as Gambusia, because they have not co-evolved with the local species. However, future research is required as little is currently known about the extent of the threat posed to pygmy perch by introduced native species.

The DPI 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 that 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. The Queensland Department of Primary Industries and Fisheries (DPIF) have in place a translocation policy to address the same potential risks associated with stocking. All future stocking will be in compliance with the NSW fishery management strategy or the Queensland translocation policy in NSW and Qld respectively.

Control methods: Currently, few options exist to control Gambusia in water bodies occupied by pygmy perch. The use of poisons, or other destructive methods are inappropriate in places where Gambusia coexist with large populations of native fish, although poison could be potentially used in sites dominated by Gambusia. Further research is needed to develop effective control methods for Gambusia that can be used with minimal harm to native species, along with strategies to prevent their spread to water bodies where they do not occur.

Future research in reproductive biotechnology may lead to innovative, host-specific control methods. For example, vaccines that cause an animal's immune system to attack its own eggs or sperm are being investigated for use on feral foxes, rabbits and mice [13]. Gambusia, as live bearers of their young, coupled with their lack of close relatives in the native fish fauna, could be a suitable research subject for this type of vaccine, known as immuno-contraception.

Predation by Gambusia is listed as a key threatening process under the NSW *Threatened Species Conservation Act 1995* because of its impact on a variety of frog species and a threat abatement plan has been prepared.

5.5 Collection and aquarium keeping

BACKGROUND

Oxleyan pygmy perch are an endangered species and it is illegal to catch and keep, buy, sell, possess or harm them without a permit or licence, and penalties apply, including fines of up to $220,000 and two years jail.

The number of pygmy perch illegally collected for aquariums is impossible to estimate. Although their collection is far less damaging to their survival than habitat degradation. Aquarium collectors have been seen removing large numbers of indigenous fish from wallum heath water bodies [3]. There have also been several articles in aquarium journals on collecting and keeping pygmy perch.

The random collection of pygmy perch for aquariums is likely to be harmful to some small, restricted populations of the species, particularly when they are difficult to keep and breed and more fish are collected to replace aquarium mortalities. While collection alone is unlikely to remove a complete population, even in highly accessible areas, any reduction in numbers may affect the population's ability to recover from floods, pollution or introduced species such as Gambusia. An example of this effect on an indigenous population has been documented for populations of honey blue-eye *Pseudomugil mellis* [35].

There have been some proposals to involve aquarium keepers in the recovery of pygmy perch through captive breeding. However, reports indicate that pygmy perch are difficult to keep or breed and frequently die. In view of a study that revealed high levels of genetic difference in pygmy perch populations in southeast Queensland [24], any restocking in NSW should be undertaken with great care.

For these reasons, the NSW DPI has not placed a high priority on captive breeding or restocking programs for pygmy perch.

Alternatively, groups of aquarium enthusiasts and native fish breeders, especially the Australia New Guinea Fishes Association (ANGFA), have been involved in past and recent activities that have made a valuable contribution to pygmy perch recovery. These activities include the distribution of information to members and the community and field trips to locate, record and collect native species assisted by volunteers.

6. Implementation and reporting

Implementation of the recovery plan in NSW will be lead by NSW DPI in conjunction with other responsible bodies and stakeholders. In Qld a range of potential contributors are identified as having implementation responsibilities. The recovery plan contains timeframes to guide implementation activities and sets out specific objectives in three program areas.

The recovery statement will be updated in the future, and will form the primary mechanism to report on the progress of the recovery plan. In particular, the recovery statement will document:

- The progress of implementation activities, outcomes, and investment in each program area
- Updates on the latest information and research results in relation to pygmy perch
- The achievement of the plans objectives assessed against the performance criteria contained in the plan
- Recommendations for changes or amendments to the statutory plan if the review indicates that the objectives of the plan are not being met.

7. Further information

Further information about the recovery planning process may be found in the *Oxleyan pygmy perch recovery plan*, or by contacting:

NSW Department of Primary Industries
Fisheries Management Branch
Port Stephens Fisheries Centre
Private Bag 1
NELSON BAY NSW 2315
www.dpi.nsw.gov.au

Queensland Parks and Wildlife Service
Threatened Species and Ecosystems Unit
Wildlife Conservation Branch
PO Box 15155
CITY EAST QLD 4002
www.epa.qld.gov.au

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Appendices

Appendix 1a: Required contents of a recovery plan

Extract from NSW *Fisheries Management Act 1994*, Part 7A

220ZN Contents of recovery or threat abatement plans

(1) Recovery plans

A recovery plan 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 this Part:

   (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 1b: Required contents of a recovery plan

Extract from the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Division 5

270 Content of recovery plans

(1) A recovery plan must provide for the research and management actions necessary to stop the decline of, and support the recovery of, the listed threatened species or listed threatened ecological community concerned so that its chances of long-term survival in nature are maximised.

(2) In particular, a recovery plan must:

(a) state the objectives to be achieved (for example, removing a species or community from a list, or indefinite protection of existing populations of a species or community); and

(b) state criteria against which achievement of the objectives is to be measured (for example, a specified number and distribution of viable populations of a species or community, or the abatement of threats to a species or community); and

(c) specify the actions needed to achieve the objectives; and

(ca) identify threats to the species or community; and

(d) identify the habitats that are critical to the survival of the species or community concerned and the actions needed to protect those habitats; and

(e) identify any populations of the species or community concerned that are under particular pressure of survival and the actions needed to protect those populations; and

(f) state the estimated duration and cost of the recovery process; and

(g) identify:

(i) interests that will be affected by the plan's implementation; and

(ii) organisations or persons who will be involved in evaluating the performance of the recovery plan; and

(h) specify any major benefits to native species or ecological communities (other than those to which the plan relates) that will be affected by the plan's implementation; and

(j) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).

(3) In making a recovery plan, regard must be had to:

(a) the objects of this Act; and

(b) the most efficient and effective use of the resources that are allocated for the conservation of species and ecological communities; and

(c) minimising any significant adverse social and economic impacts, consistently with the principles of ecologically sustainable development; and

(d) meeting Australia's obligations under international agreements between Australia and one or more countries relevant to the species or ecological community to which the plan relates; and

(e) the role and interests of indigenous people in the conservation of Australia's biodiversity.

Extract from the Commonwealth *Environment Protection and Biodiversity Conservation Regulations 2000*, Division 7.5

7.11 Content of recovery plans

(1) For paragraph 270 (2) (j) of the Act, a recovery plan must describe to the extent practicable, with spatial information:

(a) the location of species or ecological communities for which it is made; and

(b) areas of habitat that are critical to the survival of the species or ecological communities; and

(c) important populations of the species or ecological communities that are necessary for their long-term survival and recovery; and

(d) any areas that are affected by a threatening process.

(2) A recovery plan should state:

(a) what must be done to stop the decline of, and support the recovery and survival of, the species or ecological community, including action:

(i) to protect important populations; and

(ii) to protect and restore habitat; and

(iii) to manage and reduce threatening processes; and

(b) to the extent possible, what management practices are necessary to avoid a significant adverse impact on the species or ecological community.

(3) For paragraph 270 (2) (d) of the Act, the criteria mentioned in regulation 7.09 must be considered in identifying habitat that is critical to the survival of the species or community concerne

Appendix 2: Implementation costs

Table 1: Estimated costs of implementing the actions identified in the Oxleyan pygmy perch recovery plan.

No:	Action Title	Estimated Cost/yr					Total Cost
		Year 1	Year 2	Year 3	Year 4	Year 5	
	Recovery plan coordination	$30,000	$30,000	$16,000	$16,000	$16,000	$108,000
6.1	**Research and investigation activities**						
1	Undertake a survey program to better establish the distribution of pygmy perch and their habitat requirements	$6,000	$6,000	$6,000			$18,000
2	Model and map known and potential pygmy perch habitat				$160,000	$80,000	$240,000
3	Support research into the environmental tolerances, population dynamics and other aspects of the life history and ecology of the pygmy perch			$6,000	$6,000	$6,000	$18,000
4	Conduct genetic research to establish the degree of isolation between populations and factors influencing dispersal of the pygmy perch		$130,000	$15,000	$15,000		$160,000
5	Monitor populations of gambusia and other exotic or native introduced fish species within or near waterbodies occupied by pygmy perch, and implement measures to reduce their impacts		$20,000	$10,000	$10,000	$10,000	$50,000
6	Study interactions between gambusia and pygmy perch to better establish the degree of threat posed by gambusia	N/A in Yrs 1-5					
6.2	**Compliance and regulatory activities**						
7	Provide information to Councils, agencies and other relevant organisations to support appropriate planning and impact assessment			$20,000	$10,000		$30,000
8	Investigate and implement options for providing increased protection for key areas of pygmy perch habitat		$60,000				$60,000
9	Ensure compliance with the ban on collecting through communication with aquarium enthusiasts	$2,000	$2,000	$2,000	$2,000	$2,000	$10,000
6.3	**Management activities**						
10	Develop an education program to increase community awareness of pygmy perch (both in urban and rural areas) and encourage community involvement	$16,000	$16,000	$16,000	$16,000	$16,000	$80,000

No:	Action Title	Estimated Cost/yr					Total Cost
		Year 1	Year 2	Year 3	Year 4	Year 5	
11	Manage pygmy perch habitats occurring on national park estate			$12,000	$12,000	$12,000	$36,000
12	Minimise the impacts on pygmy perch habitats from current and future urban development, agriculture and forestry	$12,000	$12,000	$12,000	$12,000	$12,000	$60,000
13	Identify and restore degraded pygmy perch habitats				$100,000	$20,000	$120,000
14	Investigate options for managing existing gambusia populations and preventing their spread to other areas	N/A in yrs 1-5					$0
15	Develop and implement a public education program on identifying undesirable species and encourage reporting		$20,000	$10,000	$4,000	$4,000	$38,000
16	Develop cooperative threatened species survey and sighting programs	$6,000	$6,000	$6,000	$6,000	$6,000	$30,000
17	Establish a long-term monitoring program to assess the ongoing status of pygmy perch and the effectiveness of recovery actions			$60,000			$60,000
	TOTALS	$72,000	$302,000	$191,000	$369,000	$168,000	1118000

NOTE:

- Costs are indicative estimates only.
- Actual expenditure will be reported in the recovery statements during the term of the recovery plan.