Fisheries Notes

Carp in Victoria

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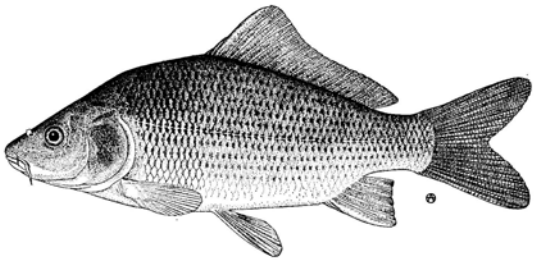
Carp has been called many names - common, European, German, Great and Chinese. Whilst in Australia the fish has until recently been known as the "European Carp", it is probable that the species had its origins not in Europe, but in Asia Minor.



The Department has now dropped the word "European" as the common name `Carp' is among the most standardised common name in the world.

The name Carp is derived from Low Latin name for the fish `carpa'. It is a name which is similar in many languages, for instance Old French, carpe; German, Karpf and Celtic, Cerpyn.

Cyprinus carpio is easily distinguished from the other members of the Carp family found in Victoria - Goldfish, *Carassius auratus* Tench, *Tinca tinca* and Roach, *Rutilus rutilus* - by the fleshy lips and small mouth with two pairs of fleshy barbels on the upper jaw.

It has a scaleless head and the body may be covered to a varying degree with heavy, curved scales. The Carp also has a long dorsal fin with from 17 to 22 branched rays.

In addition to the "standard" Carp, there are several varieties in appearance.

These are the "Mirror Carp" which has few but extremely large scales scattered over its body, and the "Leather Carp" which is virtually scaleless except for some scales at the bases of the fins.

It has been apparent since the early 1980's that Carp are interbreeding with Goldfish to produce hybrid fish which are less easy to clearly identify.

The colour varies. Adults are usually olive-green on the back, and yellowish on the belly. The fins - particularly the anal and caudal - are often reddish.

Carp have however been recovered from Victoria waters as albinos (nearly all; white) to very dark brown, almost black all over the body. The ornamental variety, Koi Carp, has colours ranging from white to gold in either solid or variegated patterns.

Carp is a native of Asia, from where it has spread by people throughout Europe, and is now established on all continents except Antarctica.

The most widely cultured food fish in the world with an annual yield of 200,000 tonnes, Carp is the world's most widely distributed freshwater fish.

Carp has been propagated in China since the first century and in Germany since the Middle Ages. It is one of the most important commercial fisheries in southern and eastern Europe, mainly in the USSR, Yugoslavia, Czechoslovakia, Hungary, Poland, Austria, Germany and France. Carp is also extensively harvested in many Asian countries.

Historical - Australian Context

Details surrounding the introduction of Carp into Australian waters are unclear.

Some authorities claim the first Carp were liberated at Prospect Hill Reservoir near Sydney in the late 1850's or early 1860's. Other state that Carp were introduced by the Geelong and Western District Acclimatisation Society in the 1870's.

Indeed, the minutes of the Ballarat Fish Acclimatisation Society for 1872 mention `Carp' as being available. These may have in fact been Goldfish.

A 1962 report by the Victorian State Development Committee concluded, however, that the species was first introduced into Australia (at the Prospect Hill Reservoir) by D.G. Stead in 1907-08.

Carp - Strains In Australia

In 1978 K.D. Shearer and J. Mulley studied blood proteins and identified three distinct strains of Carp in Australia.

- A "Prospect" strain introduced into Prospect Reservoir about the turn of the century.
- A "Singapore" strain introduced into the Murrumbidgee Irrigation Area apparently is a wild

population of Koi Carp and has colouration similar to that of the brightly coloured Goldfish.

- A "River" strain which was cultured at Boolarra in Gippsland and subsequently became established in Gippsland and elsewhere in the Murray drainage basin. This strain is frequently called the "Boolarra" strain.

It seems that the first two strains of Carp have been in Australia for many years and caused no particular problem. In striking contrast, fish of the "River" strain became very widely distributed in little more than 10 years.

Carp - The Issue

Despite the fact there was very little supporting evidence, Carp have been considered as "harmful" by Australians - particularly anglers and hunters - and also by fisheries authorities in the United States of America and Canada.

The Director of Victoria's Fisheries and Wildlife Division in the early 1970's, Mr J.C.F. Wharton, said that in general the unpopularity of Carp arose from its methods of feeding and the food taken.

Contemporary literature such as "Freshwater Fishes of Canada" published by the Fisheries Research Board of Canada in 1973 stated: *"Carp are considered detrimental to native fish populations because they increase the turbidity of the water and uproot and destroy submerged aquatic vegetation that is essential for the survival of native species, since such growth provides cover, food, and sometimes spawning sites. They also adversely affect duck populations by the destruction of rooted aquatic plants in marshes".*

A South Australian study published in 1979 warned: *"Although European Carp are considered a freshwater fish they show considerable tolerance to increased salinity, and this, together with their tolerance to other environmental factors such as temperature and oxygen concentration, means that Carp can colonise most waters throughout Australia".*

The Victorian Experience

In Victoria, the *Fisheries Act* of 1958 prohibited stocking of non-indigenous fish (including Carp) in public waters but did not prohibit them in private waters.

An application was made to the Fisheries and Wildlife Department (as it was then known) in 1960 for approval to import Carp from Germany. The Department discouraged the venture but an advertisement appeared in the country press in July 1960 inviting inquiries from farmers wanting "a fast growing and hardy fish suitable for stocking in a majority of dams and ponds".

The original inquirer had built a series of special ponds in Gippsland and had stocked them with adult Carp. Another advertisement in May 1961 stated *Cyprinus carpio* were available - and that orders of 1,000 or more would be delivered anywhere in Victoria or the Riverina.

By the end of the month Carp had been liberated in farm dams in many parts of Victoria.

In August 1961, the then Director of the Fisheries and Wildlife Department, Mr Dunbavin Butcher flew to the United States to talk to those who had studied the impact of Carp there.

In December, the sale of Carp in Victoria was prohibited. But by then, the problem was to ensure that the fish did not escape from farm dams into Victoria's river systems.

Widespread debate on Carp led to a State Development Committee Inquiry which in turn led to the passage of the *Noxious Fish Act* in May 1962.

Anyone having Carp in their control was to notify the Department; its officers were allowed to enter private property to destroy the fish; anyone possessing Carp and failing to notify the Department was liable to a fine of $1,000.

A Carp-kill program began in May 1962 to eradicate the fish before they bred in September-October. It cost 200 working days and $50,000 to poison more than 1,300 dams throughout Victoria. (The equivalent cost at today's prices would be more than $450,000). Later tests on 200 treated dams did not produce a single live Carp. The action had seemed successful.

However, about 10 months later Carp were found in the Yallourn Storage Dam a large impoundment on the Latrobe River. Chemical poisoning failed to get a total kill as expected, and by early 1964 the fish had bred. By February 1965 they were reported as `infesting' the dam and appeared in the river downstream.

In the meantime, Carp were reported from other areas of the Latrobe Valley. According to the Department, the fish had been stocked secretly and illegally in a number of private waters, without the owners' permission.

In September 1967 representatives of the Victorian Piscatorial Council, the State Electricity Commission, the Latrobe Valley Water and Sewerage Board and the Fisheries and Wildlife Department met to discuss Carp control for the Yallourn Storage Dam.

The Department tested mid-water trawl nests unsuccessfully and shelved schemes for seine netting and permanent traps as impractical.

Attention suddenly swung from the south-east of Victoria to the far north-west when Carp were found near Mildura in Lake Hawthorn, a salty irrigation drainage lake connected by a short channel to the Murray River. Fish up to 5 kg were caught and obviously had been put in the lake some years earlier. Carp were then found in the Murray River, downstream from the Lake Hawthorn channel.

Carp have since been found in the Yallourn Storage Dam, the Morwell, Tyers, Latrobe, Thomson, McAlister, Avon, Perry, Nicholson, Tambo and Snowy Rivers, Stony and Boggy Creeks and the Gippsland Lakes in south-east Victoria; the Yarra and Maribyrnong Rivers north of Melbourne; and the Murray River from above the Hume Weir west, including the tributaries of the Ovens, Goulburn, Broken, Campaspe, Loddon and Avoca Rivers, and the Wimmera River, Lake Hindmarsh, Laanecoorie Reservoir and Kerang Lakes.

Two types of control have been used on Carp populations in Victoria: poisons and commercial exploitation, mainly by electro-shocking, while two other methods, viral and genetic were proposed.

The most often used poison, Rotenone, was used with only limited success as a control agent except in a few small farm dams.

High application cost along with potential damage to the environment and non-target species of fish restricted the use of Rotenone in Victoria.

In 1962/63 other chemicals, mainly Santobrite (sodium pentachlorophenate) or Limil (lime) were used in an attempt to eradicate Carp. Although only half of the reported numbers of stocked Carp were recovered, Divisional officers reported satisfactory results.

The Department is no longer involved in the use of poisons to eradicate Carp.

Carp - The Research Proposal

In 1976 Victoria presented a document to the Standing Committee of the Australian Fisheries Council in Perth outlining a proposed "Carp Program".

The three year program, which was approved by the government at a cost of more than $500,000 was aimed at assessing and evaluating the effects that Carp may have on other species of fish and on waterbirds, and to investigate possible methods of control.

The study, which was endorsed by the Australian Fisheries Council and the Council of Nature Conservation Ministers, was also to investigate the control of Carp by one or two possible biological techniques both of which were to be approached with considerable caution.

One biological control method to be appraised was the possible use of virus called "Spring Viraemia", thought to be specific to Carp. This project was to be undertaken with the co-operation of the British Ministry for Agriculture Fisheries and Food and scientists of the University of Zagreb, Yugoslavia.

Consignments of the "River strain" of Carp would be sent to England along with non-target species of fish and aquatic animals to make sure the non-target species were not sensitive to the virus.

The other means of control to be investigated in cooperation with scientists at the Hebrew University in Jerusalem, involved subjecting female Carp to radiation.

Female Carp were to be taken from the river before they were ready to spawn and subjected to ionising radiation of an intensity which would not affect their spawning naturally with wild males but would render all the progeny sterile.

It was hoped that either or both of these programs might significantly reduce the population of wild Carp.

Carp - The Program

A Program Leader was appointed in 1979. He wrote a formal research proposal which provided an historical background to the Carp situation, stated the program's goals and objectives and outlined the tasks and activities necessary to successfully meet the requirements.

Two goals were identified:

1. To evaluate biological methods by which Carp populations might be controlled.
2. To investigate the life history patterns of Carp inhabiting lakes and rivers and to determine the effect of Carp on the aquatic environment and co-habiting species.

Goal Number 1

To meet the first goal, a geneticist was appointed in 1979. He spent seven months in Israel studying Carp at the Fish and Aquaculture Research Station, Dor. A detailed description of this work can be found in Report No. 7.

He also wrote a report which evaluated the role of genetics in the management of Victorian populations of Carp (Report No. 6).

Two methods of biological control were suggested and evaluated: viral and genetic.

Spring viraemia of Carp (*Rhabdovirus carpio*) has caused high mortalities in Carp reared at some European Carp farms. Since the virus is thought to be specific for Carp and is not already found in Australia, it was suggested as a possible eradication method.

Its possible use as a specific agent has been tested for the Fisheries and Wildlife Service at the Fish Disease Laboratory, Weymouth, England, under the direction of Dr Barry Hill, Officer in Charge.

Because there was a chance that the virus could affect other species of fish, several species were tested for susceptibility.

During 1979 to 1980, one hundred each of nine fish species were air-freighted to England for testing: Carp, Goldfish, River Blackfish, *Gadopsis marmoratus*, Flathead Gudgeon, *Philypnodon grandiceps*, Golden Perch, *Macquaria ambigua*, Silver Perch, *Bidyanus bidyanus*, Murray Cod, *Maccullochella peeli*, Southern Pigmy Perch, *Nannoperca australis* and Eastern Little Galaxias, *Galaxiella pusilla*. Of the nine species, only Carp was found to be sensitive to the virus.

Several problems apart from susceptibility to other freshwater fish have been identified:

- All species including invertebrates using the waterways would need to be tested for susceptibility. As Dr Hill believes the virus is tolerant to salinities around that of sea-water, marine species would also need to be tested.
- The virus is most effective at temperatures less than 20°C.
- For the greater part of each year the waters inhabited by Carp would be higher, therefore the virus may not be effective.
- The mode of transmission of the virus is unknown, therefore additional research is needed.
- There is no information available on the effective dose needed. All tests were made by injection of relatively

large amounts of the virus so again more research is needed.

- There is a danger of mutation of the virus. Spring viraemia is similar to rabies, viral haemorrhagic septicaemia, pike fry disease and infectious haematopoietic necrosis.
- Survivors from natural infections may develop an immunity that lasts for four months or more. Although it is presently believed this immunity may not be inherited, it is predicted that a genetic immunity would ultimately develop.
- Carp readily hybridise with Goldfish which are not susceptible to the virus. These hybrids have not been tested at Weymouth but Dr Hill believes they will not be susceptible.
- Lastly, importing the virus may be prohibited by the Office of International Epizootics.

Considering all the problems involved in introducing the virus as outlined above, and the possible problems which Carp could cause, continuation of this portion of the program was scientifically and economically unsound.

As a result, the research on spring viraemia virus as a possible control mechanism was abandoned.

By analogy with methods used for insect control, two genetic control techniques have been considered in principle. The first of these, the reduction of spawning success by the release of sterilised fish, was discounted on the basis of the high cost and environmental consequences of releasing very large numbers of Carp.

It would have been necessary to release at least ten times the existing population size.

More complex methods, involving the release of fish whose progeny would be sterile, were considered to be beyond current technology. In addition, it was concluded that the Carp population was likely to compensate for any control measures making effective control unlikely if not impossible.

Goal Number 2

To meet the second goal, six people were appointed to conduct a field study at Shepparton.

The Shepparton area was chosen because it offered a variety of habitats with differing densities of Carp as well as a site with established ponds which were needed for experimental work.

The first task for the field study was to review pertinent literature and write four reviews to familiarise staff with recent research.

Four reports were completed:

1. A bibliography of Carp studies (Report No. 2).
2. A review of the effects of Carp on fish and vertebrates (Report No. 3).
3. A review of the effects of Carp on aquatic vegetation and waterfowl (Report No. 4).
4. The biology and behaviour of Carp: a brief review (Report No. 5).

Other tasks included:

1. To determine the present geographic distribution of Carp in Victorian rivers and lakes.
2. To determine, by various capture methods and analyses, the abundance and general patterns of life history of Carp in selected rivers and lakes.
3. To determine the effects of Carp on turbidity, aquatic vegetation, invertebrates and fish. A detailed study of waterbirds was beyond the scope of the field study.

The field staff were required to write annual reports (Reports Nos. 7, 8 and 9) which collated data and assessed progress towards the stated goal.

To meet the goal, ten sampling sites (nine standing-water sites and on flowing-water site with 10 sampling stations) were used to investigate the biology of Carp and to determine the effects of Carp on the aquatic environment. An eleventh site was set up to conduct controlled experiments on the effects of varying densities of Carp on the aquatic environment.

Results - Field Study

Information obtained on the biology of Carp:

Distribution

Sampling showed that at all sites introduced species were generally more abundant than native species.

Also, Carp, Goldfish and the Carp x Goldfish hybrid were numerically dominant in only five of the 10 sites.

The remaining five sites were dominated by the introduced species English Perch (redfin), *Perca fluviatilis*, by the smaller native species the Gudgeons, *Hyseleotris sp*, or by Australian Smelt, *Retropinna semoni*.

The larger native fishes - Golden Perch, Murray Cod, River Blackfish, and Freshwater Catfish, *Tandanus tandanus* were not common at any site.

The many small native fish species including Gudgeons and Rainbow Fish, *Melanotaenia splendida fluviatilis* and Australian Smelt were found at most sites.

Carp do not now appear to be appreciably expanding their range. In the Wimmera River system however, Carp appear to be comparatively newly introduced and are being found in increasing numbers.

(Since the early 1980's Carp have established in a number of new waters, the most significant population being in Lake Eildon. Carp was first recorded from the lake by the Department in 1981. In 1997 the presence of carp was confirmed in Lake Wendouree at Ballarat, probably introduced illegally as live bait and reported, but not confirmed at date of publication from Lake Toolondo south-west of Horsham.)

By 1990, Carp accounted for 48% of the biomass of fish taken during a fish population survey by netting)

Carp are not yet (1984) present in many coastal streams, but may get into these areas either by deliberate illegal stockings or by migrating along coastal waters during freshets.

Life cycles

A few populations of Carp in Victoria are maturing at a younger age than their overseas counterparts.

Males reached maturity at approximately one year of age when they were at least 125 mm in length. With females, the age was around two years and the length 150 mm.

The number of eggs - fecundity - was related to the weight of the female Carp. Basically, the heavier the fish, the more eggs it contained. The numbers ranged from 45,000 for a 1.7 kg fish to 1,500,000 for a 6.4 kg fish.

The number of eggs was derived from `known volume' calculations which involved assessing the volume occupied by a sample of 500 - 1,000 eggs.

The spawning activity usually involved groups of two, but occasionally three or four fish, within two or three metres of shore.

Spawning occurred between September and December, at water temperatures between 17°C and 25°C. These times and temperatures are similar to those reported for Carp overseas.

The success of spawning by Carp and other species was found to be greatly influenced by fluctuations in water level.

Hybrids of Carp and Goldfish were commonly found in wild populations but were not always easy to identify. The most reliable and east to use characteristics for identifying a hybrid are the number of scales on the lateral line (1720), and the number of gill rakers (17-22) on the lower gill arch.

Age and growth

Because of the irregular and unpredictable growth of Carp, the ageing of fish using the scale method was found to be unreliable since annual growth rings were not always produced in their scales.

The growth of Carp was found to vary enormously between those habitats studied. In fact, growth varied between some of the fastest and slowest reported rates for wild young Carp anywhere in the world.

In Loch Garry, a large billabong near Shepparton, no growth was shown by Carp, Goldfish or Redfin over an 18month period. This phenomenon was first noticed from a lack of increase in mean length of the fish.

This was confirmed by the lack of growth recorded in scales of all fish and by the lack of growth shown by tagged fish on recapture.

After flooding however, the growth rate of these fish increased greatly, probably reflecting an increase in food availability. The condition of the fish, which had been previously steady, showed a similar increase.

After December however, the fish - young Carp, Goldfish and Redfin - which had spawned during the flooding, ceased growing. It seemed that the increase in abundance of food that followed the flooding was a short-term phenomenon.

There were marked differences in the relative abundance of young fish between successive years at all sites. In most cases, this was due to the direct effects of flooding and spawning success and the availability of food.

Variations in turbidity between seasons and years appear to be related to fluctuating water levels. Turbidity increased during periods of flooding and while billabongs were drying up. Interestingly, some drying billabongs without Carp had higher turbidity values than those billabongs with Carp.

Claims have been made that Carp affect plants by increasing turbidity which decreases light penetration and results in reduced photosynthesis.

As Carp did not increase turbidity they could not have had such an effect.

Aquatic plants

The feeding activities of Carp have also been blamed for adversely affecting plants by either eating or uprooting them while searching for food in or on the substrate. Carp rarely ate plants and only circumstantial evidence was found to support these claims.

There may have been some damage to shallow rooted vegetation by feeding and spawning activities at some sites. In particular, a variety of pondweed (*Potamogeton*) may have been affected this way.

These observations support reports from the Northern Hemisphere studies where the destruction of pondweed was attributed to Carp. In this study there was no evidence of Carp affecting any other species of plants. Instead, other environmental factors such as depth of water, bottom type, level of salinity, and frequency of flooding were found to be more influential.

There may be however, critical densities of Carp at which adverse effects occur.

Waterbirds

From studies of waterbirds using the billabongs, no evidence was found to suggest that Carp adversely affected, either directly or indirectly, the waterbird populations. The Australian pelican was the only bird apparently influenced by the presence of Carp and it favoured a site with most Carp.

The size of a billabong and the abundance of plant around it were more important factors influencing the variety of birds using a site.

Results- Experimental Site

Three 1-hectare ponds were filled in summer 1980/81 and aquatic plants and invertebrates were allowed to become established. Stocking of fish began in spring 1981 and experiments ended in autumn 1982.

Selected densities of large Carp were stocked into sections of two ponds, and small Carp, with and without native fish (Golden Perch, and Silver Perch) were stocked into sections of the other pond.

Several problems arose which interfered with the experiments: mesh fences broke down, channel water used for refilling altered the water quality and large masses of water couch (*Paspalum*) became a serious weed problem.

In one pond containing Carp, the dense growth of water couch caused a build-up of organic debris. Blue-green algae grew and low dissolved oxygen levels which soon developed were found to be lethal for the fish. This led to the termination of the experiment in this pond in November 1981.

In another pond, there was an increase in the turbidity of the water following the introduction of Carp, but channel water used to refill the pond contributed to the increase. Compared with field sites, including those without Carp, turbidity values were still low.

The growth of aquatic plants, especially water couch, was not affected by Carp populations. Plants such as cumbungi (*Typha*), water milfoil (*Myriophyllum*) and water couch increased in abundance during the experiment.

Generally the invertebrates community was not affected by the presence of either large or small Carp.

Only the large planktonic microcrustacean waterflea (*Daphnia*), showed greater decreases in abundance in waters containing Carp.

It is possible that this decrease was caused by Carp feeding pressure.

In the pond containing small fish and Carp survived well, whereas no Silver Perch and only one Golden Perch were recaptured suggesting poor survival. The Carp were in good condition and had high growth rates.

The above results suggests either one or a combination of the following effects: adverse effect of Carp on the native fish; a greater susceptibility of native fish to bird predation; water quality conditions (including low dissolved oxygen) in that pond which were unsuitable for the native fish.

There were insufficient recaptures of native fish to examine the overlap in diets between these fish and Carp.

Management of Carp Populations

Carp as a pest

Under certain conditions Carp may be detrimental to the aquatic environment, usually by disturbing vegetation and perhaps by increasing turbidity of the water. The population density during which Carp caused these disturbances was one of the subjects of this research.

Subject to further investigation, Carp can be said to be a pest when they occur in ecologically/recreational/economically valuable waterbodies in densities greater than 450 kg/ha.

If densities are less than this critical value they are unlikely to cause any appreciable damage to the environment.

There may be other causes for alteration or destruction to habitats, such as salinity changes, fluctuations in water levels, and alterations to catchment areas. These types of alterations may need to be evaluated in order to assess the direct contribution of Carp in destroying habitat.

Control of Carp populations

Biological control

Considering all the problems inherent in introducing the viraemia virus and the possible problems which Carp could cause, this method of control is not recommended.

The genetic controls suggested during the early days of the Carp situation are beyond our current technology. In addition, it is likely that Carp populations would compensate for any control measures making effective control unlikely, if not impossible.

Control by killing

The use of poisons to kill Carp has proved to be expensive and rarely effective. The Department is no longer involved with the use of poisons to eradicate Carp.

If cheaper, more selective and more efficient chemicals are developed, the Department should consider testing the new product.

As Carp spawn in shallow water, a lowering of water level after spawning will kill the eggs. Because of the short incubation period for Carp (4-7 days), and the possibility of fish spawning over a long period of time, repetitive lowering of water levels at short intervals would be needed to ensure that no spawnings are successful.

It is doubtful if this could be done in most impoundments in Victoria. Besides, if only a few fish spawned there still could be a large recruitment of small fish because of the large numbers of eggs that are produced by Carp.

Control by removal

As biological means of control are not available and chemical means are not feasible, the remaining option is for control by means of physical removal. This has been tried in the United States during the 1940's and 1950's with varying success.

This method relies on the simple reduction of biomass density.

Only short-term relief could be expected, if successful, from this method as recruitment from, and growth of, remaining fish can quickly replace lost biomass. Results from the Lake Cooper, Corop, commercial fishing during 1971-1982 showed that their catch of 15.2 tonnes, equivalent to 6 kg/ha/yr, was only 4% of the density estimate made in 1981. So it is doubtful that physical removal will have any positive effect at all.

In the Victorian situation, the Department probably could not be responsible for controlling Carp by physical removal because of financial and staffing constraints.

Therefore, commercial exploitation could take place when Carp have reached or exceeded the critical biomass level, if the water body had been designated to be ecologically or recreationally or economically valuable. But if commercial exploitation is to attempt to operate as a control, small fish (less than 200 mm) as well as large fish may need to be harvested. This may not be profitable for the commercial operators. So, in all, commercial exploitation may be dubious value in controlling Carp populations.

Summary

As no means of eradication are available, we must realise that Carp are permanent residents in Victorian waters and should be treated as a resource and an occasional pest.

As previously stated, Carp can be said to be a pest when they occur in biomass densities greater than 450 kg/ha in ecologically, recreationally or economically valuable water bodies. These valuable aquatic habitats should be defined by appropriate Sections of the Department. Reynolds (1979) implied that only small water supply impoundments may pass rigourous cost/benefit studies.

The Department should be responsible for determining if a particular water body needs attention.

If it is determined that the critical biomass density of Carp is exceeded, and the Department has assessed the value of the water body and the expense and efficiency of removing Carp, commercial fishermen would be brought in to reduce the numbers of Carp to below the critical level.

How far below this level the biomass density should be reduced to should depend on the profitable catch rates of commercial exploitation and the need to produce a long-term reduction in Carp density.

Follow up studies would be needed during the early stages of implementing this management plan to evaluate the effectiveness of the removal techniques and the recovery of the affected area.

Management Recommendations

As a result of the three-year program, the following recommendations were submitted to the Department.

The Department should:

1. Retain legislation which declares Carp a noxious fish.
2. Treat Carp as a resource that may be an occasional pest.
3. Adopt as a minimum level for treating Carp as a pest, a biomass density of approximately 450 kg/ha.
4. Be responsible for evaluating complaints received about problems caused by Carp that would warrant action to control them.
5. Should encourage the commercial harvest of Carp without any limit on size or number and consider subsidising markets.
6. Monitor the effectiveness of physical removal methods as a means of controlling numbers of Carp.
7. Should support research to determine whether stocking fish-eating native fish (such as Murray Cod and Golden Perch) in waters containing Carp, would provide some measure of biological control.

These recommendations were used to develop a document that clearly stated the Department's policy on Carp. This policy (Policy Statement 05-20-0107-1, 5.12.1988) states:

Because Carp Cyprinus carpio have the potential to cause ecological and environmental problems, legislation has been enacted to prevent their spread in Victorian waters. As no means of eradication are currently available, Carp are permanent residents in Victorian waters. Carp will be treated as both a resource and an occasional pest.

- *Carp are defined as being pests when they occur in biomass densities greater than 450 kg/ha in ecologically, recreationally and economically valuable water bodies, unless there are strong arguments for acting at lower biomass densities.*
- *Regional staff will be responsible for making the biomass density estimates and for reducing the biomass density in approved waters.*
- *The Department will not remove Carp from private waters, except in an isolated water located in a previously Carp-free catchment.*
- *Carp will remain on the noxious fish list.*
- *This policy covers all varieties of Cyprinus carpio including koi, mirror and leather varieties.*
- *The Department supports commercial harvesting of Carp, subject to Regional supervision.*

References

Further information on Carp may be found in the following references.

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No. 2 Bibliography of Carp (*Cyprinus carpio* L.) studies. 45p. by D.J. Hume, S. Wolfs and H.J. Pribble 1979.

No. 4 A review of the effects of Carp (*Cyprinus carpio* L.) on aquatic vegetation and waterfowl. 16p. by G.J. Smith and H.J. Pribble 1979.

No. 5 The Biology and behaviour of Carp (*Cyprinus carpio* L.): A brief review. 30p. by D.J. Hume and H.J. Pribble 1980.

No. 6 An evaluation of the role of genetics in the management of Victorian populations of Carp (*Cyprinus carpio* L.). 47p. by A.M. Brown.

No. 7 Annual Report 1979-80. 29p. by H.J. Pribble 1980.

No. 8 Annual Report 1980-81. 100p. by D.J. Hume, A.R. Fletcher and A.K. Morison 1981.

No. 9 Annual Report 1981-82. 93p. by D.J. Hume, A.R. Fletcher and A.K. Morison 1982.

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Note: Most reports are out of stock, but copies are in the Arthur Rylah Institute Library at Heidelberg.

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