Advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee (the Committee) on an Amendment to the List of Key Threatening Processes under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

1. Name and description of the key threatening process

1.1 Title of the process

The introduction in Australian inland waters of native or non-native fish that are outside their natural geographic distribution.

1.2 Description of the process

The introduction of non-native or native fish outside their natural ranges is one of the major conservation issues in inland aquatic environments. Regional differences in fish communities are decreasing as non-native species become established and native species decline and, in some cases, become locally extinct (Rahel, 2002). Worldwide, six areas have been identified as invasion 'hotspots', including southern Australia and New Zealand. In these hotspots, non-native fish represent more than a quarter of the total number of fish species (Leprieur et al., 2008). Approximately 8% of Australia's freshwater fish species are threatened with extinction and 25% have significantly declined in distribution or occur in restricted areas (Wager and Jackson, 1993).

In Australia, 43 non-native freshwater fish species occur in the wild and, of these, 34 have established populations (Koehn and McKenzie, 2004; Lintermans, 2004). One additional species, rosy barb (*Puntius conchonius*) is now established in northern and western Australia (Corfield et al., 2008). Five of the species established in Australia were nominated by the International Union for Conservation of Nature (IUCN) as among the world's 100 most invasive species (Lowe et al., 2000). These are: carp (*Cyprinus carpio*), Mozambique tilapia (*Oreochromis mossambicus*), eastern gambusia (*Gambusia holbrooki*), rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). There are also at least 53 native species in Australia that have been introduced outside their natural geographic distribution (Lintermans, 2004).

There are several pathways that lead to the introduction of native and non-native freshwater fish species. Lintermans (2004) identifies the following human-assisted mechanisms for the introduction, legal or otherwise, of native and non-native freshwater fish species in Australia:

- Discarding of aquarium fish;
- Escape from aquaculture facilities;
- Deliberate introductions for pest control;
- Deliberate legal or illegal stocking;
- Contaminants from fish stocking;
- Bait bucket introductions;
- Transfers via water diversions;
- Escape from ponds and dams;
- Transfer on commercial fishing gear;
- Deliberate release for cultural ceremonies and
- Contaminants of ballast water in coastal and international shipping.

Of the 35 non-native species established in fresh waters in Australia, 23 were introduced through aquarium releases (Lintermans, 2004; Corfield et al., 2008). Millions of ornamental fish are kept in aquaria in homes and workplaces around Australia. In 2005 alone, over 15.5 million ornamental fish were imported into Australia, 97% of these being freshwater species (Bureau of Rural Sciences, 2007). Of the remaining 12 species established in Australian waters, eight were introduced by acclimatisation societies, one by aquaculture, one for bio-control and two from ballast water (Lintermans, 2004). These introductions are summarised in Table 1.

Table 1. Non-native fish species with established populations in Australia and reasons for their introduction (Allen et al., 2002; adapted from Lintermans, 2004).

Family and Species	**Common Name**	**Reason**	**Year of Introduction**[1]
Cichlidae			
Aequidens pulcher	blue acara	Aquarium	2000
Amphilophus labiatus	red devil	Aquarium	1992
Amphilophus citrinellus	midas cichlid	Aquarium	1992
Astronotus ocellatus	oscar	Aquarium	1998
Archocentrus nigrofasciatus	convict cichlid	Aquarium	1978
Cichlasoma trimaculatum	three-spot cichlid	Aquarium	1998
Cichlasoma octofasciatum	jack dempsey	Aquarium	2004
Haplochromis burtoni	victoria burtons haplochromis	Aquarium	1998
Hemichromis bimaculatus	jewel cichlid	Aquarium	2000
Labeotropheus/Pseudotropheus cross	hybrid cichlid	Aquarium	2001
Oreochromis mossambicus	Mozambique tilapia	Aquarium	1970s
Tilapia mariae	black mangrove cichlid	Aquarium	1978
Tilapia zillii	redbelly tilapia	Aquarium	1980s
Belontiidae			
Trichogaster trichopterus	three-spot gourami	Aquarium	c. 2000
Cobitidae			
Misgurnus anguillicaudatus	oriental weatherloach	Aquarium	1984
Cyprinidae			
Carassius auratus	goldfish	Aquarium	1876
Cyprinus carpio	carp	Aquaculture	1850-80
Puntius conchonius	rosy barb	Aquarium	1970s
Rutilus rutilus	roach	Acclimatisation	1860-80
Tinca tinca	tench	Acclimatisation	1876
Tanichthys albonubes	white cloud mountain minnow	Aquarium	2003
Percidae			
Perca fluviatilis	redfin perch	Acclimatisation	1862
Poecilidae			
Gambusia holbrooki	eastern gambusia	Bio-control	1925
Phalloceros caudimaculatus	one-spot livebearer	Aquarium	1970s

[1] Year of major/initial introduction or first record from the wild

Poecilia latipinna	sailfin molly	Aquarium	1969
Poecilia reticulata	guppy	Aquarium	1970s
Xiphophorus hellerii	green swordtail	Aquarium	1965
Xiphophorus maculatus	platy	Aquarium	1970s
Salmonidae			
Oncorhynchus mykiss	rainbow trout	Acclimatisation	1894
Oncorhynchus tshawytscha	quinnat salmon	Acclimatisation	c. 1910
Salvelinus fontinalis	brook trout	Acclimatisation	1883
Salmo salar	Atlantic salmon	Acclimatisation	1963
Salmo trutta	brown trout	Acclimatisation	1864
Gobiidae			
Acanthogobius flavimanus	yellowfin goby	Ballast water	1971
Acentrogobius pflaumii	streaked goby	Ballast water	1996

Moyle and Marchetti (2006) observed that a number of factors increase the probability of an introduced species being successful. These include: a history of successful establishment outside the species' natural range, characteristics that promote success at multiple stages of the invasion process (for example, wide physiological tolerances), introduction into habitat that matches the species' native habitat, introduction into a region with comparatively high fish species richness (including other introduced species) and introduction of many (100 or more) individuals at a time.

The threatening process concerns the impacts of introduced native and non-native freshwater fish species on Australian native species and ecological communities. It does not include the introduction of native fish species for the purpose of conservation (for example, section on Swan galaxias on page 12). It is recognised, however, that the introduction of native fish species for conservation purposes must be preceded by a comprehensive risk assessment to prevent adverse impacts on the receiving environment.

<u>1.3 Threats to native species</u>

The Committee considers that introduced fish have had, and are continuing to have, adverse impacts on a number of native fish species. This includes native species of blackfish, blue-eyes, cod, galaxioids, gobies, gudgeons, perches, pygmy perches, rainbowfish, and freshwater catfish. Several frog species are also impacted by introduced fish, including the threatened *Litoria nannotis* (waterfall frog) *L. rheocola* (common mistfrog), *L. spenceri* (spotted tree frog) and *L. aurea* (green and golden bell frog) (Morgan and Buttermer, 1996; White and Pike, 1996; Gillespie, 2001; 2009 in press; Burrows, 2004).

Native and non-native introduced freshwater fish can impact upon endemic native species through predation and competition, introduction of disease, ecosystem alterations and genetic effects.

1.3.1 Predation and Competition

Some introduced fish species prey on native animals, including aquatic insects, small fish, amphibian eggs and tadpoles, and crustaceans (e.g. Barlow et al., 1987; Sanger and Fulton, 1991; Raadik, 1995; Morgan and Buttemer, 1996; Howe et al., 1997; Koehn et al., 2000; Gillespie, 2001; Morgan et al., 2002). In particular, predation by brown trout and rainbow trout has seriously impacted the family Galaxiidae and *Gadopsis marmoratus* (River Blackfish) (Jackson, 1978; McDowall, 2006; Stuart-Smith et al., 2008).

Competition can occur through one species establishing a territory and physically excluding the other species or by both species sharing a resource that is limited (Fletcher, 1986). Introduced fish compete with native fish for food and habitat resources. For example, the decline of the *Galaxias pedderensis* (Pedder galaxias) following inundation of Lake Pedder was likely to be caused by a combination of predation and competition by brown trout and the native *Galaxias brevipinnis* (climbing Galaxias) (TSSC, 2005).

The Committee notes that further research is required to fully document the impacts of predation and competition by introduced native and non-native fish on native endemic species.

1.3.2 Introduction of diseases

The introduction of diseases and parasites through introduced native and non-native species may pose a significant threat to local fish populations. Live aquarium fish are the greatest risk group for introducing aquatic animal diseases in Australia (Corfield et al., 2008). Corfield et al. (2008) reviewed the environmental impacts of introduced ornamental fish in Australia, including the impacts associated with the spread of parasites and pathogens, and showed that 21 ornamental fish species harboured disease agents alien to Australia.

Key examples include:

- Aquarium fish led to the spread of the goldfish ulcer disease that was introduced into Australia via infected goldfish, and which subsequently spread to native fish such as *Bidyanus bidyanus* (silver perch) (Corfield et al., 2008).
- Lernaea (*Lernaea cyprinacea*) is an introduced parasite that burrows into the fins of infected fish, or in finely-scaled species, into the skin itself. Carp and introduced trout are effective vectors of the parasite. Recreational anglers and fish researchers have noted heavy infestations of native fish by lernaea, particularly the EPBC Act listed species, *Maccullochella peelii peelii* (Murray cod) and *Macquaria australasica* (Macquarie Perch). Lernaea infestations may be a significant source of mortality for native fish species. Ebner (2006) documented sub-adult Murray cod killed by heavy lernaea infestation, and Bond (2004) documented reduced swimming performance in *Galaxias olidus* (mountain galaxias), followed by death of all specimens, in a study in experimental aquaria.
- Introduced fish are also the source of the Asian fish tapeworm (*Bothriocephalus acheilognathi*), which has caused substantial mortalities in *Hypseleotris klunzingeri* (Western carp gudgeon) in the Canberra region (Dove et al., 1997). As with lernaea, this parasite has the potential to be a significant source of mortality for native fish species.
- Introduced redfin perch are the main host for Australia's first recorded finfish virus, the Epizootic Haematopoietic Necrosis Virus (EHNV) (Langdon et al., 1986; Whittington and Reddacliff, 1995; Reddacliff and Whittington, 1996; Whittington et al., 1996). EHNV is highly pathogenic to a number of native species, including Macquarie perch, mountain galaxias and silver perch (Langdon, 1989).

1.3.3 Ecosystem modifications

The ability to modify habitats and ecosystems is a trait of many invasive species (Bomford, cited in Koehn, 2004). In particular, carp can destroy or reduce the value of habitat for native fish by increasing turbidity and destroying aquatic plant beds (Roberts et al., 1995; Harris and Schiller, 2001). Introduced fish may lead to changes in algal abundance, leaf litter abundance and water quality (Burrows, 2004).

1.3.4 Genetic effects

The introduction of native or non-native fish species may lead to hybridisation with closely related local native fish species (Moyle, 1976). Non-native fish species established in Australia are not from the same taxonomic families as native fish, and therefore hybridisation is extremely unlikely to occur (Fletcher, 1986; Arthington, 1991). However, introduced native fish can hybridise with endemic native species, leading to reduced genetic fitness and hence viability of endemic native fish populations. Introductions of Murray cod into the Clarence River in northern New South Wales pose a substantial threat to the endangered endemic eastern freshwater cod (*Maccullochella ikei*) (Rowland, 1993). An experimental programme of cross-breeding Murray cod and eastern freshwater cod in a hatchery produced few viable eggs and an extremely high proportion of physically deformed larvae (Rowland, 1993).

There are a number of other native fish species that could be affected by hybridisation if related species are introduced into their range. For example, introductions of silver perch from the Murray-Darling Basin into the Lake Eyre Basin could lead to adverse genetic impacts on *Bidyanus welchi* (Welch's grunter) (NSW DPI, 2006).

<u>1.4 Listing status under State and Territory legislation</u>

Victoria
'The deliberate or accidental introduction of live fish into public or private waters within a Victorian river catchment, in which the taxon to which the fish belongs cannot reliably be inferred to have been present prior to the year 1770 AD' is listed as a Key Threatening Process under the Victorian *Flora and Fauna Guarantee Act 1988*.

New South Wales
'The introduction of fish to fresh waters within a river catchment outside their natural range' is listed as a Key Threatening Process under the NSW *Fisheries Management Act, 1994*.
'Predation by the plague minnow *(Gambusia holbrooki)*' is listed as a Key Threatening Process under the NSW *Threatened Species Conservation Act, 1995*.

2. How judged by the Committee in relation to the EPBC Act criteria

Section 188(4) of the EPBC Act states:

A threatening process is eligible to be treated as a Key Threatening Process if:
a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent; or
b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment; or
c) it adversely affects 2 or more listed threatened species (other than conservation dependent species) or 2 or more listed threatened ecological communities.

A. Could the threatening process cause a native species or an ecological community to become eligible for listing as Extinct, Extinct in the Wild, Critically Endangered, Endangered or Vulnerable?

There are a number of species not listed as 'threatened' under the EPBC Act that are likely to be negatively impacted by introduced fish. However, there are currently insufficient data available to enable quantitative assessment of the impacts on most of these species against this criterion. There is however, evidence that the threatening process could cause *Ambassis agassizii* (olive perchlet), *Galaxias olidus* (mountain galaxias) and *Nannoperca vittata* (western pygmy perch) to become eligible for listing as threatened. This evidence is presented below.

Ambassis agassizii (olive perchlet)

This species' eligibility for listing under the EPBC Act can be assessed using relevant criteria set out in the Environment Protection and Biodiversity Conservation Regulations 2000. The species would be considered to be 'vulnerable' if it met any one of the criteria set out in the regulations. The following criterion is relevant in the case of olive perchlet: 'It has undergone, is suspected to have undergone or is likely to undergo in the immediate future, a substantial reduction in numbers'.

The olive perchlet (also known as Agassiz's glassfish) is historically known from the Murray-Darling system in South Australia, Victoria, western New South Wales and southern Queensland. The species is also known from coastal drainages of New South Wales and Queensland between Lake Hiawatha (NSW) and the Mowbray River (QLD) (Allen, 1996; Allen et al., 2002).

The olive perchlet has declined in geographic distribution in most of the Murray-Darling Basin (Lintermans, 2007). It is now extinct in Victoria and only known from a single translocated population in South Australia (Morris et al., 2001; Lintermans, 2007). In New South Wales, previously recorded populations of the olive perchlet are now likely to be locally extinct (Gilligan, 2005). The species is still present in coastal streams from northern NSW to north Queensland (Lintermans, 2007).

Significant factors in the species' decline in the Murray-Darling Basin are predation by introduced fish, particularly eastern gambusia and redfin perch, cold water pollution that restricts spawning, habitat degradation and rapid fluctuations in water levels resulting from river regulation (Lintermans, 2007).
One introduced fish species, carp, accounts for 58% of the total fish biomass across the Murray-Darling Basin, and in some rivers more than 90% of the total fish biomass (Native Fish Strategy for the Murray-Darling Basin, 2003; Davies et al., 2008). Carp are known to destroy aquatic vegetation through dislodging plants during foraging (Roberts et al., 1995). The olive perchlet inhabits the vegetated edges of rivers, creeks and swamps, and appears to be heavily reliant upon aquatic vegetation for cover (Allen and Burgess, 1990; Moffat and Voller, 2002). The species also uses aquatic vegetation as shelter in which to release its eggs, which then attach to vegetation and rocks (Morris et al., 2000, Lintermans, 2007). Destruction of vegetation by carp is likely to have a significant negative impact on the olive perchlet (Koehn 2004).

The Murrumbidgee catchment was invaded by carp in 1972. Although other threats may also have been impacting on the olive perchlet, the invasion of carp closely coincided with the olive perchlet's shift from being relatively common to locally extinct in many parts of the catchment (Gilligan, 2005). Gilligan (2005) states that carp are "likely to be the principal, or at least a major factor" in the species' decline in the catchment. Given the high biomass of carp in the Murray-Darling Basin, habitat degradation caused by carp is also likely to be impacting on the olive perchlet in other parts of the Murray-Darling Basin.

Future declines in population size and geographic distribution are likely if introduced fish continue to expand into the olive perchlet's habitat. Koehn (2004) noted that there is still potential for carp to expand their range.

Carp impact on the olive perchlet by destroying habitat required for shelter and reproduction. Local extinctions in the Murrumbidgee catchment are attributed to the impacts of carp and it is likely that they have contributed to the species' decline in geographic distribution throughout the Basin. However, there are a number of threats impacting on the olive perchlet and the current evidence available on the role of introduced fish in the species' decline tends to be circumstantial.

Summary of assessment: The olive perchlet was historically widespread in the Murray-Darling Basin but its geographic distribution has undergone a significant decline. The Committee considers that this decline is likely to have been accompanied by a commensurate reduction in population numbers. Introduced fish are likely to have been a significant cause of this decline through habitat degradation and predation.

Further, the decline in population size may continue due to the continuing threat posed by introduced fish. The level of this threat is not quantified at present but could occur as a result of ongoing expansion of introduced fish distribution, additional expansion as a result of stochastic events (e.g. flood conditions) and through intentional and unintentional human action.
The Committee judges that the ongoing spread of introduced fish in the Murray-Darling Basin and other olive perchlet habitat could cause the olive perchlet to become eligible for listing under the EPBC Act.

Galaxias olidus **(mountain galaxias)**

Mountain galaxias constitutes a species complex that is currently under review (Raadik, pers. comm., 2010.). The review aims to identify and describe any forms that warrant separate species status (Raadik, 2001). For the purpose of this advice, mountain galaxias is treated as a single species.

This species' eligibility for listing under the EPBC Act can be assessed using relevant criteria set out in the Environment Protection and Biodiversity Conservation Regulations 2000. The species would be considered 'vulnerable' if it met any one of the criteria set out in the regulations. Two criteria are relevant:

- 'It has undergone, is suspected to have undergone or is likely to undergo in the immediate future, a substantial reduction in numbers'; and,
- 'Its geographic distribution is precarious for the survival of the species and is limited'.

The mountain galaxias occurs from southern Queensland, in tributaries of the upper Darling River system, to eastern South Australia. It is found at moderate to high elevations in rivers draining the Great Dividing Range and associated mountains, and also occurs upstream of Narrandera on the Murrumbidgee River (Morris et al., 2001).

Introduced trout predate on and compete with mountain galaxias for food and habitat resources (Fletcher, 1986; Bishop and Tilzey cited in McDowall 2006). A number of studies have shown that introduced trout have caused a decline in the species' abundance through a reduction in area of occupancy. Trout have also fragmented the species' distribution into a number of small, isolated populations (Cadwallader, Jackson and Williams, Jackson and Davies, Jones et al*.,* Koehn and O'Connor, Lintermans and Rutzou, Lintermans, cited in: Lintermans, 2000). For example, Tilzey (1976) studied the interaction of brown and rainbow trout with mountain galaxias in NSW streams. He found that invasion of a stream containing mountain galaxias by rainbow trout led to the disappearance of mountain galaxias from this location. In the same stream, mountain galaxias still occurred above a waterfall, which presented a natural barrier to trout. The invasion of rainbow trout is likely to have caused the disappearance of the mountain galaxias in the lower section of the stream.

In many rivers, mountain galaxias are now only present in upstream areas inaccessible to trout. Lintermans (2000) found that removal of introduced rainbow trout from a stream in the Australian Capital Territory (ACT) resulted in recolonisation by mountain galaxias*.* In this study, rainbow trout were eradicated from a small section of a creek, upstream of an impassable barrier. Introduced trout were not eradicated downstream from the barrier. Following eradication of the rainbow trout, mountain galaxias naturally recolonised the stream. However, recovery of the mountain galaxias did not occur downstream of the barrier, where introduced trout were still present. The results of this study indicate that recovery of the mountain galaxias in this stream was a direct response to the removal of introduced trout. This is consistent with a survey of the lower Cotter River catchment (ACT) in 1990, which found that mountain galaxias only occurred in stream sections where downstream barriers prevented access by introduced trout (Lintermans, 2000).

Future declines in population size and geographic distribution of mountain galaxias are likely if introduced fish continue to expand into the species' remaining habitat. This could cause further fragmentation of existing populations and reduced genetic variability.

The lack of predator-avoidance behaviour in the mountain galaxias is likely to be a major contributor to the decline of this species (Closs, McDowall, Tilzey cited in Lintermans, 2000). Mountain galaxias and brown trout may also compete for food as their diets overlap (Fletcher cited in Fletcher, 1986). Competition for habitat is also possible due to the aggressive, territorial nature of introduced trout (Fletcher, 1986).

There is some evidence that the introduced oriental weatherloach may be responsible for a localised decline of mountain galaxias in part of the Ginninderra Creek catchment in the ACT (Environment ACT, 2002). Oriental weatherloach may affect native species by competing for spawning sites, disturbance or predation of eggs, competition for food and shelter, and alteration of habitat (Lintermans et al., 1990; Environment ACT, 2002).

Oriental weatherloach have a mutually exclusive distribution with the mountain galaxias in Halls Creek, ACT. This may represent exclusion by oriental weatherloach or exploitation of habitat unsuitable to mountain galaxias (Lintermans et al., 1990). The distribution of the oriental weatherloach appears to be expanding (Koster et al., 2005) and its spread into the mountain galaxias' habitat could result in future declines.

Summary of assessment: The mountain galaxias is likely to have previously been extensively and continuously distributed in upland and foothill freshwater habitats within its range. However the species has been adversely affected by predation and competition from introduced fish species.

The Committee considers that the species has undergone a substantial reduction in numbers consistent with a substantial reduction in the area of occupancy. The species is currently confined only to places largely inaccessible to introduced fish. The species is also now severely fragmented into a number of small isolated populations, such as above waterfalls or other impassable barriers.

Further, the decline in population size and geographic distribution may continue and may be precarious for the species' survival if the threat of introduction of non-native fish continues. The level of this threat is not yet quantified but is occurring or could occur as a result of ongoing expansion of introduced fish distribution, additional expansion as a result of stochastic events (e.g. flood conditions) or through intentional and unintentional human action.

The Committee judges that this threatening process could cause the mountain galaxias to become eligible for listing under the EPBC Act.

Nannoperca vittata **(western pygmy perch)**

This species' eligibility for listing under the EPBC Act can be assessed using relevant criteria set out in the Environment Protection and Biodiversity Conservation Regulations 2000. The species would be considered to be 'vulnerable' if it met any one of the criteria set out in the regulations. The following criterion is relevant in the case of western pygmy perch: 'Its geographic distribution is precarious for the survival of the species and is limited'.

The western pygmy perch is endemic to Western Australia where it's known from coastal drainages between the Arrowsmith River north of Perth and the Philipps River east of Albany (Allen et al., 2002). The species is one of the most common and widespread native fishes in the south-west (Allen et al., 2002).

Both eastern gambusia and redfin perch are threats to the western pygmy perch. In tank-based experiments, the presence of eastern gambusia affected the survival of the western pygmy perch through fin-nipping which lead to parasitic and fungal infections (Gill et al., 1997). In the wild, western pygmy perch are unable to co-exist with eastern gambusia in lentic waterbodies that don't contain cover. This is due to an increase in the mortality rate through fin-nipping and competition for food and space (Gill et al., 1997). However, in habitats that contain cover, the species do co-exist (Gill et al., 1997).

Redfin perch is known to predate on the western pygmy perch (Pen and Potter, 1992) and is likely to have eliminated the species from much of the Murray River in Western Australia (Hutchinson, 1991). Hutchinson (1991) found that the two species only co-existed at one of the 17 sites sampled and this site had only been recently invaded at the time of the study. Morgan et al. (2002) found that the western pygmy perch disappeared from the Big Brook Dam of the Warren River shortly after the introduction and proliferation of redfin perch. However, in some situations redfin perch may have little impact on the western pygmy perch, such as in waterbodies where an alternative food source is readily available (Pen and Potter, 1992).

Future declines in, and fragmentation of, the western pygmy perch's geographic distribution may occur due to the impacts of introduced fish. Impacts are likely to be greater in environments lacking cover or where food and space become limited, for example when pools contract in size during summer and autumn (Pen and Potter, 1992).

Summary of assessment: Introduced fish have reduced the abundance of the western pygmy perch in some rivers and changed its distribution through predation, competition and aggressive interactions.

The Committee judges that the ongoing spread of introduced fish into the western pygmy perch's habitat, particularly in combination with other threats, such as degradation of habitat leading to reduced cover and refuges, could cause the species to become eligible for listing under the EPBC Act.

Conclusion for Criterion A: The Committee considers that the threatening process is eligible under this criterion as the process could cause three native species, the olive perchlet, mountain galaxias and western pygmy perch, to become eligible for listing as threatened under the EPBC Act.

B. Could the threatening process cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment?

There are insufficient data available to assess the threatening process against this criterion.

C. Does the threatening process adversely affect two or more listed threatened species (other than conservation dependent species) or two or more listed threatened ecological communities?

As discussed under 'Threats to Native Species', a number of species are impacted upon by this threatening process. The following species, listed as threatened under the EPBC Act, are examples that demonstrate the adverse impacts of introduced fish on threatened Australian native species. These species are being affected by introduced fish primarily through predation, competition and habitat degradation. There are also likely to be additional species listed as threatened under the EPBC Act that are affected by this process.

- *Craterocephalus fluviatilis* (Murray hardyhead)
- *Galaxias fontanus* (Swan galaxias)
- *Galaxias fuscus* (barred galaxias)
- *Galaxias johnstoni* (Clarence galaxias)
- *Litoria aurea* (green and golden bell frog)
- *Litoria booroolongensis* (Booroolong frog)
- *Litoria spenceri* (spotted tree frog)
- *Melanotaenia eachamensis* (Lake Eacham rainbowfish)
- *Scaturiginichthys vermeilipinnis* (redfin blue eye)

***Craterocephalus fluviatilis* (Murray Hardyhead)**

The Murray hardyhead is currently listed as 'vulnerable' under the EPBC Act. The species is endemic to the mid and lower Murray-Darling River system in South Australia, Victoria and New South Wales.

The Murray hardyhead was formerly widespread and abundant, however it has suffered population declines and is now absent from most of its former distribution in the Murray-Darling River system (Ebner and Raadik, 2001; Allen et al., 2002; NSW Fisheries, 2005; Wedderburn et al., 2007, 2008; Backhouse et al., 2008). The species is currently known from approximately 13 populations - nine in South Australia and four in Victoria. As many as 15 populations may have become extinct in the last 50 years (Backhouse et al., 2008).

In NSW, there has been only one report of the Murray hardyhead since 1970 (Harris and Gehrke, 1997). A 2004 survey failed to detect populations of the Murray hardyhead at three locations where they had previously occurred in the Murrumbidgee catchment, and it is highly likely that the species is locally extinct (Gilligan, 2005; NSW Fisheries Scientific Committee, 2006).

The historical decline in the species' distribution and population size has been attributed to the general threats facing native freshwater fish in the Murray-Darling River system. These include increasing salinity, river regulation, decreasing irrigation run-off (to wetlands used as disposal basins), high nutrient levels, acid sulphate soils, environmental contamination, sedimentation, barriers to migration and impacts of introduced fish. The species is now further threatened by many years of extensive dry conditions occurring throughout the Murray-Darling Basin (Backhouse et al., 2008).

Although the precise impact of introduced fish on the species is unknown, its small size, pelagic habit and requirement for aquatic vegetation in which to spawn make it susceptible to predation and habitat degradation (Backhouse et al., 2008). Carp, goldfish, redfin perch and eastern gambusia all currently occur in Murray hardyhead habitat. Predation and competition from carp, redfin perch and eastern gambusia have been identified as threats to the species (NSW Fisheries, 2005; NSW Fisheries Scientific Committee, 2006).

The Murrumbidgee catchment was invaded by Carp in 1972. This is likely to be a major factor in the decline of the Murray Hardyhead in this area. Although other threats may also have been impacting on this species, the invasion of carp closely coincided with the species' shift from being relatively common to locally extinct in many parts of the catchment (Gilligan, 2005). Carp are known to destroy aquatic vegetation, which is required for the Murray hardyhead to spawn and therefore are likely to have contributed to the species' decline. Gilligan (2005) also notes that carp contributed to declines in populations of the olive perchlet (*Ambassis agassizii*), southern purple-spotted gudgeon (*Mogurnda adspersa*) and southern pygmy perch (*Nannoperca australis*) in this area.

Summary of assessment: Introduced fish are very likely to be a cause of decline in the population size and distribution of the Murray hardyhead, with local extinctions common in the river system. The behaviour of carp is likely to have had an adverse impact on the species which is susceptible to predation and habitat degradation.

The Committee judges that this threatening process is adversely affecting the Murray hardyhead.

Galaxias fontanus **(Swan galaxias)**

The Swan galaxias is currently listed as endangered under the EPBC Act. The species is endemic to Tasmania and occurs naturally in the headwaters of the Swan River and tributaries of the upper Macquarie River in eastern Tasmania (Allen et al., 2002; Department of Primary Industries and Water Tasmania, 2006).

Since the 1980s, three natural populations of Swan galaxias have experienced severe declines in numbers and the species now has a severely fragmented distribution throughout its habitat (Sanger and Fulton, 1991; Sanger, 1993). The Swan galaxias is currently known from nine isolated natural populations, occupying a total stream length of 11 km (Department of Primary Industries and Water Tasmania, 2006). The species has also been successfully introduced to several fish-free streams for conservation purposes. These introductions have resulted in nine additional established populations, which occupy a stream length of approximately 30 km (Department of Primary Industries and Water Tasmania, 2006).

The main threat to the Swan galaxias is predation and competition from introduced fish, including brown trout and redfin perch. The decline in population numbers of the Swan galaxias is largely due to invasion of its habitat by these two introduced species (Sanger and Fulton, 1991; Department of Primary Industries and Water Tasmania, 2006). The Swan galaxias' geographic distribution has also been fragmented into isolated populations as a result of introduced fish. The species is unable to co-exist with introduced trout and all natural populations are limited by the presence of brown trout downstream (Sanger and Fulton, 1991; Department of Primary Industries and Water Tasmania, 2006).

The Swan galaxias may also be impacted by the native common jollytail (*Galaxias maculatus*). The native jollytail was recently introduced into the upper Macquarie River and has become a potential threat to Swan galaxias populations in the catchment (Department of Primary Industries and Water Tasmania, 2006). The jollytail has established a large population in the lake and is spreading downstream and into at least one tributary containing Swan galaxias (Jackson, pers. comm., 2006). The jollytail may be able to exclude Swan galaxias through competition for food and habitat, as the Swan galaxias has evolved in the absence of any other galaxias species and the jollytail is possibly a more aggressive species (Jackson, pers. comm., 2006).

Other potential threats to the Swan galaxias include hydrological effects from vegetation clearing and climate change. The species may also be threatened by the construction of water storage infrastructure as this could lead to inundation of habitat, introduction of non-native fish, destruction of barriers that prevent non-native fish invading Swan galaxias habitat, and alteration of flow regimes (Department of Primary Industries and Water Tasmania, 2006).

Summary of assessment: The Swan galaxias has experienced a reduction in numbers and its geographic distribution is severely fragmented. The species is unable to co-exist with some species of introduced fish. Predation and competition by introduced fish are the main reasons for the decline and habitat change of Swan galaxias in Tasmania. These impacts are likely to result in continued reduction in numbers in the future if introduced native and non-native fish invade other areas of the species' distribution.

The Committee judges that this threatening process is adversely affecting the Swan galaxias.

Galaxias fuscus **(barred galaxias)**

The barred galaxias is currently listed as endangered under the EPBC Act. The species is endemic to south-eastern Australia and is restricted to small tributaries of the upper Goulburn, Big and Acheron Rivers, north of the Great Dividing Range in Victoria (Morris et al., 2001).

The barred galaxias has suffered a reduction in numbers over most of its distribution and remaining populations are fragmented. Five populations are presumed to have become extinct since the species was first described in the 1930s (Raadik, 1995). The species is currently known from 12 populations occurring in seven small streams (Lintermans and Raadik, 2003). The main threat to the barred galaxias is predation by introduced brown trout and rainbow trout (Raadik, 1995; Morris et al., 2001; Koehn and Raadik, 2003). Introduced trout have expanded into nearly all existing barred galaxias populations and are continuing to expand further into upstream habitats. This has led to a decline in the species' distribution. There is strong evidence that brown trout and rainbow trout prey directly on adults and juveniles of the species (Raadik, 1995). This threat is exacerbated by the small size and fragmentation of existing populations.

Competition from introduced trout is also considered to be a threat to the barred galaxias. There is evidence that introduced trout compete with the barred galaxias for food and habitat resources (Shirley, cited in Morris et al., 2001).

The barred galaxias may also be threatened by stream sedimentation, reduced runoff to streams and reduced stream shading from the removal of instream cover and vegetation. As known populations are small and isolated they may also be at risk of extinction from catastrophic events such as drought, bushfire and landslides (Department of Sustainability and Environment Victoria, 2006).

Summary of assessment: The barred galaxias has experienced a decline in numbers and its geographic distribution is fragmented across a number of populations due to predation and competition by introduced fish. This decline and fragmentation is likely to continue because introduced fish prey directly on the species and may compete for food and habitat resources.

The Committee judges that this threatening process is adversely affecting the barred galaxias.

Galaxias johnstoni **(Clarence galaxias)**

The Clarence galaxias is currently listed as endangered under the EPBC Act. The species is endemic to Tasmania where it is known from seven populations in small isolated parts of the upper Derwent catchment in the southeastern Central Plateau (Department of Primary Industries and Water Tasmania, 2006).

While the historical distribution of Clarence galaxias is unknown, the species was described in 1936 from Brown Marsh Rivulet (Scott, 1936) in the lower part of the Clarence River catchment. It has not been recorded in this system since that time. Brown trout are now common in Brown Marsh Rivulet and appear to have replaced Clarence galaxias completely (Sanger and Fulton, 1991). Clarence galaxias doesn't occur in any areas containing brown trout. In addition, all populations are limited downstream due to the presence of brown trout or physically unsuitable habitat (Department of Primary Industries and Water Tasmania, 2006).

Brown and rainbow trout are thought to prey on and compete with Clarence galaxias (Crook and Sanger, 1997). Heavy predation on Clarence galaxias by illegally introduced rainbow trout has been observed in Johnsons Lagoon (Department of Primary Industries and Water Tasmania, 2006). Future declines in population size and geographic distribution of Clarence galaxias are likely if brown trout expand into the species' remaining habitat. Other predatory non-native species, such as redfin perch, are also likely to be a threat if introduced into the species' habitat (Department of Primary Industries and Water Tasmania, 2006).

Summary of assessment: Distributional evidence strongly suggests that the distribution and population size of the Clarence galaxias has been adversely affected by introduced fish. The species is unable to co-exist with some species of introduced fish and is threatened by predation and competition. A future decline in population size and geographic distribution may occur if non-native fish expand into the species' remaining habitat.

The Committee judges that this threatening process is adversely affecting the Clarence galaxias.

Litoria aurea **(green and golden bell frog)**

The green and golden bell frog is currently listed as vulnerable under the EPBC Act. The species has been recorded along the south-east coast from East Gippsland in Victoria, to Byron Bay in New South Wales (DEWHA Species Profile, 2008)**.**
The green and golden bell frog was formerly considered to be an extremely abundant species (NSW Department of Environment and Conservation, 2005). Rapid declines in the distribution and abundance of the green and golden bell frog were first noticed in the early 1990s and the species now has only a fragmented distribution throughout this former range (NSW Department of Environment and Conservation, 2005; White and Pyke, 1996). The species is considered to be absent from at least 90% of its historical distribution (Mahony, White, cited in NSW Department of Environment and Conservation, 2005; White and Pyke, 1996). Surveys of populations throughout the distribution of the green and golden bell frog indicate that many populations are small, with most estimates being less than 20 mature individuals (White and Pyke, 1996).

The Draft Recovery Plan for the green and golden bell frog identifies the following factors as possible causes of the species' decline: habitat loss, modification and disturbance, fragmentation and isolation of habitat, predation by introduced fish, disease and water quality (NSW Department of Environment and Conservation, 2005).

The NSW Scientific Committee determined that predation by eastern gambusia is a serious threat to the green and golden bell frog. Eastern gambusia is known to prey upon eggs and tadpoles of the species (Morgan and Buttermer, 1996; White and Pike, 1996). In addition, breeding by the species is almost completely restricted to water bodies where eastern gambusia is absent (NSW Scientific Committee, 1999). In contrast, studies have shown that amphibian tadpoles possess effective survival traits, such as unpalatability, which allow them to coexist with predatory endemic native fish (Kats et al., Hero et al., cited in Gillespie, 2001).

One study found that eastern gambusia significantly reduced tadpole survival in the absence of aquatic vegetation. However, in the presence of aquatic vegetation, the effect was substantially reduced, and no significant impact of eastern gambusia could be detected on the species after three days (Morgan and Buttermer, 1996). These findings indicate that presence of eastern gambusia may significantly affect the survival of tadpoles, but that this is likely to be influenced by habitat structure and tadpole behaviour (NSW National Parks and Wildlife Service, 2003).

Summary of assessment: Introduced fish prey on eggs and tadpoles of the green and golden bell frog; this is likely to have led to a decline in population numbers and fragmentation of the species' distribution.

The Committee judges that this threatening process is adversely affecting the green and golden bell frog.

Litoria booroolongensis **(Booroolong frog)**

The Booroolong Frog is currently listed as endangered under the EPBC Act. It was historically known to occur in catchments within the Northern Tablelands, Central Tablelands and Southern Highlands of eastern Australia, predominantly in western-flowing streams of the Great Dividing Range. There are also several historic records of the species from the eastern slopes of the Great Dividing Range north of Sydney (NSW National Parks and Wildlife Service, 2004).

The Booroolong frog has undergone a severe decline and is no longer present across more than 50% of its former range. Since 1998, surveys have been undertaken to determine the extent and cause of decline in the species. Although no definite causes have been identified, several threatening processes have been proposed as contributing to the decline, including habitat disturbance, the disease *chytridiomycosis*, and predation of tadpoles by introduced fish (TSSC, 2007). Nearly all streams currently occupied by the Booroolong frog are also inhabited by a range of introduced fish including brown and rainbow trout, carp, goldfish, redfin perch and eastern gambusia (Gillespie, 1999, 2000; Hunter and Gillespie, 1999). Research has demonstrated that tadpoles of the Booroolong frog are palatable to introduced trout, redfin perch, eastern gambusia and carp (Hunter 2003, Hunter unpublished data). Providing alternative prey and shelter did not change the tadpole consumption rates for redfin perch, eastern gambusia or carp (Hunter unpublished data). This research also showed that Booroolong frog tadpoles were not palatable to two native fish species, mountain galaxias and two-spined river blackfish (*Gadopsis bispinosus*) (Hunter, 2003, Hunter unpublished data).

It is very likely that introduced non-native fish species are adversely affecting the Booroolong frog throughout its distribution. These impacts may be substantial in areas where this species exists in small populations, along small sections of a stream (Hunter, pers. comm., 2006). In addition to predation by introduced non-native fish, the potential for carp to increase suspended sediment loads in streams is likely to impact on the Booroolong frog by reducing the availability of rock crevices used by this species as sites for laying eggs (Anstis et al., 1998; Hunter, pers. comm., 2006).

Summary of assessment: Introduced fish are a threat to the survival of the Booroolong frog as they have the potential to prey on tadpoles of the species, and alter the habitat. These, together with other threatening processes, has resulted in a severe decline in the species' geographic distribution.

The Committee judges that this threatening process is adversely affecting the Booroolong frog.

Litoria spenceri **(spotted tree frog)**

The spotted tree frog is currently listed as endangered under the EPBC Act. The species is confined predominantly to the north-west side of the Great Dividing Range between the Central Highlands in Victoria and Mt Kosciuszko in New South Wales (Gillespie and Hollis, 1996).

The spotted tree frog is currently known from 13 populations, many of which are small and restricted to relatively short sections of streams (Robertson and Gillespie, 1998). Extensive surveys of the species' distribution and abundance have revealed that the spotted tree frog suffered significant reductions in numbers in the 1970s and early 1980s (Watson et al., 1991;

Robertson and Gillespie, 1998). Surveys undertaken in 1996 failed to locate the species at four streams where it had previously been recorded. These surveys also failed to detect the spotted tree frog at sites on a further four streams where it had been previously recorded, but located the species elsewhere along those streams (Gillespie and Hollis, 1996). In 1996, a population at Bogong Creek suffered a major decline to extremely small numbers, possibly as the result of severe flooding or disease (Gillespie and Hines, 1999).

Threats that have been implicated in the decline of the spotted tree frog involve disturbance to streams and in catchments of streams (Gillespie and Hollis, 1996). This includes: timber harvesting, eductor dredging, human disturbance, weed invasion, predation by exotic animals (including introduced non-native fish), impoundments, herbicides, inappropriate fire regimes and possibly grazing (Robertson and Gillespie, 1998).

Gillespie (2001) examined the role of introduced trout in the decline in numbers and population fragmentation of the spotted tree frog and found that the species is susceptible to predation from brown trout and rainbow trout. The study showed that in a stream pool experiment, the presence of rainbow trout significantly reduced survival of tadpoles of the spotted tree frog (Gillespie, 2001). In contrast, native fish species that were capable of preying on tadpoles ate very few of this species. This suggests that tadpoles of the spotted tree frog may be unpalatable to native fish species with overlapping distributions (Gillespie, 2001).

The impact of introduced trout predation on developing tadpole survival is expected to be far greater in natural habitats than that observed in the stream pool experiment (Gillespie, 2001). Introduced trout may not directly eliminate the spotted tree frog, but do reduce recruitment levels or restrict populations to certain sections of streams, causing fragmentation and reducing population size (Gillespie, 2001). The distribution of the spotted tree frog in relation to introduced trout, along with differences in age-specific survival between populations, provides evidence of the predatory impact of non-native fish on this species (Gillespie, 2001; 2010).

At lower altitudes the species may also be subject to predation by redfin perch, carp and eastern gambusia (Harris, 1999).

Summary of assessment: Introduced fish are predators of spotted tree frog tadpoles and there is documented evidence of their adverse impact on recruitment success. They may also contribute to the fragmentation of populations. It is likely that introduced fish have contributed to a significant decline in numbers and the fragmentation of populations.

The Committee judges that this threatening process is adversely affecting the spotted tree frog.

Melanotaenia eachamensis **(Lake Eacham rainbowfish)**

The Lake Eacham rainbowfish is currently listed as endangered under the EPBC Act. The species was originally thought to occur only in Lake Eacham on the Atherton Tablelands in North Queensland. The species was abundant in this location in the 1970s, but became locally extinct by 1987. Additional natural populations have since been found at other locations on the Atherton Tablelands between the Barron and South Johnstone river systems (Allen et al., 2002).

Barlow et al. (1987) found that the fish fauna in Lake Eacham changed significantly between 1983 and 1987. A number of native species, including the Lake Eacham rainbowfish, underwent a decline in numbers during this period. These declines occurred as populations of introduced native species including the mouth almighty (*Glossamia aprion*), banded grunter (*Amniataba perciodes*), archer fish (*Toxotes chatareus*) and bony herring (*Nematalosa erebi*) became established in the lake. Although the exact timing of these introductions is unknown, the mouth almighty was first observed in the lake in 1983, the archer fish and the bony herring in 1984, and the banded grunter in 1987 (Barlow et al., 1987).

The local extinction of the Lake Eacham rainbowfish was primarily due to interaction with introduced native species, in particular, predation by the mouth almighty (Barlow et al., 1987). Further, the dietary habits of the introduced native species (apart from the bony herring) suggest that they contributed to the decline of the Lake Eacham rainbowfish by predation (Barlow et al. 1987).

Summary of assessment: Predation by introduced native fish is likely to be a significant factor in the local extinction of the Lake Eacham rainbowfish in Lake Eacham. Extant populations of the species could also be adversely impacted by introduced fish.

The Committee judges that this threatening process is adversely affecting the Lake Eacham rainbowfish.

Scaturiginichthys vermeilipinnis (redfin blue eye)

The redfin blue eye is currently listed as endangered under the EPBC Act. The species is endemic to Queensland, where it is restricted to Edgbaston Springs north of Aramac. These springs are a single complex emanating from the Great Artesian Basin (Fairfax et al., 2007).

The redfin blue eye has been recorded as naturally occurring in eight separate springs (Wager, 1994). The species has suffered a decline in area of occupancy since its discovery in 1990, with five populations becoming extinct (Wager, 1994; Fairfax et al., 2007). In 2006, the species was known from five populations occurring in four springs, two of which were naturally recolonised following previous extirpations (Fairfax et al., 2007). Attempts to translocate the species to springs elsewhere within the complex have failed. Changes in water flow to the springs may have caused these failures (Fairfax et al. 2007).

Eastern gambusia is likely to be a significant threat to the redfin blue eye in the wild and is implicated in the local extirpation of redfin blue eye populations (Wager and Unmack, 2004; Fairfax et al., 2007). In 2006, eastern gambusia was present in four of the five springs where redfin blue eye populations had been extirpated. Four out of the five remaining subpopulations of the species occured in springs that were free from eastern gambusia (Fairfax et al., 2007). Although there was evidence of spatial separation within the spring pool where the species co-occurred, they are forced together when seasonal extremes affect spring size and water temperature (Wager, 1994: Fairfax et al., 2007) and redfin blue eyes have recently become locally extinct in the last pool where they co-existed with eastern gambusia (Fensham personal communication).

Eastern gambusia has been observed nipping the tail fins of redfin blue eyes (Unmack and Brumley, 1991; Wager, 1994). This occurs particularly where eastern gambusia are larger than redfin blue eyes (Wager, 1994). Wager (1994) attributed the absence of juvenile redfin blue eyes in one spring to predation of eggs or fry by eastern gambusia. Domestic stock, feral goats and pigs that utilise the springs and can negatively affect water quality and flow patterns are likely to intensify the impact of eastern gambusia. Water levels and flow have also declined due to the construction of artesian bores (Faifax et al., 2007) and this is likely to negatively affect the species.

Summary of assessment: The redfin blue eye has experienced a decline in area of occupancy associated with the extinction of populations from several springs. Adverse impacts from introduced fish are likely to be a significant factor in these extinctions. These impacts include aggressive interactions (fin nipping) and possibly predation on the eggs or fry of redfin blue eyes. Redfin blue eyes now exist only in pools that have not yet been reached by eastern gambusia.

The Committee judges that this threatening process is adversely affecting the redfin blue eye.

Conclusion for Criterion C: The Committee considers that the threatening process is **eligible** under this criterion as the process is adversely affecting population numbers and geographic distribution of at least nine listed threatened species, primarily through predation, competition and habitat degradation.

CONCLUSION: The threatening process does not meet s188(4)(b) of the EPBC Act. However, the threatening process does meet s188(4)(a) and s188(4)(c) of the EPBC Act, and is therefore **eligible** to be listed as a Key Threatening Process.

3. Threat Abatement Plan Recommendation

Degree of threat

Thirty five non-native species are established in Australian freshwaters and at least 53 Australian native species have been introduced outside their natural geographic distribution. These introductions have resulted in adverse impacts on a number of fish and frog species, including many listed as threatened under the EPBC Act. Native species, such as the Murray hardyhead, have experienced both a reduction in numbers and local extinctions of populations. Some species, including the mountain galaxias, are no longer found in rivers where they previously occurred and have undergone a decline in geographic distribution. This is largely a result of predation, competition and degradation of habitat by introduced fish. The impacts of disease and hybridisation have also contributed to declines in some cases.

Potential of threatened species and ecosystems to recover

The threats posed by introduced native and non-native fish can be controlled by preventing further spread into new habitats, eradication of introduced fish and rehabilitation of ecosystems. Threatened species have the ability to recover from the impacts of introduced fish in Australia. Local eradications of introduced fish have led to re-colonisation of habitats by native endemic species. Some species, such as the Swan galaxias, have been successfully introduced to new streams for conservation purposes.

Threat abatement actions

The table below outlines areas for threat abatement, initiatives underway in each area and options for implementing additional actions. This has been developed to highlight areas where the development of a Threat Abatement Plan could assist in implementing actions.

1. Policy Coordination

Threat abatement area	Current initiatives	Recommended (additional) action
a. An aligned legislative framework for preventing and controlling the introduction of freshwater fish would assist in a coordinated approach to management across jurisdictions.	Agreement has been reached via the Vertebrate Pests Committee Pest Fish Working Group on an interim list of significant pest fish. The Pest Fish Working Group are taking the lead on developing a comprehensive strategy to address this issue including policy, surveillance, control plans, research,	Specific legislative changes would need to be undertaken by individual states and territories to achieve an aligned legislative framework in this area. This would not be aided by a TAP.

Threat abatement area	Current initiatives	Recommended (additional) action
	species prioritisation, response, communication and resourcing.	
b. Define key biodiversity assets - Introduced fish in many cases are well established and eradication is not feasible at all sites. Therefore, action should focus on achieving an outcome of protecting native species and ecological communities while acknowledging the need to focus on gaining maximum benefit possible with limited resources. This may be achieved by determining which inland waters are key to the native species impacted by this Key Threatening Process, then developing management plans (including monitoring) for introduced species at each identified water body.	State and Territory Government fish stocking policy/plans recognise some inland waters as important for native species.	There is potential for additional action to be undertaken through existing mechanisms including the Pest Fish Working Group and by encouraging further consideration of protecting the identified key inland waters in state and territory fish stocking policy/plans. A voluntary review could be undertaken of current state and territory strategies related to stocking and/or a national policy could be developed for adoption by state and territory jurisdictions. These actions would not be aided by a TAP.

2. Prevention

Threat abatement area	Current initiatives	Recommended (additional) action
a. Prevent the entry of certain live fish to Australia - Entry of live fish to Australia, especially aquarium species, via the large permitted live fish list under the *EPBC Act 1999* and *Quarantine Act 1908* heightens the risk of new introductions to inland waters.	The Ornamental Fish Management Implementation Group (OFMIG), under the Natural Resource Management Ministerial Council, has developed an agreed list of high-risk noxious aquarium species. A 'grey' list has also been developed that requires further scientific investigation to determine if they should be added to, or exempt from, the national noxious species list. A process is in place to assess these 'grey' list species.	No additional actions are recommended. Therefore, a TAP is not required to address this area.
b. Educate the public about introduced fish	Currently the OFMIG is developing a	The Australian Government can assist

Threat abatement area	Current initiatives	Recommended (additional) action
(both non-natives and natives outside their natural range) to try to stop introductions (other than approved stocking) in designated sites. Develop and disseminate public education material about the potential for introductions of introduced fish via dumping unwanted fish, use of introduced fish as live bait and accidental movement.	strategy in consultation with the ornamental fish industry to undertake this education.	with public education through website promotion and sharing information with other stakeholders such as the Vertebrate Pests Committee. The Pest Fish Working Group could consider augmenting the OFMIG strategy to cover non-ornamental species. As this is underway, a TAP is not required to undertake this action.

3. Early Warning and Rapid Response

Threat abatement area	Current initiatives	Recommended (additional) action
a. Develop and disseminate public education material and guidelines for encouraging passive monitoring for new incursions and a protocol to follow in the event of a suspected incursion. High risk areas that are key for surveillance should be identified.	None identified.	General principles could be developed by the Pest Fishing Working Group under their comprehensive strategy. However, as this is local area information it would need to be undertaken at a state and territory level. This action would not be aided by a TAP.
b. Develop guidelines for the rapid eradication of new incursions of introduced fish or incursions to new areas, determine who would undertake an eradication and seek their in-principle agreement.	None identified.	Principles could be developed and agreed at a national level through the Pest Fish Working Group. Jurisdictions would need to undertake actions in conjunction with the National Environmental Biosecurity Response Agreement for new incursions or to apply these principles at the local management level for incursions to new areas. This action would not be aided by a TAP.

4. Containment and control

Potential abatement actions include exclusion of introduced fish from sites identified key for the conservation of a species. Further discussion of these actions are outlined under section '1. Policy Coordination: Defining key biodiversity assets'.

5. Research and Development

Threat abatement area	Current initiatives	Recommended (additional) action
a. Identify those species that currently impact on a national scale or have the potential to impact on a national scale.	The Australian Government has commissioned the following four reports to identify these species and their impacts: - An overview of the impacts of translocated native fish species in Australia (2008) - Review of the impacts of gambusia, redfin perch, tench, roach, yellowfin goby and streaked goby in Australia (2008) - Review of the impacts of introduced ornamental fish species that have established wild populations in Australia (2008) - Review of the literature on the impacts of introduced salmonids on Australian native freshwater fish (In draft).	Each report identifies priority research requirements which have been compiled into a table of priorities and time frames. These priority research requirements could be circulated to relevant stakeholders. A TAP is not required to undertake this action.
b. Technical information on practical management strategies that can be applied under Australian conditions. An understanding of the level of control and method of control is necessary.	None identified.	On-ground management is the responsibility of individual jurisdictions and the technical requirements will vary across Australia. Individual jurisdictions may need to develop these data, although the collation of technical information for all jurisdictions to use is recommended. This would be best done through the Vertebrate Pests Committee to encourage participation from all jurisdictions. This action will not be aided

Threat abatement area	Current initiatives	Recommended (additional) action
		by a TAP.
c. Risks involved with aquaculture diseases and fish stocking including quality scientific data on impacts on native fish and aquatic communities, population genetic structure, carrying capacity, and monitoring.	None identified.	Specific regulatory changes would need to be undertaken by individual states and territories. This will not be aided by a TAP.
d. Improving the knowledge of the behavioural and biological traits of the introduced species to identify how control actions may be more effectively and efficiently applied.	Carp Hotspots work by the Invasive Animals Cooperative Research Centre has identified a limited number of breeding locations for carp in the Murray Darling Basin.	Additional action could include identifying specific research requirements. This could be done through a TAP.

6. Public Education Awareness and Involvement

Threat abatement area	Current initiatives	Recommended (additional) action
a. Education about established introduced species and what action stakeholders can take for effectively reducing the impact from the introduced species. This action would need to be linked to the identified priority sites (threat abatement area 1b). Provide information on the best methods for reducing the impacts from invasive fish species generally so that action can be effective in the long term.	None identified.	Guidance could be provided through the OFMIG and Pest Fish Working Group, but implementation would need to be undertaken by state and territory governments and local community groups. This action could be guided by a TAP. Scientific information about pest fish impacts could be made available on the DEWHA website and via the OFMIG and Pest Fish Working Group. Links could be established to information held by jurisdictions and research organisations. A TAP is not required to undertake this action.

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CONCLUSION: The preceding analysis shows that while there are some existing initiatives in place to address the threats from this process, there are also a number of additional actions that could be undertaken. However, a national Threat Abatement Plan is not considered to be the most efficient and effective way to undertake these actions. Instead, the Committee recommends that additional actions be implemented through current initiatives, including the Ornamental Fish Management Implementation Group and the Vertebrate Pests Committee Pest Fish Working Group. In addition, the Committee recommends that relevant stakeholders, including recreational fishing groups, should be engaged in these processes.

The Committee has prepared 'Threat Abatement Guidelines' which provide a summary of the Key Threatening Process along with advice on what additional threat abatement actions could be undertaken.

The Committee further recommends that the Australian Government undertake additional actions in line with these 'Threat Abatement Guidelines' and report on the progress of this as part of the five year statutory review on whether to have a Threat Abatement Plan for this Key Threatening Process.

4. Recommendations

The Committee recommends that:

A. The list referred to in section 183 of the EPBC Act be amended by including in the list of Key Threatening Processes: "The introduction of native or non-native fish into Australian inland waters that are outside their natural geographic distribution."

B. A Threat Abatement Plan is not considered a feasible, effective and efficient way to abate the process at this time.

C. The Committee's Threat Abatement Guidelines be considered when undertaking actions in relation to this Key Threatening Process.

D. The Australian Government undertake additional actions in line with these Threat Abatement Guidelines and report on the progress of this as part of the five year statutory review on whether to have a Threat Abatement Plan for this process.

Threatened Species Scientific Committee
24 May 2011

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Terminology used in the advice

Terms used throughout this advice are defined as follows.

Fish	Wholly aquatic vertebrate species with internal gills.
Introduction	The movement, by human agency, of a species outside its natural geographic distribution. This movement can be either within a country or between countries.
Native species	As defined under Section 528 of the EPBC Act.
Non-native species	A species that is not indigenous to Australia or an external Territory.
Natural Geographic Distribution	The distribution in which a species can be reliably inferred to be present prior to the year 1400 AD.
Inland waters	All freshwater and non-marine saline habitats (permanent and ephemeral) that are not estuarine, coastal or oceanic but that include anchialine waters.