Environment Waikato Technical Report TR04/03

Investigations into the application of Australian methods for the control and management of Carp *(Cyprinus carpio)* in New Zealand

Victoria, Tasmania and Queensland, Australia.

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1 Introduction

The introduction of fish species from foreign areas has occurred consistently throughout New Zealand's short history of colonisation. It is believed that a total of 21 species of exotic fish have now become established in New Zealand (Dean et al; 2001). Carp (*Cyprinus carpio)* are thought to be perhaps the least desirable of these exotic fish.

Carp originated in China but are now probably the most widely distributed fish species in the world. They have been bred for both ornamental purposes (Koi strain) and as an aquaculture species (European strain). Although genetic differences are found between Carp from Asia and Europe, they are generally considered to belong to the same species. For the purpose of this report both Koi and European Carp will simply be referred to as Carp (*Cyprinus carpio)*.

Carp are known to increase water turbidity as well as damage aquatic plants (Koehn et al; 2000). This is primarily through their feeding habits which involve "mumbling" or sieving mud and detritus (Brown; 1995). It appears they may also affect nutrient concentrations within waterways (Koehn et al; 2000) and may affect bank stability in some situations (Brown; 1995).

Recognition of the detrimental effects Carp cause to the New Zealand aquatic environment has increased in recent years. This increase in profile has prompted the gathering of information and knowledge by different agencies to help in the management and control of Carp within New Zealand. This report forms part of the fulfilment of these information needs.

1.1 Background

Carp (Koi strain) were widely spread within captive situations in New Zealand by the early 1980's. In response to changing perceptions and increasing knowledge of Carp at this time, stronger legislation was developed to deal with the potential threat they posed should they become established in the wild. In 1980 the noxious fish regulations were gazetted. An amendment was made to the Freshwater Fisheries Regulations stating Carp were prohibited from being held by any person. However, authorities allowed those in possession of Carp at the time of the amendment to continue to keep them under special permits. This continued possession inevitably lead to the spread of Carp from captive situations into natural habitats. Efforts were made to eradicate feral Carp found in natural habitats but eventually a well established population was found in the Whangamarino wetland. This large wetland system is directly linked to the Waikato River (McDowall; 1997) and over the ensuing years the fish have grown very rapidly and dispersed throughout the entire lower Waikato River system.

The legal status of Carp is currently determined by two pieces of legislation. The Freshwater Fisheries Regulations 1983 classifies Carp as a noxious fish and states that no person shall be in possession or have under their control Carp, and shall not rear, raise, hatch or consign Carp. The Biosecurity Act 1993 classifies Carp as an unwanted organism and states that it is illegal to release, purchase or sell Carp and also prohibits the breeding of the species (Miller; 2001).

Environment Waikato now includes Carp in the Waikato Regional Pest Management Strategy (RPMS) 2002. The RPMS states that Carp pose a significant threat to New Zealand's freshwater ecosystems. Carp are listed in the RPMS as a Containment (Occupier Control) Animal Pest. This places the emphasis on the land owner to be responsible for removing the Pest from their property. However, Environment Waikato does have the legislative power under the Biosecurity Act to enforce land owners to undertake this removal.

1.2 Purpose

The purpose of this study was to investigate the potential and feasibility of using techniques developed by Australian agencies as a means of managing and controlling Carp here in New Zealand. This study was made possible with the support of both the Queen Elizabeth II Technicians' study award and the Biosecurity Group of Environment Waikato.

The study focused on working with various agencies within the states of Victoria, Tasmania and Queensland with particular emphasis on investigating similar situations that have parallels here in the Waikato Region.

The major project objective is to apply this knowledge to the Waikato Region by seeking opportunities for achieving control and/or eradication within unrestricted waterways. The outcomes generated by this project are designed to enhance Environment Waikato's capacity and involvement in management of Carp issues within the Waikato Region as well as enhance knowledge on a national scale.

1.3 Carp in Australia

Although carp were known to have been bought to Australia as early as 1860, widespread distribution did not occur until around 1964. This distribution is thought to be a result of a release of fish of the Boolara strain into Lake Hawthorn near Mildura, Victoria. The connection of Lake Hawthorn to the Murray River system meant it was inevitable that Carp would obtain access to this catchment. Their distribution was significantly aided by large floods in 1974 and 1975 which enabled them to colonise new areas. Over the ensuing years carp became widespread and obtained high densities throughout the 1.073 million km^2 catchment of the Murray River system. Carp have now spread to all areas of the Murray-Darling river system and are now the most abundant large freshwater fish present in this system.

Carp have also been introduced to many other river systems and localities, often through their use as live bait. Several strains of carp are known to be present on mainland Australia. The following introductions were made:

- The Prospect strain was introduced into the Prospect Reservoir, Sydney, New South Wales in 1907 and 1910
- the Yanco strain was introduced to the Murrumbidgee Irrigation Area in New South Wales in possibly the 1930's or 1940's
- the Boolara strain was introduced into the Gippsland Lakes and Lake Hawthorn, Victoria in 1962
- the Koi strain was introduced in the Australian Capital Territory in 1976, Lake Crescent in Tasmania in the early 1990's and into coastal rivers near Perth also in the early 1990's

The Boolara strain of carp has proved to be the most invasive and is now well distributed throughout south-eastern Australia. This strain of Carp does not presently occur in New Zealand.

The success of carp in Australia may also be linked to environmental change that has occurred in freshwater systems during the last century. Degradation of river systems due to habitat disturbance, drainage, forestry clearance and harvesting, sedimentation, pollution, overfishing, introduction of other exotic fish and plants and a decline in native fish populations may all have contributed to providing an opportunity for Carp to expand in both range and numbers (Koehn et al; 2000).

2 Investigation of Australian methods and techniques

November was chosen as the most beneficial time to visit Australia. Carp are becoming active at this time of year and consequently most agencies are beginning their field work for the summer months. The study took place between November 9 and December 5, 2003.

2.1 Arthur Rylah Institute for Environmental Research (ARI), Victoria

The Arthur Rylah Institute for Environmental Research belongs to the Department of Sustainability and Environment and operates within the State Government of Victoria. One of their specialities is the provision of knowledge and research in the area of freshwater ecology.

ARI has been extensively involved in research to obtain information on key biological and life history aspects of Carp. Information is being collected with a view to the formulation of strategic plans to address Carp impacts. Much of this work has been undertaken in the Murray-Darling river system.

2.1.1 The Murray-Darling River

The Murray-Darling River experiences variable flood or drought periods which may endure for several years. The gradient of the river is low with a fall of only 5cm per kilometre in some reaches. The system consists of many floodplains, wetlands and tributaries of which most are low lying below 250m elevation.

The river system is now heavily managed through the use of structures and impoundments to manipulate flows mainly for irrigation use and water supply. This manipulation has changed flows and therefore the seasonal inundation of floodplains and wetlands have been altered. These flow alterations have had a large impact on the ecology of native fauna and flora.

Extensive floodplains and woodlands occur throughout the middle reaches of the Murray River with the Barmah-Millewa forest being one of the largest at 65,000 ha. Barmah-Millewa consists of one of the largest stands of Red Gum in the world and its values are internationally recognised under the RAMSAR convention. The forest is comprised of both permanent and temporary lakes, billabongs, ephemeral streams, tributaries, swamps and large seasonally inundated floodplains.

The Barmah-Millewa has previously been known as a significant area for native fish but numbers have declined with Carp now accounting for a large proportion (86%) of total fish biomass present in this area. Information on Carp within the Murray-Darling was limited with little known about movement, spawning requirements or recruitment dynamics.

It is already known that Carp spawn in shallow waters over vegetation so it seems inundated floodplains may act as a nursery area for young fish. These spawning habits mean that the shallow wetland system at Barmah-Millewa was implicated as a major source of Carp spawning and recruitment in the Murray-Darling system. This presented an opportunity to research and examine the biology and the recruitment dynamics of Carp within this large floodplain environment. It is envisaged that the results of this work will be used to help in building a strategic approach to management of Carp within the Murray-Darling river system (Stuart & Jones; 2002).

Barmah-Millewa was of particular interest from a New Zealand perspective as there are strong parallels with the Whangamarino wetland in the lower Waikato River here in

New Zealand. Whangamarino wetland may form the major spawning and recruitment area for Carp in the Lower Waikato River. As with the Murray River, the main river stem is faster flowing and may not provide the preferred habitat of Carp. Consequently, wetlands and small tributaries may provide the mechanism for possible control of Carp numbers during spawning events.

The location of Barmah-Millewa within the Murray River system can be seen in Figure 1.

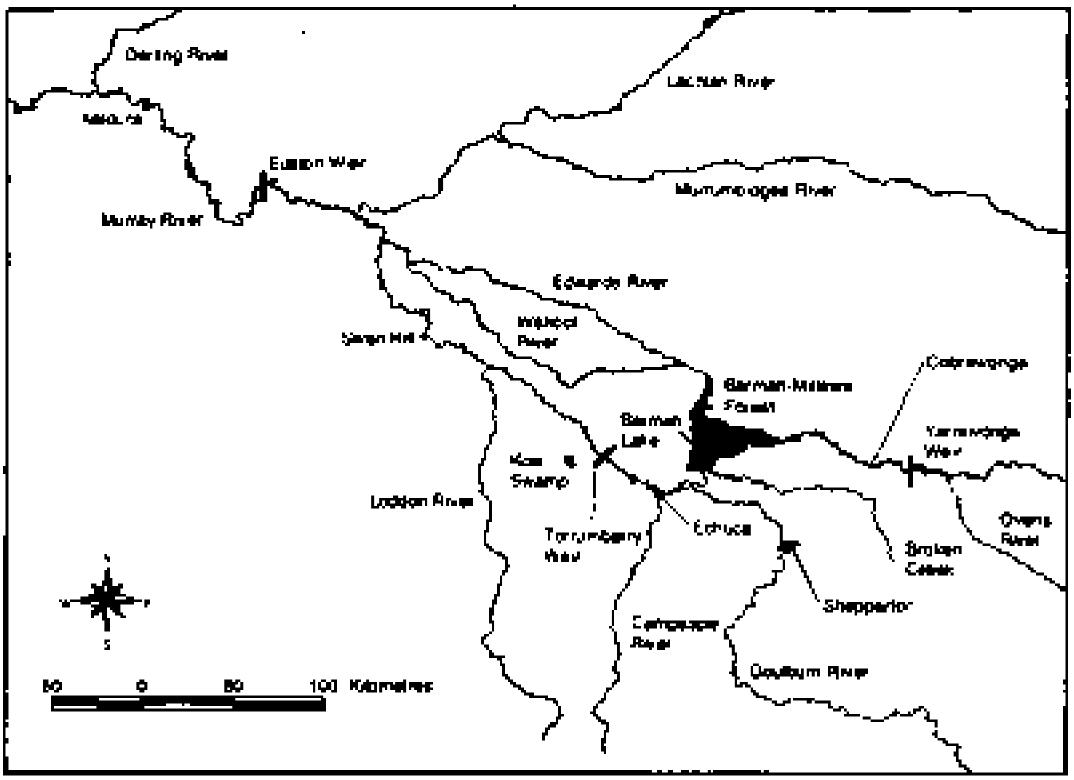

Figure 1: Map of Murray River showing Barmah-Millewa (shaded) and Torrumbarry weir location (Stuart and Jones; 2002)

2.1.2 Torrumbarry Weir and Fishway

Torrumbarry weir (Figure 2) is a major control structure on the Murray River to the west of Echuca. The weir acts to control and manage water flow for irrigation, flood and water supply purposes. The weir is operated by Goulburn Water with two weir keepers operating permanently at the site. Flow is constantly monitored and regulated and a lock operated for boat passage.

A fishway is attached to the structure and provides an upstream migration route for both native fish species and Carp. The weir is located downstream from the Barmah-Millewa forest and is a major point of access into the wetland area. Because of this, Torrumbarry forms an important site for management of both the native and carp fishery. The fishway can be manipulated for both experimental purposes and also to control fish movement upstream.

Figure 2: Murray River - looking upstream towards Torrumbarry weir

The fishway is a vertical slot design with an upstream control gate (Figure 3). The gate provides the ability to regulate or remove flow through the fishway. The flexibility of this structure enables experimentation and manipulation of conditions to test various methods and practices in Carp and native fish management. One such experimental procedure is the trial of a Carp control cage.

Figure 3: Fish pass on Torrumbarry Weir

2.1.2.1 Carp Cage

A major constraint in harvesting and removal of Carp is the time taken to deal with separating native fish from Carp in the catch. It is also desirable to have an easily removed mechanism for Carp harvest to reduce the amount of effort needed in dealing with the fish. The Carp cage has been experimented with to help find solutions to some of these harvesting and removal concerns. The cage exploits Carp behaviour of attraction to flow and their desire to jump towards that flow.

The cage is pictured in Figure 4 with the water flow provided by the white PVC piping pictured at the front of the cage. It is expected that as fish travel upstream, natives will continue along the bottom of the fishway and travel under the cage while Carp swimming further up the water column are attracted to the flow coming from the pipe system. By jumping towards the flow, Carp navigate the cage and become trapped.

Figure 4: Carp cage at top of Torrumbarry Weir fish pass

Native fish continue approximately 2 metres further up the fishway and enter into the cage pictured in Figure 5. The access slot is to the front left of the structure. There is also rubber matting to protect fish on the base of the cage to avoid damage as the cage is lifted. A winch system is used to hoist this cage out of the water. All native fish in this cage are identified, measured and released into the area upstream of the weir. Any carp present within this trap are also weighed, measured and removed.

The combined function of both cages provides the double benefit of capturing Carp and allowing assessment of the native fishery.

Figure 5: Native fish cage at top of Torrumbarry fish pass

Although still in the experimental stages the concept of the design and its feasibility as a harvest mechanism are definitely viable. The concept could be applied to any point where the control of fish access upstream is desirable.

2.1.2.2 Transmitter Trials

The fishway provides an optimal opportunity to trial the retention of transmitters on Carp. Carp caught within the cages are readily available and fish of appropriate sizes are easy to obtain.

The fishway can be sealed off by using the fish cages at the upstream end and a temporary barrier further down the fishway to stop escape downstream but retain water flow. Fish can be fitted with transmitters and released back into the fishway. When retrieval is required, the fishway can be dewatered by blocking off flow at the upstream end.

Transmitter trials were conducted over a three day period. Two Carp had transmitters attached to their dorsal fins and were released back into the fishway. The transmitters were attached after fish had been immersed in a solution of Alafaxan anaesthetic at a ratio of 1.5ml to 20 litres of water. This product is innocuous to humans and ARI have found that it is difficult when using Alafaxan to overdose fish.

The transmitters were obtained from Biotelemetry Tracking (Australia) who are located in South Australia. Each are valued around A$130.00. Transmitters are attached by four wires inserted through the dorsal fin and then twisted together. The wire ends are trimmed and the aerial remains free. A logger is used to pick up the signal emitted from the transmitter. A directional aerial is attached to the logger and the frequencies of the different transmitters are scanned to identify the location of the individual fish.

Figure 6: Attaching transmitter to the dorsal fin of a Carp

Carp were held for two days and then the fishway was dewatered to enable the retrieval of the fish. One carp remained with the transmitter firmly attached while the other fish had escaped, presumably through the downstream structure. The escaped fish was to be tracked and located.

The use of this type of transmitter may require further trialling before being used extensively.

2.1.3 Barmah-Millewa Forest Research

The work undertaken by Arthur Rylah Institute within the Barmah-Millewa Forest and surrounding areas has spanned almost two years. It provides information essential to formulating strategies for the management of Carp within this critical area.

The work includes many different components each with a different method and information outcome. The ability to visit sites and see the difficulties involved with obtaining information as well as the effort and resources required outlines the commitment needed if work such as this is to be undertaken in New Zealand.

The environmental conditions experienced in Barmah-Millewa are extreme, with high temperatures, fluctuating water levels and a large research area in which to work. The nature of the floodplain areas are illustrated in Figure 7.

Figure 7: Floodplain (Steamer flat) at Barmah-Millewa

2.1.3.1 Boat Electrofishing

This sampling identified valuable population characteristics, population distribution and movement of Carp within the Barmah area. The work highlighted the dominance of exotic fish species within the area and gave an indication of the abundance and distribution of native species.

Nine sites were electrofished around and within the Barmah-Millewa forest to enable the population structure and abundance of Carp to be quantified. Each site was sampled ten times over a variety of seasons and flows with species, length, weight and sex for all catches recorded.

2.1.3.2 Radio-Telemetry

Movement of fish can be for reasons such as feeding, spawning, colonisation and also to escape or avoid unfavourable conditions. By recording the types of movements and also the distance travelled, some life history characteristics for a fish species can be identified. Information of this nature can be critical in predicting the movements of fish such as Carp and enabling effective control of populations. It can also enable the effective enhancement and management of native fish populations.

The use of radio-telemetry provides the key in being able to track and locate animals in an aquatic environment. Over areas as large as Barmah-Millewa, vehicles, boats and on occasion planes were used to track and identify the location of fish with implanted transmitters.

Two Carp tracking programs were undertaken – one project for adult Carp and one for sub-adult Carp and Murray cod between August 1999 and March 2001.

46 adult Carp were fitted with transmitters throughout the study. 36 of these fish were located at Barmah while 9 were downstream of Yarrawonga (see Figure 1). All fish had surgically implanted transmitters and were located at fortnightly intervals. As well as using mobile tracking means such as boats and vehicles, three fixed remote stations were located on the Murray River. These stations recorded Carp transmitter frequencies and the direction travelled if the fish passed by the installation (Figure 8).

Figure 8: Fixed logger structure on the banks of Murray River

When manual tracking located fish, additional information such as habitat details and various water parameters was collected.

10 sub-adult carp and 10 sub-adult Murray Cod were also implanted with transmitters in March 2001. This study was one of the first attempts to monitor movement patterns of sub-adult fish within the Murray-Darling Basin using telemetry. The work indicated that some differences exist between the home range size of adults and sub-adults of both species. It and also found that sub-adult fish may provide a more comprehensive indicator of stream health for rehabilitation than adult fish alone (Stuart & Jones; 2002).

Figure 9: Tracking native fish using a handheld aerial, Murray River

2.1.3.3 Larval Sampling

The main purpose of larval sampling is to quantify the importance of the flooded habitats at Barmah-Millewa for the spawning and recruitment of Carp. Double wing larval nets were used at 4 sites throughout the area from September 2000 to January 2001. The results of this work confirmed Barmah-Millewa as a major point source of larval carp in this mid-river region. It also provided information on temperature triggers for spawning (15°C) and established that fish continue to spawn in large cohorts until late December or early January. Few fish were found to spawn in the river when there was access to off stream areas and other exotic fish species such as goldfish and weatherloach also use the floodplains to spawn.

2.1.3.4 Fishway Experiments

Fishways allow the movement of both native and non-native fish within river systems. They can provide species such as Carp with opportunities to colonise new areas of rivers which they were unable to access prior to construction. These structures can also provide a key point at which to control exotic species and undertake research on their biology and movements. Fishways such as at Torrumbarry and also Rice's Weir (Figure 10) can provide insight into Carp and other species movements. ARI conducted experiments on swimming abilities of both Carp and Goldfish at Rice's Weir This fishway is located on Broken Creek, one kilometre from its junction with the Murray River. Their work identified that young of the year Carp were able to negotiate velocities through the current fishway designs. It also identified the potential to remove large quantities of fish at one location during migration movements. This work will continue to aid in the design and management of fishways on the Murray-Darling river system.

Figure 10: Rice's Weir, Broken Creek

2.1.3.5 Large Scale Carp Removal Trials

The ability to remove large numbers of Carp efficiently and effectively in sometimes remote locations may be an important management tool. Often the use of main access points to spawning areas is the key in targeting fish removal. Three experiments were conducted in the Barmah-Millewa area to test the feasibility of such large scale removal of Carp.

A wire mesh barrier was constructed at the outlet of Barmah lake. This was designed to prevent the upstream migration of overwintering Carp from the main river channel into the lake and floodplain system. The barrier consisted of v-shaped wings with a funnel type trap in the centre of its 120m span. Capture rates of fish were monitored and fish were removed from the trap using an electrofishing boat. All fish caught were weighed, measured and sex determined. Fish appeared to respond to rising river flows while temperature had very little impact on movement into the trap.

Another large scale harvest also occurred at the same time as the experiment in Barmah Lake. Moira lake (see Figure 1) is similar to Barmah lake but has a regulating structure at its outflow. The structure was closed in December 2000 and a large scale harvest took place in February and March 2001. 76 tonnes of carp were removed by netting from above the structure by K & C Fisheries. There appears to be potential to utilise this type of harvest on an annual basis. The success of using harvesting as a means of population control is relatively unknown. Other factors such as limitations on food resources may be already operating to control the total biomass of the population.

Manipulating water levels to control spawning activities and carp numbers is simple and has potential for use in many situations. Richardson's Lagoon is located close to Torrumbarry Weir and was used as a test site for the effectiveness of complete draw-down of water levels. The aim of this experiment was to kill all carp and then introduce screens on inflows to prevent re-infestation. Initially a survey was conducted to see what fish species were present in the lagoon and ensure no populations of threatened fish were present. This was confirmed and the natural evaporation of the lagoon was supplemented by pumping deeper pools in a draw-down in March 2002. The lagoon was left dry until autumn 2003 and then refilled. Screens were installed at inflows to prevent juvenile and adult carp re-entering the lagoon. The project was successful although it is envisaged this process will need to be repeated on a cycle of 3-5 years (Stuart and Jones; 2002).

Figure 11: Screening structure on inlet to Richardson's Lagoon

2.2 Inland Fisheries Service (IFS), Tasmania

The Inland Fisheries Service is responsible for the management of the State of Tasmania's freshwater resources in a sustainable manner. The emphasis of the IFS is to ensure the best use of resources but also to protect freshwater fauna and its habitat for the benefit of future generations (http://www.ifs.tas.gov.au/about.html).

Under this mandate, the IFS is involved in the management of exotic species such as Carp within the State of Tasmania.

2.2.1 The History of Carp in Tasmania

It is thought that Carp (Koi strain) have been present in Tasmania as aquarium and pond fish since the turn of the century but there is no knowledge of them becoming feral and establishing wild populations. The Boolara strain of Carp which has overtaken rivers in mainland Australia was first found in several farm dams in northern Tasmania in the early 1970's. Another population of Boolara Carp were also recognised near Stowport in 1980. Both of these populations were eradicated using the pisicide rotenone. No further discoveries were made until February 1995 when staff from the Inland Fisheries Commission caught Carp in Lake Crescent while following up on a sighting by an angler. Carp were also confirmed to be present in Lake Sorell, a lake located across a narrow isthmus and connected to Lake Crescent through a canal. It is thought carp moved from Lake Crescent to Lake Sorell via a man made drain which at high flows connects Kemodes Bay in Lake Sorell with the northern end of Lake Crescent. These are at present the only known populations of Carp within the State of Tasmania.

Both populations of Carp within the two lakes have been genetically identified as a mix of both the Boolara and Koi strains. This mix indicates that the introduction was probably of wild fish from mainland Australia rather than aquarium fish.

2.2.2 Lake Crescent and Lake Sorell

Lake Crescent and Sorell are both large and shallow with Lake Crescent covering an area of 2305ha in area and Lake Sorell covering 5310ha. They are located in the south-east corner of the Tasmanian Central Plateau (Figure 12) and are around 30km north of the town of Bothwell. They are situated at an altitude of 800m. Both lakes are similar chemically and physically having the same climate, geology and soils. Catchment vegetation consists predominately of eucalypt forest with some pastoral landuse.

When both lakes are full, they support large areas of wetland which are directly connected to the lakes themselves. The lakeside marshes at Lake Crescent have been recognised by the RAMSAR convention as being of international importance. The lakes also support an endemic snail (*Austropyrgus sp*), frogs, snakes, waterbirds, water rats, platypus and an endemic galaxiid (*Galaxias auratus*) or the golden galaxiid (Inland Fisheries Service; 2003). The two lakes have also been important trout fisheries for recreational anglers and sustain populations of both Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*) (Walker and Freeman; 2003).

Water management is also a priority within the catchment. The outflow from Lake Crescent supplies the Bothwell and Hamilton town water supplies as well as irrigation needs for the surrounding land users.

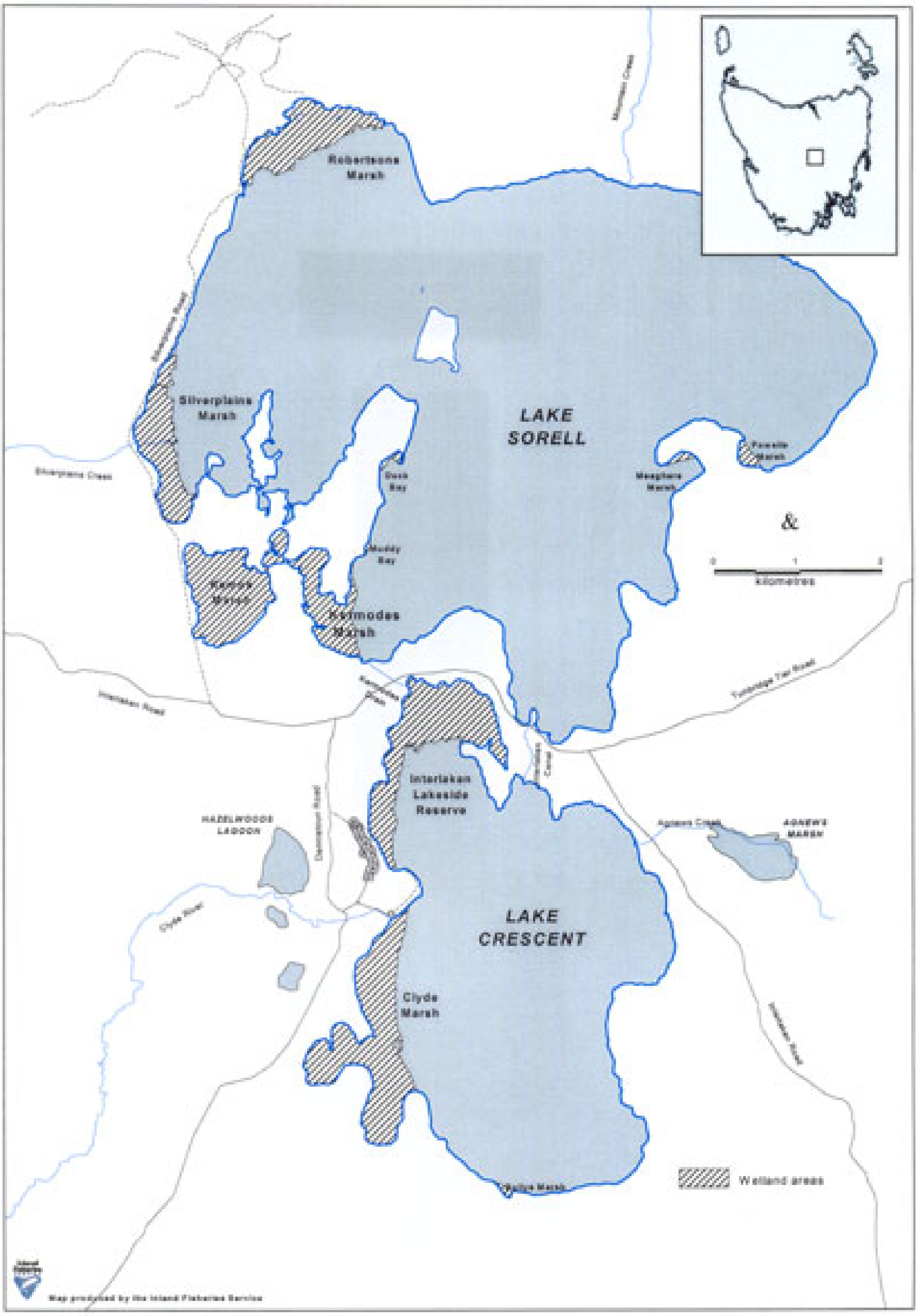

Figure 12: Map of Lake Crescent and Sorell

2.2.3 Response to Carp presence

In response to confirmation of Carp presence and the threat they pose to Tasmania's environment and economy, the State Government initiated an interagency approach to the problem with the formation of a Carp task force. As a follow on from this task force, a Carp working group was formed which incorporated representatives from the IFS, Department of Environment and Land and the Department of Primary Industries.

The objective of the Carp Taskforce and working group is:

"To eradicate carp from Tasmanian waters and, in the meantime, to minimise the impact of carp on Tasmania from economic, recreational and ecological points of view".

To meet this objective these broad strategies were adopted:

- Contain Carp in lakes Sorell and Crescent
- Improve the capacity of the containment screens that isolate both Carp populations
- Refine the water management plan to provide for the water supplies of Bothwell, Hamilton and the local irrigators
- Reduce the existing Carp population
- Eradication of Carp
- Protect the native flora and fauna that may be threatened by Carp or Carp management
- Gain an understanding of the factors that control the success of Carp populations in both lakes
- Develop, guidelines for recreational and commercial access to both lakes
- Protect cleared waters from reintroduction from both interstate and intrastate
- Implement an education and communications strategy to minimise damage to tourism and increase awareness of issues in both the community and fishing groups

The Carp Management Program was formed within the IFS as a consequence of these objectives and has been working towards these strategies since its inception in 1995.

2.2.3.1 Closure of Lake Crescent

Both lakes were regulated differently for angling purposes. Lake Sorell was open for artificial lure only while Lake Crescent was open to bait fishing where long lines were permitted. Anglers row their bait out over the marshes and into open, deeper water. The native galaxiid (*Galaxias auratus*) is often used as bait for this purpose (Wisnewski and McLaine; 2001).

Such importance is placed on the containment of Carp within both lakes, that Lake Crescent has been completely quarantined since the discovery of Carp. This response was driven by the knowledge that most introductions of Carp have been human assisted. The higher the density of Carp, the greater the likelihood that Carp or Carp eggs could, and may be transferred to other waterbodies. The closure is also related to the nature of fishing allowed (live bait) within the lake and the high number of Carp present. The risk of spread of Carp by human means was considered high.

The closure began on 17 February 1995 and includes Lake Crescent and the upper Clyde River. Both are closed to the public for all purposes which includes angling, boating of any sort, wading, swimming, duck shooting and any other contact that involves water. Increased enforcement by fisheries officers to ensure compliance by anglers was undertaken and the lake remains closed. Consideration is being given to allowing a limited open season on Lake Crescent now that Carp numbers are so low.

The importance of the closure of the upper Clyde River cannot be underestimated. The lakes are at the headwaters of the Clyde River which in turn feeds the Derwent River – one of the major river systems in Tasmania. The lower Derwent supplies Hobart with domestic water and any further intrusion of Carp from the lakes could lead to widespread distribution of Carp throughout the lower Derwent River system. If Carp were to spread throughout this system, the risk from human transport (both fish and larvae) would increase due to a greater distribution of fish in both numbers and geographical location.

Lake Sorell was not closed as it was deemed to be low risk due to the small numbers of Carp present.

2.2.4 Methods considered for eradication

Eradication of Carp from both Lake Crescent and Sorell was always the preferred option. However, the practicalities of achieving such a result have never been that simple and the record of successful eradication's in waterbodies such as these are few. Several technologies have been considered since Carp were found in 1995. Each is discussed below.

2.2.4.1 Rotenone

The application of a pisicide such as rotenone in waterbodies as large as Lake Crescent and Sorell is relatively untested. An American consultant was approached to consider the feasibility of this option and responded with a cost of US$4.8 million. The problems associated with the application of poison to a water mass this size and the cost to other species such as the golden galaxiid made this approach unusable.

2.2.4.2 Carp Specific Poison

The idea of a poison specific to Carp is currently being developed. As this form of poisoning eliminates costs to other aquatic species it would be much more desirable and could be used multiple times to achieve eradication. This is not a feasible option at the present time and remains under development.

2.2.4.3 Suicide Gene

This option remains at the theoretical stage at present and involves the integration of a lethal gene into the wild Carp population through many generations. This gene can then be manipulated by a specific cue which when activated has the capacity to kill the entire Carp population. The logistics and politics of introducing genetically modified fish into the wild may prove to be a stumbling point given the current level of public feeling to these issues.

2.2.4.4 Spring Viraemia Virus

This virus is a problem for Carp hatcheries and farms within Europe where Carp are held at high densities. This virus has not been seen to be present amongst Carp populations in Australia. There has been no indication that this virus would be helpful in controlling wild populations of Carp within Australia and may prove to hold a high risk to aquaculture as well as native and recreational fisheries.

2.2.4.5 Daughterless Carp

Research is being conducted by CSIRO (http://www.marine.csiro.au) in Hobart looking at the application of a daughterless gene into the Carp population. The technology involves the manipulation of Carp genes to produce a population whose offspring are all males. Although still breeding normally, fewer and fewer females are produced and the Carp population will eventually be dominated by males. The use of this technology is predicted to significantly reduce the Carp population within 20-30 years. Although research is well underway on this project, the technology is not available for use in the Tasmanian situation and is not likely to be available in the immediate future.

2.2.4.6 Physical Removal

Using a fish down approach is the most applicable technology to be employed at the present time and has been chosen as the preferred means of eradication by the IFS Carp Management Program. This method has the lowest environmental impact to achieve an eradication of the Carp populations. The primary focus is to remove all females from the lakes to prevent the population expanding through spawning.

Through a combination of containment and then utilisation of telemetry technology it is believed that an eradication can be achieved. The use of water level management is also an integral part of the physical removal plan. Level manipulation allows control over access to marsh areas which are the preferred spawning sites for Carp.

2.2.5 Physical Methods of Carp removal employed by the IFS Carp Management Program

Physical removal of Carp from both Lake Crescent and Lake Sorell was considered the most feasible option in the Tasmanian situation. This method requires various parameters to be set in place – containment of the population, effective use of netting and electroshocking techniques, data collection and estimation of the populations. The techniques employed during the process by the IFS Carp Management Program are discussed below.

2.2.6 Structures in place for containment

One of the primary concerns of the IFS Carp Management Program has been containment of the existing carp populations.

IFS have constructed screens on both the interconnecting canal (Interlaken canal) that flows between both lakes and also at the beginning of the Clyde river which flows from Lake Crescent.

The screens installed in the canal between Lakes Sorell and Crescent have primarily been used to isolate the two populations from each other. Initially, the screens constructed in the Interlaken canal were to stop Lake Crescent fish moving into Lake Sorell. When a population was found in Lake Sorell in 2001, numbers of carp in Lake Crescent were so low the screens were used to isolate each population and manage them individually.

Water capacity of the screen structures has also been an important component due to the need for management of both lake levels and water flow for other users.

2.2.6.1 Interlaken Canal Structure

Figure **13** illustrates the screening structure at the Interlaken canal. All water that travels between the two lakes flows through 25mm grates and then onto the 5mm screens before entering the canal to proceed on to Lake Crescent. The grates act to limit the size of fish able to enter the structure. They have been removed in Figure 13 for trials to see if any adult carp were trying to use the canal. Each screen needs to be cleaned of fish every morning. Access to each screen is via a manhole (between metal handrails in Figure 13) where fish are scraped off the screen and checks are made for the presence of Carp. All fish collected from each screen are released back onto the Lake Sorell side of the structure.

Figure 13: Interlaken screen structures (between Lake Sorell and Lake Crescent)

The limitations on these screens is that they have a small surface area and may not be able to cope with high flows such as during flood events. There is also very little difference in head between the two lakes. In high flows this may also cause a backing up of water from Lake Crescent through the canal and cause the screens not to function properly. These issues have not been addressed as drought conditions have prevailed within the area for the past five years. It is envisaged that structural concerns such as these will need to be addressed in the future if the populations still need to be managed on an individual basis.

2.2.6.2 Lake Crescent and Clyde River structure

Once Carp were located within Lake Crescent, the existing water control structure within the Lake Crescent canal (Figure 14) was utilised to install fine mesh screens to prevent spread of Carp. The existing structure was limited but immediate installation of a physical barrier was of priority. A mesh size of 1.1mm was used through which all water leaving the lake must pass. As with the structure present in the Interlaken canal, a series of grates are attached upstream to prevent larger fish entering onto the screens.

Figure 14: Structure between Lake Crescent canal and upper Clyde River

The mesh size of 1.1mm is considered capable of screening most eggs and small fish but there is some doubt whether this size of mesh is capable of screening larvae which can be as small as 0.7mm in diameter. As to whether the larvae would survive passage through the stainless screens, that is open for speculation. The screens are not capable of providing a 100% barrier but it is considered there is a low probability of Carp escaping and establishing downstream. Spawning areas within Lake Crescent are some distance from the screens and it is considered that larvae would be too large to pass through the screens by the time they reached the outflow.

In times of high flow, it is possible to replace the 1.1mm mesh screens with 5mm mesh to prevent the chance of a spill. This may be likely to occur during the winter months of May to October. If high flows required a change in mesh size during this time of year, it is likely that lower water temperatures would mean larvae and eggs are unlikely to be present.

This structure was upgraded during the time of my visit with the remaining two of the four bays installed with 1.1mm mesh to increase the capacity of the structure. As with the structure at the Interlaken canal, the screens here must also be cleaned every day to ensure they perform to capacity. A manhole system is also used here.

Annual surveys are undertaken throughout the downstream catchment in both the Clyde river and the upper Derwent river. Netting and electroshocking techniques are used in these surveys and thorough checks made to establish if containment has been achieved. No Carp have been captured downstream of the Lake Crescent structure indicating that containment so far has been effective.

A water level recorder operates via a telemeted system downstream on the Clyde River and gives information on level and flow. The IFS controls the flow through the structure in response to instruction from the water managers of the region.

2.2.6.3 Spillway structure

Adjacent to the Lake Crescent structure is a spillway for overflow from the lake during flood events. Due to the risk of Carp escaping during such an event, screens have also been fitted on the spillway outflow. 5mm mesh has been used accepting that a flood event is only likely during the colder winter months and larvae and eggs are unlikely to be present.

Figure 15: Spillway structure located next to Lake Crescent canal

2.2.7 Exclusion Fences

Another form of containment has been applied to the preferred spawning habitats within each lake. Simple structures of mesh attached to metal stakes have been constructed around areas which Carp have previously preferred for spawning. These areas are marsh habitat with water flow through these areas towards the lake. Simple traps have been constructed within the mesh fence which rely on the habit of Carp to swim against the flow. Each trap is a one way entry tube into a holding cage with an opening lid to enable the trap to be emptied. This provides a cheap, easy mechanism to both exclude Carp from spawning habitats and to capture Carp trying to move towards these areas.

Figure 16: Carp exclusion fence, Lake Sorell

With water levels remaining low during the previous few years, operation of these exclusion fences has been relatively simple. The design will not function once levels exceed the top of the mesh fence although extensions could be attached to the fence to raise the total height of the structure and still effectively exclude fish.

2.2.8 Biotelemetry and tracking fish

The key point in the IFS Carp Management Program is the use of biotelemetry (radiotracking) methods in locating fish. It provides a way of monitoring location and behaviour of animals and can be utilised in both terrestrial and aquatic environments. The essence of biotelemetry involves the transfer of information via radio signals from radio transmitters to a remote receiver system. Radio transmitters are attached or implanted into the animals being monitored.

It was identified early in the Carp Management Program that Carp tend to aggregate for breeding and feeding and that this behaviour had the potential to allow removal of large numbers of fish at one time. The most important factor was the location of females and their subsequent removal to prevent spawning occurring. Locating the fish was the only problem and by relying on visual means proved unreliable. The use of biotelemetry and the implantation of transmitters into male fish was the solution. The movements of the fish are tracked by boat using a radio telemetry receiver attached to a directional antenna (Macdonald; 2003).

2.2.8.1 Types of Transmitters

Ultrasonic transmitters are used in the IFS Carp Management Program and many brands with different specifications have been trialled. Key issues with transmitters are battery life, strength of frequency, size, weight, durability, signal output and price. Another consideration was which radio frequencies were to be used as they must fall within the operating frequencies covered by a radio-communications class licence. These operations are administered under Commonwealth Law in Australia. Figure 17 illustrates several types of transmitters used in the IFS Carp Management Program (Macdonald; 2003).

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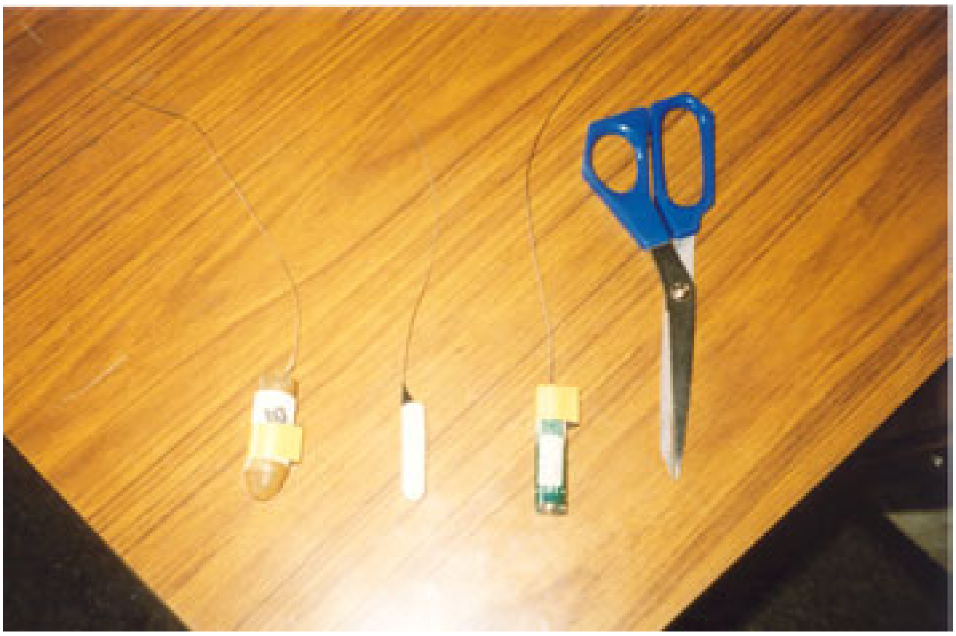

Figure 17: Different types of transmitters for use in tracker fish

2.2.8.2 Implanting Transmitters

The IFS Carp Management Program uses surgically implanted transmitters for its biotelemetry work on Lakes Crescent and Sorell.

Surgical implantation of transmitters has already been used in other research on fish species such as salmon and catfish as well as Carp. The methods for surgical implantation are many and the IFS Carp Management Program have developed their own preferred method of implantation which works best in the Tasmanian environment.

To achieve the greatest success in survival and condition of implanted Carp, most are implanted during the colder months to reduce the chance of infection due to lower water temperatures. This also enables an expanded recovery time before the onset of spawning and aggregation behaviour in the spring. The IFS Carp Management Program have found through observation that implanted male Carp return to their normal behaviour patterns quickly after surgery.

Sterile conditions are used for implantation with all equipment thoroughly cleaned in 100% ethanol and flamed off. Figure 18 illustrates preparation for surgery.

Figure 18: Preparation for surgically inserting transmitters into male carp

A purpose built cradle (Figure 19) is used to hold fish while surgery is conducted. A cloth mesh over the cradle enables the gills of the fish to be kept immersed in water during surgery.

Figure 19: Holding cradle for fish and incision for insertion of transmitter

Male fish should ideally be a minimum weight of 1.5kg but preferably over 2kg for transmitter implantation. The implanted weight of the transmitter should be less than 2% of the actual body weight of the fish when weighed in air to ensure transmitter retention and a return to normal behaviour.

The following procedure is used for implantation:

- Secure fish firmly in cradle
- Remove scales along a 50-70mm line slightly offset on either side of the mid-ventral line (posterior to the pelvic fin and anterior to the anus)
- Using a scalpel, make an incision without penetrating the inside body wall
- Cut length should be between 30-40mm and should be just big enough to insert the transmitter

- Using tweezers, grasp one side of the incision and lift the wall away from the gut
- Complete the incision through the body wall and ensure no viscera are severed
- Confirm the fish is a male (if at all uncertain) by examining gonad material
- By holding the fish firmly with the transmitter aerial trailing posteriorly, push the transmitter in to the body cavity
- Ensure minimal disturbance of body organs
- Once the transmitter is inside the body cavity, secure the transmitter in place by threading the antenna on to a suture needle and sew through the gut wall exiting at the posterior end of the incision. Needle nosed forceps may also be used
- Suturing is carried out using 200mm lengths of monofilament nylon which is threaded onto suture needle
- Each suture is started about 5mm on either side of the wound and tied off with a standard locking knot
- Sutures are continued around 5-7mm apart until the wound is completely shut
- Trim back the tails of the sutures to around 2mm
- Number coded T-bar tags are also implanted beside the dorsal fin of each fish
- Numbers are recorded and this forms another method of identification when fish are recaptured (in case of transmitter loss)

Fish are allowed to recover but holding time is kept to a minimum before they are released into the lakes. It is preferred not to hold fish for prolonged periods of time as it has been observed that this leads to increased stress. Fish that are handled less seem to have a greater transmitter retention and survival rate after surgery.

2.2.8.3 Tracking Fish

Each transmitter that has been implanted into a fish has a different and unique radio frequency, which is utilised when tracking fish within each lake. The majority of tracking is conducted by boat although some land based tracking with hand held antennas can be undertaken to identify fish locations when they are close to the shore. Each frequency is programmed into a telemetry receiver (LOTEK) which scans continuously for around three seconds per frequency. When a frequency is identified, the receiver is paused to locate that particular frequency. The directional antenna connected to the receiver on the boat (Figure 20) can be manipulated to identify the exact position of the fish. The strength of the signal increases as you get closer to the fish.

Figure 20: Tracking set up on IFS boat – directional antenna attached to receiver near steering position

The directional antenna is mounted on PVC pipe within the boat and is approximately 2 metres above the water. This increases signal strength while keeping the antenna out of the boat drivers' way and also decreases interference from outboard motors and electric's on the boat itself.

In the case of tracking fish from shore, the same type of directional antenna is used (Yagi).

Tracking of fish occurs on a daily basis during the peak spawning months of September to March. Every tracker fish is located within each lake and their position recorded. Data is recorded on a standard prepared sheet Figure 21. Information on the data sheet includes frequencies, date of implant, type of transmitter and last recorded position. At any one time there are between 10-15 tracker fish within each lake. It is considered that this number is sufficient to identify any aggregations in each lake and small enough not to miss any signal during scanning of frequencies. Tracker fish are monitored at least once per week during the winter months or when weather permits. Both lakes are large with long fetches so conditions are often windy and rough and this can hamper tracking activities.

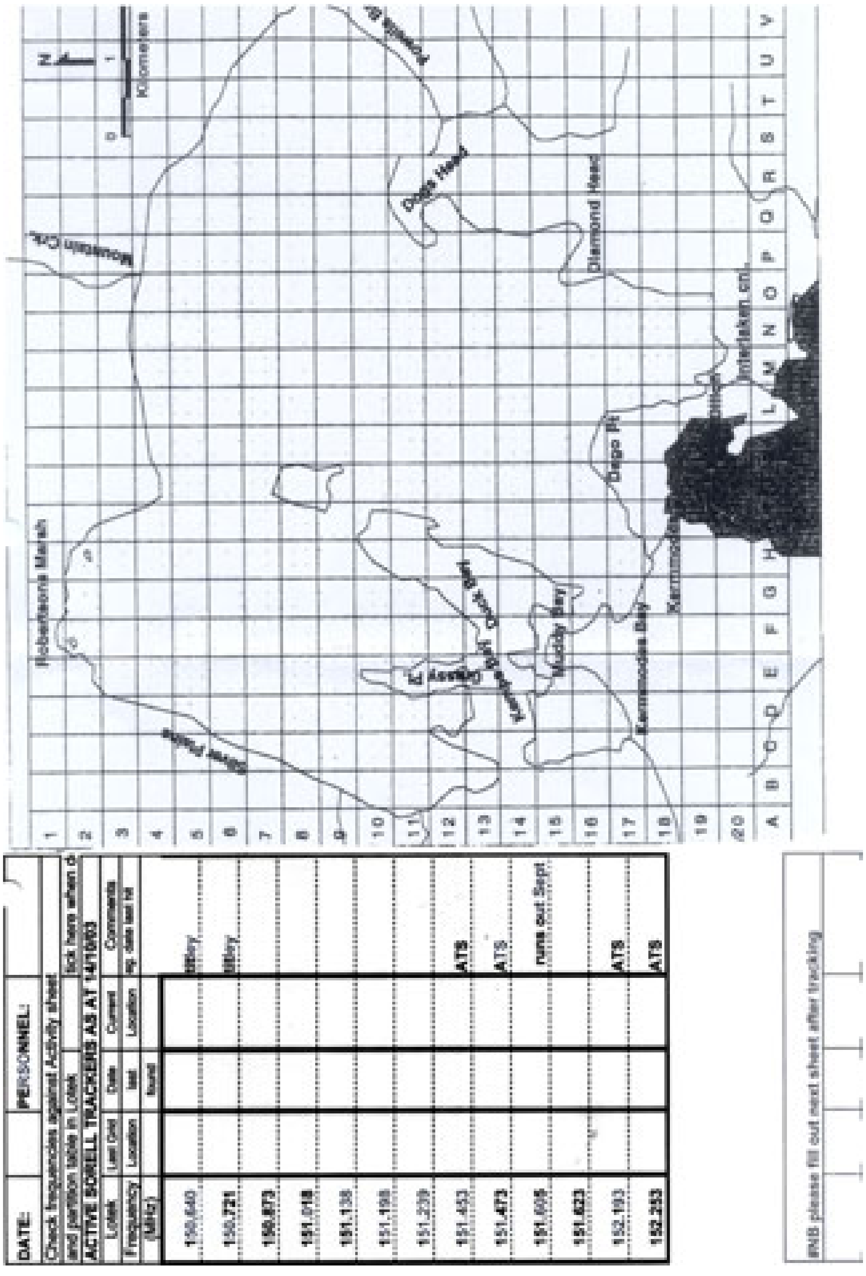

Figure 21: Field sheet used for plotting and recording location of tracker fish (Lake Sorell)

2.2.9 Netting and Electroshocking

Once tracker fish have been identified and located, a decision is made as to whether aggregations of two or more tracker fish may indicate the presence of a female for spawning activities. If this appears possible and is supported by the proximity of preferred spawning habitat, then netting and electroshocking techniques are used to harvest the fish.

The use of both these techniques has been refined by the IFS Carp Management Program with much work having gone into identifying the selectivity of different gill net sizes for different population age structures of fish in both lakes.

2.2.9.1 Net Selectivity

An essential component of controlling populations of fish by using physical removal techniques is the ability to effectively target fish populations using selective equipment. This is essential to obtain maximum yield from effort as well as reduce impact on non-target species. It is also important to understand the habits of carp at each age size class. By combining both age knowledge and equipment selectivity, resources can be targeted more accurately to achieve successful outcomes.

2.2.9.2 Gill nets

The use of gill nets is a very effective tool in catching fish. Gill nets are moderately selective on which fish and of what size fish they are best suited to catch. This net selectivity relates to mesh size, elastic stretching of the net, flexibility and strength of the nylon, visibility of the nylon as well as the shape of the fish.

The IFS Carp Management Team uses gill nets in the size range of 2.5-7 inches (6.35-17.78cm) which are made from mono-filament mesh hung on blue polypropylene rope with lead net weights. As more information is now known about the length and size of the populations remaining within each lake, size variations in gillnets have been accurately used to target those remaining fish. Each size of gillnet mesh has been shown to be intricately linked to achieving catch success with particular lengths of fish.
Figure 22 shows the collection of gillnets on Lake Sorell after extensive netting and electroshocking in marsh areas.

Figure 22: Collecting gill nets on Lake Sorell

2.2.9.3 Fyke Nets

Fyke nets are predominately used for surveying and capturing juvenile carp. They are generally set in the shallow areas of the lakes to exploit the feeding behaviour of the juvenile carp as they move into the shallows overnight to feed.

Fyke nets are the only type of net that can be left unattended and not pose a threat to wildlife such as platypus, native hens and water rats. They consist of a tapering cylindrical structure with a wing attached to the widest end of the structure. The tapered end is kept floating at the water's surface by attaching a buoy and raising the end out of the water by attaching it to a stake 300mm above the waters surface. Fyke nets are generally set at right angles to the shoreline.

The selectivity of fyke nets has shown that although they tend to catch all sizes of the fish population, they favour small fish (between 80 – 260mm fork length) which can be more difficult to catch using other methods.

2.2.9.4 Purse Seine Nets

The seine nets used by the IFS Carp Management Program are 100m long and have 9 ply cotton rope mesh attached to both a top and bottom rope. The idea of a seine net is that it is placed around an aggregation of fish and then the two ends are pulled together to form a purse around the fish. This type of net is primarily used to sweep large areas close to the shore and is best used where the shallows are sandy and free of rocks, sticks and snags. Unfortunately there are few areas of either Lake Crescent or Lake Sorell which are suitable. When seine nets are used, they are usually used to collect aggregations which have been held within gillnets. Seine nets do not appear to be selective towards any particular size of fish.

2.2.9.5 Electroshocking

Both an electroshocking boat and electroshocking backpacks are used in conjunction with nets. Both are employed as a tool to push fish into nets rather than outrightly catch carp while shocking. The electroshocking boat is pictured in Figure 23 and is used during large sets of nets slightly offshore. The boat moves between the shore and the nets with an aim to shock fish into moving into the nets and then becoming entangled. At any one time 1 kilometre of nets may be set with one team collecting behind the electroshocking boat and resetting in front.

The effectiveness of the electroshocking boat is highest amongst the sub-adult and adult carp population with little success on juvenile and small carp.

Figure 23: Electric fishing boat - Lake Sorell

Backpack electroshockers are also used in areas where it is not possible to use the electric fishing boat such as shallow marshes. Figure 24 illustrates backpack electroshocking in shallow marshes on Lake Crescent. In this case, once fish are located, gill nets between 100-200metres long are set around the aggregation. The area is then panelled off into long strips around 10 metres wide using more nets. Each strip is then electroshocked and the nets removed and fish harvested. All tracker fish are returned to the lake.

Figure 24: Backpack electroshocking - Lake Crescent marshes

2.2.10 Population structure and estimates

Estimation of fish abundance is the key in effective fisheries management. To manage a population of carp to achieve eradication requires accurate abundance measurements. Knowing how many fish are present enables the implementation of strategies, allocation of resources and tracking progress during eradication. The IFS Carp Management Program has two key strategies in place which help achieve these goals – population estimates and data collection.

The use of various population estimation techniques depends on which method is appropriate to the situation. Methods vary depending on conditions within the waterbody being assessed as well as what assumptions are used on the study. In the case of Lake Crescent and Sorell, two methods were employed over the period of 1998-2001.

2.2.10.1 Population estimates – 1998-1999 Mark-recapture exercise

During the summer of 1998-1999, a Petersen mark-recapture exercise was undertaken to estimate the size of the carp population in Lake Crescent. The initial study was based on a single mark-recapture closed population model and the accuracy of this method relied on the validity of the following assumptions:

- That a closed population exists
- All animals have the same chance of being caught in the first sample
- Marked and unmarked animals are equally catchable
- That animals do not lose tags between sampling periods
- All fish retained in the recapture are observed by at least two people to avoid errors in reporting tags or fin clips

The mark-recapture exercise used a variety of nets and net sizes. Gill nets, seine-nets, fyke-nets and boat and backpack electroshocking were employed. The marking of fish was conducted over 13 days commencing on November 13 1998.

Tracker fish were searched for every morning and when found in close proximity the associated aggregations were netted and electrofished. Forty four fyke nets were set around the perimeter of the lake and were checked daily, while gill nets were placed randomly around the lake. Random beach seining was also conducted when possible. The average time of nets in the water was 8 hours.

Adult fish were identified as those which were running ripe with adult females retained and killed while adult males and juveniles were weighed, measured, anal fin clipped and tagged and then released. The tagged Carp were left for 18 days to disperse and settle before the recapture commenced. The same methods were employed for the recapture of the fish as were used in the initial capture process.

A total of 366 fish were tagged and released with a total of 71 tagged fish recaptured. After applying statistical techniques, a population estimate for the Petersen method was 2053 Carp while using the Schnabel method was 1910 (Donkers; 2003).

2.2.10.2 Population estimates – 2000-2001 juvenile cohorts in both Lake Crescent and Lake Sorell

Since the initial mark-recapture study conducted in Lake Crescent, there has been successful recruitment of Carp in both lakes as a consequence of spawning events in the summer season of 2000-2001.

It was not considered desirable to conduct a mark-recapture exercise on these juveniles given that it would involve the release of females back into the population. Sex of juvenile fish is difficult to determine and it would be inevitable that females would be released. With this in mind, an effort based parameter was used to give a broad range of a population estimate. Catch per unit effort (CPUE) is commonly used to estimate population abundance and relies on repetition of fishing effort in different locations. The same amount of effort and fishing gear must be applied to all areas.

Monthly juvenile surveys are conducted in both lakes during summer months using fyke nets to check on recruitment. The surveys use 45-60 fyke nets set around the margins of the lake and involve a relatively stable effort being repeated. The CPUE data from these surveys has been used to estimate abundance of these cohorts in both lakes. An estimation of 3012 juveniles was obtained from Lake Sorell cohort from 2000 while an estimated 125 juveniles was calculated for Lake Crescent. These calculations are based on 2000-2001 population levels and are therefore much lower due to fishing effort over the ensuing years (Donkers; 2003).

2.2.10.3 Data Collection

The IFS Carp Management Team have collected a comprehensive set of data during their operations at Lake Crescent and Sorell. Thorough documentation of fish biological data such as length, weight, sex, and gonad weight has provided a good understanding of the population. Growth rates using this data have been predicted which, when combined with net information has helped in achieving optimal return for effort. A large number of otoliths have also been collected for ageing purposes. The analysis of these has proved to be variable and due to these discrepancies more emphasis has been placed on the use of other biological data as well as the expertise of the IFS Carp Management Program team and their familiarity with the Carp population.

Copies of both the IFS Carp Program Fish Survey Data field sheet as well as the field sheet used for recording fishing effort and equipment are contained in Appendix 1. All data recorded is stored electronically within the IFS computer system.

Figure 25: Processing of females and fish of unknown sex - Lake Crescent

Figure 26: Retrieving gonads for sex determination of fish

2.2.10.4 Male Fish

As Carp are removed from both lakes, population size decreases. As Carp numbers become lower, it is more difficult to secure an ongoing supply of male fish to use for transmitter implantation as tracker fish. Due to these constraints, all Carp that have been confirmed as males are released into and held in a pen in the Interlaken Canal. Figure 27 shows the pen and the release of some males after a successful netting and electroshocking session on Lake Sorell. The risk to the program should the fish escape is low but the benefits of an ongoing supply of male fish are substantial.

Figure 27: Release of Carp into holding pen - Interlaken Canal

The IFS Carp Management Program is investigating the possibility of constructing purpose built holding tanks to ensure more security and allow monitoring for disease.

2.2.11 Costs

The use of physical removal to control Carp has involved a large allocation of resources with the majority of costs associated with staff time and capital outlay.

A total of A$3.5 million has been spent between 1995 and the end of the 2002/03 budget year. A further $A400,000 is budgeted for the 2003/04 financial year.

Large capital purchases have been made for the programme such as the electrofishing boat ($68,000), screens, outlet structures and canal works ($240,600) and various other equipment and consultants (IFS; 2003).

The IFS Carp Management Program have also purchased a house on the shores of Lake Crescent to enable them to effectively manage the operation from a purpose built and maintained facility. They also operate two boats (Figure 28) (plus the electrofishing boat) which also require vehicles. Staff are required to work many weekends and during summer have long hours and are based away from their homes. This requires various allowances to be paid in addition to salaries.

Figure 28: IFS Boat rig - Lake Crescent

Figure 29: Propeller damage - IFS boat, Lake Crescent

Upkeep of equipment is also an ongoing expense. The nature of the work and the shallowness of the lakes combined with a rocky shoreline puts pressure on equipment and often means significant repairs and maintenance to nets and boats. Figure 29 illustrates common damage to propellers due to difficulty in navigation and access in both lakes.

2.3 K&C Fisheries, East Gippsland, Victoria

Keith and Cate Bell own K&C Fisheries and operate out of Sale in East Gippsland, Victoria. K&C Fisheries have been operating exclusively in the Carp Fishery industry for 17 years and are Australia's largest and most consistent harvester of carp. They process in excess of 1,000 tonnes of carp per year with K&C Fisheries undertaking the primary processing of various Carp products.

Much of K&C Fisheries' development has focused on developing cost effective and consistent harvesting techniques and establishing viable products and markets. As unprocessed Carp is low in value, the company relies on volume and the ability to target sufficient fish to meet demand.

In recent years, prolonged drought conditions have increased salinity within the Gippsland lake systems and reduced the recruitment of Carp to the fishery. Aquifers within the region are now lower than sea level with salt water intrusion spreading throughout the lake system. This has been exacerbated by the damming and diversion of one major catchment within the basin for the purpose of increasing Melbourne's water supply.

2.3.1 Harvesting Options

Many techniques have been developed as K&C Fisheries has evolved to meet the demands and needs of market requirements. The company takes a hands on approach and tailors various techniques to achieve the optimum return on their fishing effort.

K&C Fisheries have looked interstate to establish other consistent supplies but maintaining a high quality of fish and still being economically viable in remote locations has proved difficult.

At present, the main techniques being used are using an electric fishing boat for work within the river systems and the deployment of purse seines within Carp traps. In both processes, the freshness of the product is of the highest importance. Ice in holding bins is used as a storage mechanism to ensure the product is kept as fresh as possible before returning to the processing facility in Sale.

2.3.1.1 Electric Fishing

Using the electric fishing boat is an effective harvesting technique within river systems and particularly around river margins. The anode which attracts fish is a net. The fish are netted and "flicked" onto the boat. Once a significant amount of fish has been gathered the catch is loaded into the ice boxes on the centre of the boat. Unlike many other electric fishing boats, there are no safety switch mechanisms on the boat allows constant operation. The two man crew does not use gloves nor waders.

Figure 30: K&C Fisheries Electric Fishing boat for carp harvest

2.3.1.2 Carp Traps and purse seining – McLeod Morass

Community involvement has lead to a successful project occurring at the McLeod Morass in East Gippsland (Figure 31). Local landowners pioneered a trap which uses the principal of attracting carp towards flowing water. Regulators of the wetland, East Gippsland Water, enhanced the original structure and installed it permanently. Once the fish are in the trap they are harvested by K&C Fisheries and processed for use as fishbait and liquid fertiliser.

Figure 31: McLeod Morass, East Gippsland

The trap itself is simply constructed with mesh and waratahs providing the perimeter barrier. Several one way plastic tubes are located within the structure throughout the perimeter fence. Fish are attracted to the flow coming from the controlling structure and enter through the plastic tubes into the enclosure. The trap is completed by the barrier structure in Figure 32 which is also used to regulate flow through the trap.

Figure 32: Flow controller, water inlet and barrier for carp trap - McLeod Morass

A purse seine net is used for harvesting. The net is run out around the perimeter fence and pulled towards shore (Figure 33 and Figure 34). Fish are then loaded by crane into iced fish bins and transported to Sale for processing.

Figure 33: Purse seining within the carp trap - McLeod Morass

Figure 34: Pulling purse seine ashore within Carp trap - McLeod Morass

One tonne of Carp was harvested during one visit with a total of 24 tonne harvested from this trap within the previous two months. The trap was cheap to construct, easy to install and very effective. The McLeod Morass structure has been a pilot and has proved that this type of structure could be easily introduced into other areas with similarly successful results. Appendix 2 contains a newspaper article which has been published from a report collected on the day I visited.

Using localised traps such as this within wetlands is very cost effective and successful in controlling Carp numbers.

2.3.2 Products

K&C Fisheries have been innovative and successful in achieving a wide variety of products for both the domestic and export market.

Domestic products include the supply of fish as bait for the crayfish industry, whole fish for human consumption at both the Melbourne and Sydney fish markets and supply to both the pet food and fertiliser industries.

Export products now consist mainly of Carp roe for the European market and supply of fish to the petfood industry. Previously K&C Fisheries also exported Carp trunks to both the Middle East and Poland but this is no longer viable.

The supply of Carp roe in particular is a market where there is potential for growth. The large size of Carp harvested in Australia provides a good quantity of roe compared to the smaller European fish. All fish harvested for removal of roe are processed in the export facility, which conforms to strict handling requirements imposed by the Australian Quarantine Service and required by exporters. Roe is removed (Figure 35), salted and prepared for export (Figure 36). Any further processing required by the market is conducted when the product reaches Europe.

Figure 35: Roe processing facility at K&C Fisheries

Figure 36: Salted Carp roe prepared for export

2.3.3 Aquaculture

A recent development that K&C Fisheries have pursued is the development of an aquaculture unit on site. Investigations and trials are underway to see if this venture has the potential to provide adequate numbers of various species to restock some waterways. Both native fish such as brim and bass are being trialled as well as cultivation of sufficient numbers of carp for consistent harvest. The venture is also cultivating both rotifers and algae to provide food for the fish during growth.

2.4 Department of Primary Industries, Queensland

The Department of Primary Industries (DPI), a division of the Queensland Government, have the prime responsibility for controlling exotic fish species within the state of Queensland. They have embarked on two main strategic approaches in their efforts to deal with this issue - a programme of educational material and the development of an operational strategy for control of Exotic Pest Fishes within the state's freshwaters.

2.4.1 Educational Material and Control Strategy

The educational material targets upper primary and lower secondary age children and is for use within the existing school curriculum. It provides easy to read material with various exercises targeted at helping children to identify these fish and learn why they are classified as pests.

The control strategy has been formulated to complement other strategies prepared at both the Federal Government level (National Management Strategy for the Control of Carp (2000-2005)) and within the Queensland State Government (Queensland Pest Animal Strategy). It is designed to address growing community concern about the increasing exotic fish problem and the effects these fish have on native species and their habitats. The strategy takes a conservative approach and recognises that eradication of these fish is not possible at this time but that management and prevention of further spread is achievable. The goals of the strategy are as follows:

- Prevention of the further spread of exotic pest fish species that are currently established in Queensland and prevention of other species establishing in the wild

- Reduction of the impacts of exotic pest fishes to an acceptable level and to achieve eradication where possible

- Ensure that exotic pest fish eradication and control methods are both environmentally and socially acceptable

- Gain community awareness and understanding of the impacts of exotic pest fishes and what management strategies are being used to counteract these impacts.

- Ensure science and evaluation along with best practice management are used to achieve effective exotic pest fishes management

- Interlink and co-ordinate State management of exotic pest fishes with national management strategies

The strategy has been implemented on a state wide scale with work consistently being undertaken to try to achieve these goals. Work on which species should be added to the exotic pest fish species list is ongoing.

2.4.2 Rotenone Application

Rotenone is used in waterways as a piscicide and an aquatic insecticide. It has been effective in its use by fisheries managers overseas and has also been used in an experimental fashion with trials undertaken in New Zealand. It is used widely in Queensland for the management and control of exotic pest fish.

The DPI carried out a Carp eradication at a location south of Brisbane on a public golf course during my visit. The golf course owner expressed concern at the Carp present in his pond and asked for an eradication to take place. As the ponds existed within a catchment known to have Carp, DPI charged the landowner for the rotenone product that was used although they did not charge for the time involved in the application of the product.

Powdered rotenone was used and a total of 3 ponds with interconnecting channels were treated. The quantities of rotenone to be used was calculated using the following formula:

Surface area in hectares x average depth in metres x 5 = kg of rotenone powder to give 0.5ppm concentration

Surface area = length (m) x breadth (m) = m^2

Surface area = $m^2/10{,}000\ m^2$ = (x) hectares

(x) hectares x depth (m) x 5 = (x)ppm @ 0.5 concentration

(x)ppm x 8 = (x) kg of rotenone to give 5ppm conc

This concentration is considered to be adequate to kill Carp.

The required quantity of rotenone was added to a mobile mixing tank and a wetting agent added (Figure 37). Guar gum was used in this instance but normal dishwashing detergent is also commonly used. The wetting agent enables the powdered product to blend with the water more easily. A breathing mask, gloves and disposable protective suit were also worn.

Figure 37: Mixing tank for rotenone application

A liquid version of rotenone is also available but powder is cheaper to purchase but is more difficult to use.

Application is via hose directly onto the water body (Figure 38). In this instance, the shape of the pond shorelines was conducive to achieving a thorough mixing of the product through the waterbody. In a larger ponds or waterbodies with inaccessible shorelines, boats can be used to distribute the product through the centre of the treatment area.

Figure 38: Application of rotenone via spray hose onto pond

Once the ponds were treated, approximately half an hour elapsed before the first fish were seen on the surface of the water. These fish were mullet which are more sensitive to Rotenone than Carp. Other non-target fish species can be caught and placed in tanks containing Potassium Permangenate which acts as an antidote to Rotenone if a selective kill is required. The first carp appeared around 50 minutes after application followed closely by eels. The fish were collected by volunteers for disposal. The entire operation consisted of approximately 5 hours work.

Figure 39: Carp harvested from rotenone control

3 Applications

It has been noted that biological and life history information collected on Carp in Australia may not have relevance to the New Zealand situation (Tempero; 2004). However, although all research methods and results must be considered carefully when translocating to another country, the techniques and core findings may certainly be applicable.

Many of the techniques used in the Australian context are applicable to the New Zealand situation but may need to be modified to be effective in environments specific to New Zealand.

Based on my investigations and experiences during the Australian visit and the existing knowledge of Koi Carp issues here in New Zealand there are a number of key observations that can be made from the Australian experience.

The main requirements for obtaining effective management are:

- Collaboration between agencies (Environment Waikato, Department of Conservation, Fish and Game Council, Universities and other interested parties)
- A plan for both information gathering and monitoring (distribution and population) of Carp in the Waikato
- A long term strategic plan for management and control of Carp
- Enforcement of legislation (Biosecurity Act and Freshwater Fisheries Regulations)
- Eradication of key populations found outside the designated containment zone
- Control the population within the designated containment zone
- Education of the general public as well as key strategic groups such as anglers

4 Recommended actions

In order to achieve these management requirements, I advocate the following measures for Environment Waikato:

- Organise regular liaison and meetings with other agencies to co-ordinate research approaches and provide a unified approach to Carp management
- Develop a multi-agency long-term strategy to identify key areas of concern in Carp management. Seek clarification of roles and commitment of resources from all involved agencies.
- Undertake research to gain knowledge and understanding of Carp biology in three key areas:
  - Population distribution – both within the Waikato River system and its tributaries as well as other catchments and waterbodies..

- Establish the current population size – undertake population estimates (using statistical sampling procedures) in lakes, wetlands and rivers to gather baseline information on current population levels as well as ongoing population monitoring.

- Movement of the population – using biotelemetry (radiotracking), gather information on Carp movements, spawning habitats, distances travelled and preferred feeding areas

➢ Actively generate interest for Masters or PhD students to undertake these research requirements by using funds allocated in the RPMS. A nationwide approach should be made to Universities.

➢ Monitoring by undertaking surveys outside the designated containment area to ascertain the distribution of Carp. Ongoing surveillance of waterbodies and in particular those of significance and with high biodiversity value.

➢ Enforcement of legislation. Commitment to enforcement firstly requires clarification of different agency roles (Department of Conservation, Environment Waikato). Once achieved undertake prosecution of key individuals to send strong messages to the public and elevate the understanding of the legal status of Carp in New Zealand.

➢ Education through development of information such as factsheets for use both within Environment Waikato and for the public. Inclusion of information within Environmental Education Enviro-schools programme and as part of relevant displays and events.

5 Summary

The key to dealing with Carp in New Zealand is to access all relevant information that may help in the management of this unwanted organism. It is imperative that strong national as well as international links are forged and that all action is co-ordinated and well resourced. Australia forms an essential ally in providing information and skills in dealing with many aspects of Carp management. They are able to help by providing options, information, techniques as well as identifying pitfalls.

This project has investigated techniques and collected information which is extremely relevant and certainly transferable to the New Zealand situation. The information gathered from this study will be distributed amongst New Zealand organisations and will help to fill existing knowledge gaps.

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Appendix 1

Carp Program Biological Data

IFS Carp Program Fish Survey Data

Capture Date:

Processing Date:

Scribe: **Data Entered in Computer by:** **Date:**

Measurer:

Gonad Condition: 1= Immature, gonad tissue developing; 2= Gonad non-vascularised, eggs/milt visible; 3= Mature, vasularised but not running; 4= Running ripe; 5= Spent

#Do not weigh stages 1 or 2 for females or 1 for males#

Method Codes: N=Net; FN=Fyke Net; PN=Pound Net; BP=Back Pack; B=Electro-boat; P=Pits; T=Fish Traps; S= Seine net # eg. BN5 = N5

Otolith label code = Lake code+Method code+Capture date+ Number code i.e. CN51201981 (See example)

							LABEL CODE							
Fish No. (Total)	Capture Date	Length (mm)	Weight (g)	Gonad Weight	Sex	Gonad Condition	Lake Code (C/S)	Method Code (See Key)	Capture Date Code	No. Code	Otoliths Taken	Tag no.	Location	Comments
1-x(total)	*11/01/94*	*400*	*2000*	*200*	*F*	*3*	*C*	*N5 (mesh size)*	*120198*	*(1-n)/method*	*2*	*672*	*F12*	*e.g. Fish pen / Mirror/ unusual condition*

Data collection form for processing fish

DATE:		PERSONNEL:	

LOCATION: Crescent..... Soreli.... Bowdens..... Other Specify.......

Method (code)	Locatn grid ref	Time IN	Time OUT	length (m)	carp	others	ner tag nos. / notes ###NB>write down tag no.s and cross off as retrieved
total carp caught:							

RELEASED FISH DETAILS				Locations			
Length	Weight	TagNo	Pretag	Capture	Release	Method	Comments (eg Tracker number)

fill in while setting/retrieving

Method	code	tag nos.	Method	code
Single Fyke	SFN	141-200	Pit	P
Double Fyke	DFN	201-250	EF Boat	B
Mullet Net	N2.5	[illegible]	Back Pack	BP.
Gill Net	N4	[illegible]	Combination	C
Flounder Net	N5	[illegible]	Seine Net	S
	N6	[illegible]		[illegible]
	N3	3		
	N4	4		
	N5	5 & 5	other(specify)	

Tag No.s and nets to be marked on map at the front.

out in folder map sheet up

Data form for documentation of netting effort

Appendix 2

Practical thinking leads to carp removal

Thanks to an innovative trap design, professional fisherman, Keith Bell, is removing an enormous amount of carp from Macleod Morass.

The vermin fish are being used as liquid fertiliser and crayfish bait.

Keith removed another tonne of fish this week, making it 24 tonne in the past two months.

He has been able to do this due to a trap that was the brainchild of the Bairnsdale Field and Game Club and, in particular, member David Brownlow.

David, who is a landowner adjoining the Morass, built a carp trap and quickly proved the effectiveness of the design as it cornered huge numbers of the pest fish.

"We use wire enclosures to keep lambs in during winter, away from foxes, and I thought one day that they could be easily converted into a trap for carp," said David.

East Gippsland Water extended the structure, which has two inlet points that allow the fish to push through a plastic gate and move into the trap. They are attracted through the gate by the regulated flow of fresh water and due to the design of the trap inlet, cannot escape.

Keith and both East Gippsland Water and Parks Victoria gave recognition to David for the successful concept.

"David certainly proved the point and it has been very effective," said Keith.

"This is very much a pilot in many ways and if this trap works, which it certainly is, they can be introduced into other areas, not only here, but in other wetlands," he said.

Viewing the removal of the carp this week was Johlene Kelly, environmental officer with Environment Waikato, New Zealand.

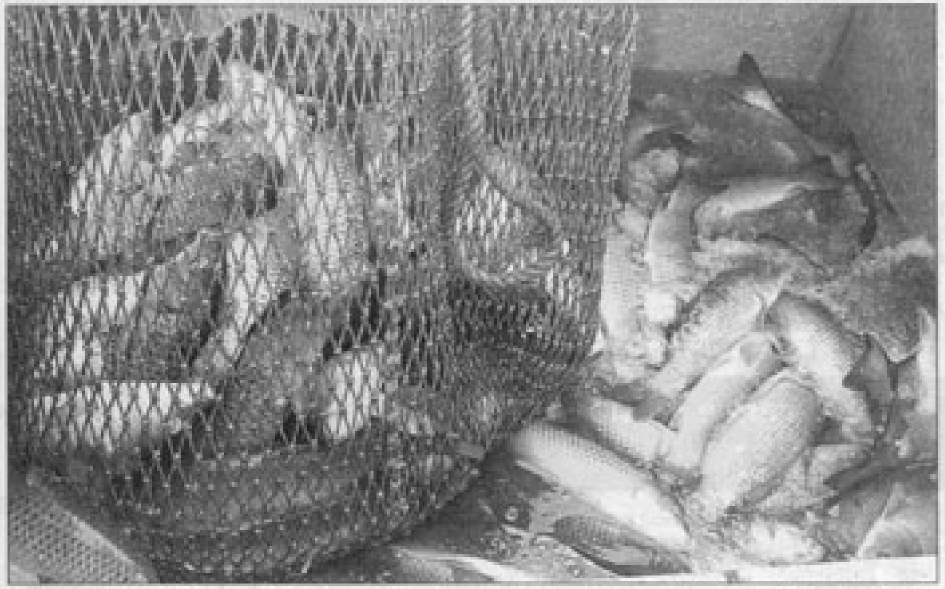
Johlene said there was a similar problem with carp in New Zealand, although it was a slightly different strain to here.

"This is a method of reducing numbers that certainly works and we have many similar type wetlands in New Zealand where this sort of thing could be introduced," she said.

Once fish have entered the trap, Keith and his staff walk a net around the outside fence of the structure and haul the fish ashore where they are loaded straight into an ice slurry for transportation.

"We pulled about a tonne out today, which would be around 300 fish, but on occasions we have been able to take more than three tonnes out of the trap at the one time," said Keith.

The trap is very simple in its design and can be constructed with very little outlay.



LEFT: Carp fisherman, Keith Bell and Johlene Kelly, from Environment Waikato, in front of the Macleod Morass carp trap (one of the inlet gates can be seen over Johlene's shoulder). RIGHT: Carp are unloaded into an ice slurry for transportation. These fish will end up as either liquid fertiliser or crayfish bait. KA95-227A221