

Invasive freshwater fish in New Zealand: DOC's present and future management

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ABSTRACT

New Zealand's freshwater ecosystems and biodiversity are subject to a number of threats, including invasion by exotic species. Twenty-one species of freshwater fish have been introduced to New Zealand and have established self-sustaining populations. Some of these freshwater fish pose a significant threat to freshwater biodiversity and have been classified accordingly in the legislation to restrict their distribution. Despite legislative controls that have been in place for the last 10–15 years, these species have generally expanded their ranges in New Zealand, and two species were detected in the South Island for the first time in 2000. Following the identification of koi carp and *Gambusia* in Nelson/Marlborough, the Department of Conservation (DOC) undertook an extensive survey of the area and attempted to eradicate the known *Gambusia* populations using rotenone. This paper discusses the Department's approach to date, and what work is being planned for the future, to manage invasive freshwater fish in New Zealand.

1. INTRODUCTION

New Zealand has many freshwater ecosystems, including more than 70 major river systems and 770 lakes, and at least 73 significant wetlands (Anon. 2000; Cromarty & Scott 1995). These environments provide habitat for a diverse array of indigenous aquatic flora and fauna including 38 endemic species of water plants (Coffey & Clayton 1988), hundreds of native species of aquatic and semi-aquatic invertebrates from 11 orders (Collier 1993; Winterbourn et al. 2000), at least 36 species of freshwater fish (McDowall 2000), and about 34 species of waterbirds (M. Williams pers comm.) that utilise freshwater ecosystems for at least part of the life cycle.

New Zealand's freshwater ecosystems are subject to a number of impacts including hydrological modification and drainage, pollution and sedimentation, nutrient enrichment, deforestation, abstraction, and invasion. Human activity has resulted in the drainage of c. 90% of New Zealand's wetlands, alteration of catchments affecting about half of the length of New Zealand's rivers, and the introduction of more than 228 species of alien aquatic plants and animals (Collier 1994).

The Resource Management Act 1991 provides a comprehensive framework for local and regional authorities to sustainably manage the effects of land and water use on aquatic ecosystems. By comparison, the management of new and existing introduced aquatic species is fragmented amongst several agencies, including DOC, Ministry of Agriculture and Forestry, Ministry of Fisheries, and Fish & Game New Zealand. Inter-agency coordination and policy development will be required to protect indigenous freshwater biodiversity from the impacts of existing introduced species, and prevent the establishment of new invasive aquatic species in New Zealand.

Kohler & Courtenay (undated) recognise a range of impacts that introduced aquatic organisms can have on indigenous aquatic communities including: habitat alteration; trophic and spatial alteration; gene pool deterioration; and transmission of parasites and disease.

2. INVASIVE FRESHWATER FISH

Exotic fish introductions (legal and illegal) to New Zealand have taken place since the 1860s and have resulted in the establishment of 21 species of freshwater fish to the aquatic fauna. An additional species, caudo (*Phalloceros caudimaculatus*) has been reported from stock troughs in Northland, apparently drawn with water from an adjacent stream. To date, the presence of caudo in the wild has not been confirmed, despite repeated searches (McDowall 2000).

Ten of the 21 established introduced fish species are considered to be comparatively low risk as eight species have highly restricted distributions and are considered unlikely to spread beyond their current range, and two species are considered unlikely to breed in New Zealand environments (Rowe & Schipper 1985; Rowe pers. comm.). Therefore, 11 species of exotic freshwater fish that are known to occur in New Zealand have the potential to form self-sustaining populations in other freshwater ecosystems, beyond their present range.

3. MANAGING NEW INTRODUCTIONS

In order to manage the risks that introduced species pose to new environments, it is important to ensure that the risks of introductions on freshwater ecosystems and species are adequately (and explicitly) assessed prior to a species being introduced into a new water body (McDowall 1968; Pearsons & Hopley 1999).

In recognition of the consequences that species introductions may have on aquatic communities, the introduction of all aquatic species (flora and fauna) to new waters requires the approval of the Minister of Conservation under s. 26ZM of the Conservation Act 1987. The introduction of fish and fish eggs to sports fish or game bird habitats requires the approval of the local fish and game council under r. 59 of the Freshwater Fisheries Regulations 1983. The Biosecurity Act 1993 and Hazardous Substances and New Organisms Act 1996 contain additional tools to assist with the management of new incursions of

exotic species and proactive identification of unwanted species for exclusion from New Zealand.

Risk assessments have been carried out for some of the species that have been introduced to New Zealand's fresh waters. These assessments have generally been undertaken prior to species introductions, or immediately after illegal releases have been detected, to determine future management direction. Some assessments have resulted in decisions not to liberate or retain some species in New Zealand waters (e.g. channel catfish, largemouth bass, marron crayfish).

Management recommendations taken from risk assessments of non-salmonid introduced freshwater fish in New Zealand are summarised in Table 1. These risk assessments and management recommendations have formed the basis of species classifications within the current legislative and regulatory framework (Table 2). Since these risk assessments were undertaken in the 1980s, further research has improved our knowledge of the impacts of some fish species on aquatic ecosystems. As a result, concerns now extend to the impacts of rudd and perch on submerged macrophytes (Wells 1999; Dugdale 2000) and indigenous fish (Ludgate & Closs 2000), respectively. Native fish-*Gambusia* interactions have also been studied, and results indicate that *Gambusia* may pose a threat to some threatened native fish species (Rowe 1998; Ling & Willis 1999).

Salmonids have been implicated in the decline of indigenous freshwater fish in New Zealand via competition and predation. These impacts are thought to have resulted in the fragmentation of some native fish populations (McDowall 1968; Townsend & Crowl 1991). Research has also identified that salmonid presence may alter behaviour and habitat use of indigenous species via competitive interactions (McIntosh et al. 1992; McIntosh & Townsend 1994, 1995).

TABLE 1. RECOMMENDATIONS FOR MANAGEMENT OF NON-SALMONIDS IN NEW ZEALAND.

FISH SPECIES	DISTRIBUTION (AT THAT TIME)	CONCERN	RECOMMENDATION	SOURCE
Goldfish	Widespread	Minimal		McDowall (1984)
Guppies	Thermal waters	Minimal		McDowall (1984)
Sailfin molly swordtails	Thermal waters	Minimal		McDowall (1984)
Perch	Widespread in parts of NZ	Impact on trout stocks	Management as acclimatised fish	McDowall (1984)
Tench	Widespread	Minimal	Management as acclimatised fish	McDowall (1984)
Catfish	Lake Taupo, Waikato River, and isolated sites	Nuisance species	Management as acclimatised fish	McDowall (1984)
<i>Gambusia</i>	Widespread north of Waikato	Interactions with small fish	Management as acclimatised fish	McDowall (1984)
Rudd	Widespread north of Waikato	Interfere with trout angling	Avoid spread beyond existing range	McDowall (1984), Cadwallader (1977)
Koi carp	Few self-sustaining wild populations	Impacts on water quality and aquatic habitats	Prevent further spread and eradicate existing populations where practicable	McDowall (1984), Hanchet (1990)
Orfe	Confirmed from 1 pond North of Auckland	Unknown	Consider impacts and eradication possibility. Containment to existing sites	McDowall (1990)

TABLE 2. LEGAL STATUS OF INTRODUCED FISH SPECIES.

SPORTS FISH ¹	NOXIOUS FISH ¹	UNWANTED ORGANISM ²	PROHIBITED ORGANISM ³	RESTRICTED SPECIES ⁴
Brown trout	Koi carp	Koi carp	Stickleback	Silver carp
Rainbow trout	Rudd	Mosquitofish	Any venomous fish	Grass carp
Chinook salmon	Walking catfish	Fish from Esocidae family		
Sockeye salmon	Pike	(e.g. pikes)		
Brook trout	Pirahna species			
Atlantic salmon	Tilapia species			
Lake trout				
Tench				
Perch				
Rudd (Auckland-Waikato only)				

¹ Freshwater Fisheries Regulations 1987.

² Biosecurity Act 1993.

³ HSNO Act 1996.

⁴ Conservation Act 1987.

(Modified from Rowe pers. comm.)

It is acknowledged that salmonids are widespread in New Zealand waters and highly valued in many of these—making a significant contribution to the local and national economy. In recognition of the need to provide for indigenous biodiversity, many authors have emphasised the need to manage new and existing salmonid populations to protect indigenous biodiversity while maintaining high quality sport fishing opportunities. These management recommendations have led to the current Fish & Game New Zealand policy of no new introductions of sports fish to waters where they do not already occur (Anon. 2000).

4. MANAGEMENT OF EXISTING POPULATIONS

In addition to undertaking statutory impact assessments for introductions to new sites, management of existing introduced freshwater fish has generally involved five approaches:

- removal (control or eradication)
- management as a sports fish
- containment
- exclusion
- no management.

Brown trout, rainbow trout, brook trout, lake trout, Atlantic salmon, chinook (or quinnat) salmon, sockeye salmon, perch, tench and rudd (in Auckland-Waikato only) are managed as sports fish in New Zealand. The capture and possession of brown bullhead catfish was originally managed by acclimatisation societies, but catfish are no longer recognised as sports fish. Regional fish and game offices prepare 10-year Sports Fish & Game Management Plans that detail future management priorities for sports fish.

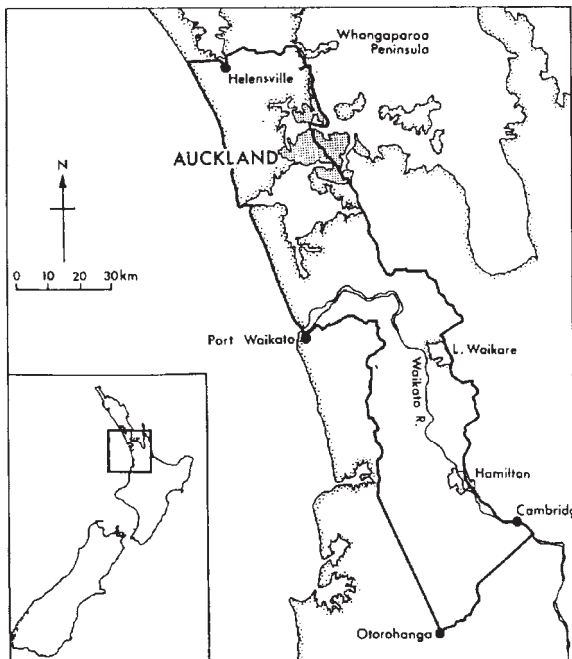


Figure 1. Auckland-Waikato koi carp containment area (Koi carp Containment Area Boundary Notice 1990, NZ Gazette, 11 October 1990, No.176, p. 3808).

To date, there have been relatively few attempts to control or eradicate introduced freshwater fish, as conservation efforts have largely focused on habitat protection for indigenous freshwater fish species, and the management of freshwater protected areas. Conservancies of DOC identify conservation management objectives and priorities within their regions in 10-year Conservation Management Strategies.

A detailed management policy has been developed for only one species of invasive freshwater fish—koi carp. This is because koi carp are widely perceived to be the 'least desirable fish in the New Zealand fish fauna' (McDowall 1990), and they have been largely restricted to the Auckland-Waikato region.

The management goals that have been articulated for koi carp are to:

- prevent further spread of koi
- minimise the impacts of koi on aquatic biota and habitats.

In order to achieve these goals, a containment area has been gazetted (Fig. 1) and live koi carp have been designated as a noxious fish species. Regulations have been established that make the possession of live koi carp illegal (unless permitted). Within the gazetted containment area, recreational fishing is permitted if koi carp are killed immediately on capture, and commercial harvesting of koi carp may be carried out under permit from DOC.

5. RANGE EXPANSION OF INVASIVE FRESHWATER FISH SPECIES

Despite the development of specific management goals for koi carp, previous management recommendations relating to specific fish species, and generic controls on aquatic species introductions to new environments, some undesirable introduced freshwater fish have expanded their ranges in New Zealand (Fig. 2). In March and July 2000, koi carp and *Gambusia* were recorded from the South Island (Motueka) for the first time.

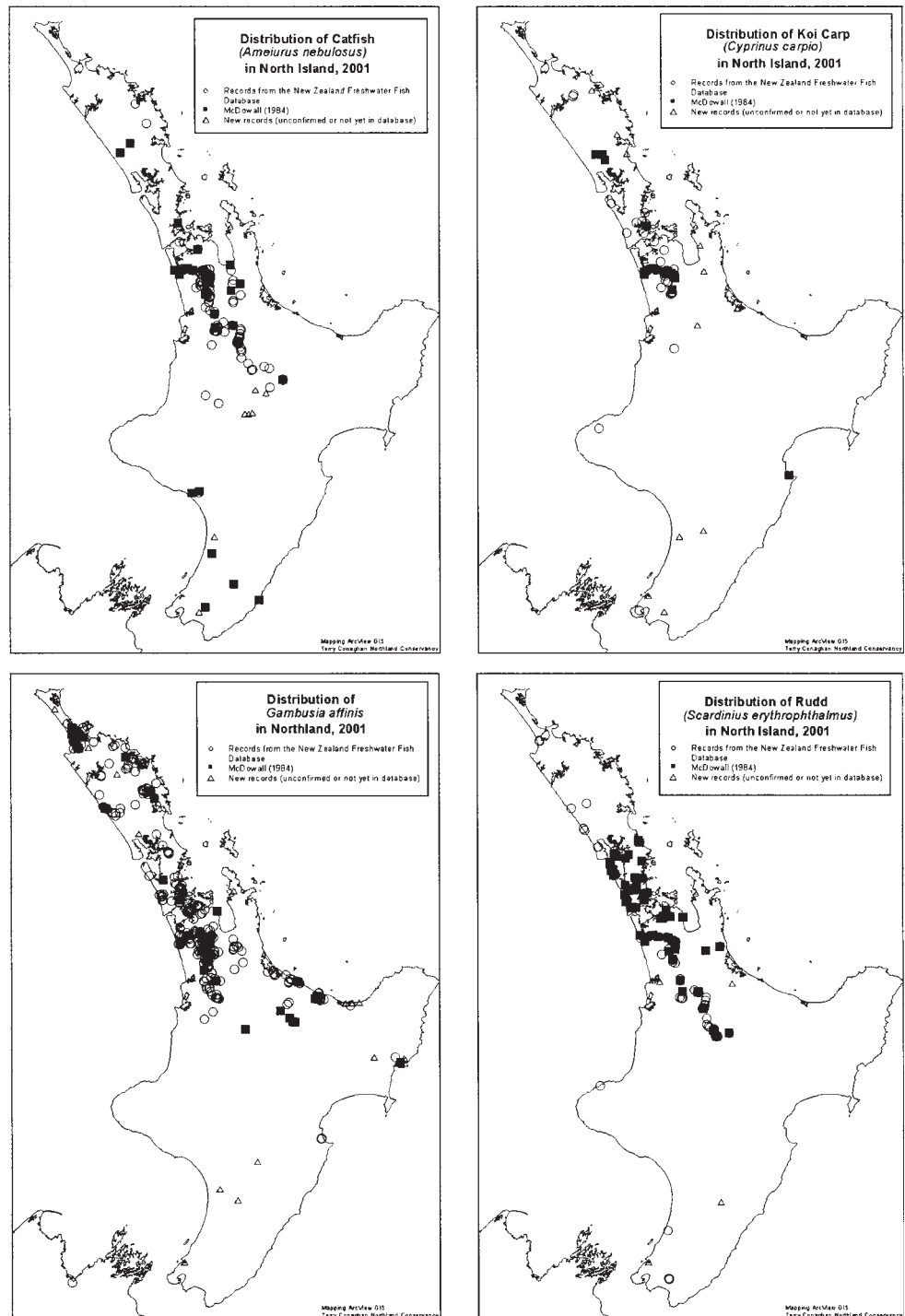
In response to these reports, and in recognition of the threat that koi carp and *Gambusia* pose to South Island fresh waters, DOC declared these species to be unwanted organisms under the Biosecurity Act 1993. 'Unwanted organism' status and the provisions of the Biosecurity Act 1993 provide additional management tools for the future management of koi and *Gambusia*, including penalties for, and restrictions on, the possession, sale, and transmission of these species.

To guide its management response to the incursions, DOC undertook a thorough delimitation survey to establish the distribution of koi carp and *Gambusia* in the Nelson/Marlborough region. A technical working group that included several independent scientists was established to assist the Department formulate its approach to the survey, including survey methodology and data collection.

Figure 2. Range expansion of catfish, koi carp, rudd and *Gambusia* 1984–2001.

Key

- ! Records listed in McDowall (1984).
-) Records from NIWA Freshwater Fisheries Database (as at 30 March 2001).
- + Unconfirmed records and sighting known to DOC staff (as at 30 March 2001).



The survey was conducted between September 2000 and March 2001 and covered a total of 219 water bodies and 54 streams and waterways. *Gambusia* were recorded from 19 sites, one of which also contained koi carp. These populations were almost exclusively found in irrigation ponds within a small area (10-km radius) of Motueka (Shaw & Studholme 2001). One population of *Gambusia* was recorded in a natural stream. In addition to koi carp and *Gambusia*, the surveys identified previously unknown populations of coarse fish in Nelson/Marlborough, including 14 sites with rudd, and 24 sites with tench. A high correlation (89%) between *Gambusia* and coarse fish presence

(particularly tench) was noted, and all sites that contained rudd were also found to contain tench (Shaw & Studholme 2001). It is likely that coarse fish have been established illegally at these sites for recreational fishing. It is possible that *Gambusia* have been introduced intentionally by landowners or coarse fishers as a forage fish for coarse fish, or as a means of controlling invertebrates. They may also have been accidentally transferred during coarse fish introductions.

On the basis of the results of the Nelson/Marlborough delimitation survey, a decision was made to attempt to eradicate the known *Gambusia* populations using powdered rotenone. This decision was based on the restricted distribution of the known populations, and the artificial and confined nature of the sites. The summer drought and extremely low water levels further increased the feasibility of successfully eradicating *Gambusia* from the sites.

In order to apply rotenone to water, DOC obtained appropriate approvals and resource consents from landowners and local authorities. Rotenone was also provisionally registered as a pesticide pursuant to the Vertebrate Pesticide Regulations, which allowed it to be used experimentally at these sites.

Rotenone was applied to 18 of the 19 water bodies known to contain *Gambusia* (including one site with koi carp), at concentrations recommended by Willis & Ling (2000) and Ling (2003). Application was by way of fire hoses for all sites except one, where a helicopter with a spray boom was used (Shaw & Studholme unpubl. data). Initial monitoring suggests that *Gambusia* have been successfully eradicated from the treated sites, but this will need to be confirmed by long-term monitoring.

6. FUTURE MANAGEMENT OF INVASIVE FRESHWATER FISH IN NEW ZEALAND

DOC has obtained funding to undertake a full delimitation survey of the South Island to determine whether other populations of koi carp and *Gambusia* exist. Extensive surveys will be undertaken across the South Island in the summer of 2001/02, which will build on the surveys carried out last summer in Nelson/Marlborough. A similar (but less intensive) survey programme will also be undertaken in the North Island to establish the distributional limits of invasive freshwater fish.

It is anticipated that the results of the delimitation surveys will provide a 'snapshot' of the range of koi carp and *Gambusia* nationally, as well as other species (e.g. rudd and catfish) that occupy the same types of habitats. This information will enable the Department to develop future management objectives for these species, which may involve identifying exclusion and containment zones. The information collected in the surveys will also be used to identify and prioritise sites for future protection and/or management action.

In order to effectively manage invasive fish populations, the Department needs to ensure that it has access to fish control tools and advice on the best way to use them, and that it has well developed standards and procedures for the way in which it undertakes fish control projects. In order to develop techniques to control invasive freshwater fish, DOC's Science & Research Unit is developing a Pest Fish Research Strategy which will establish research priorities for the next

five years. The Department is also working on obtaining a full registration for the use of rotenone in New Zealand, as it is a widely used and effective tool for managing invasive freshwater fish worldwide.

As well as undertaking the invasive freshwater fish surveys, DOC has developed public awareness material to educate people about invasive fish species and the threats that they pose to New Zealand's freshwater ecosystems. Because people are the main vector of invasive freshwater fish spread between catchments (intentionally and accidentally), public education and awareness is considered to be a key aspect of invasive freshwater fish management. There is no doubt that preventing fish from spreading to new sites is preferable to managing incursions as they are detected and where control may be feasible.

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