THE NEW ZEALAND HYDRILLA PROBLEM

A review of the issues and management options

Geoff Walls
Advisory Scientist
Department of Conservation
NAPIER
August 1993

ISSN 1171-9834

Reference to material in this report should be cited thus:

Walls, G., 1994.
The New Zealand Hydrilla problem. A review of the issues and management options.
Conservation Advisory Science Notes No. 71, Department of Conservation, Wellington. 42p.

Commissioned by: Hawkes Bay Conservancy
Location: NZMS

SUMMARY

Hydrilla (Hydrilla verticillata) is an exotic water weed present in New Zealand in just four lakes (Tutira, Waikopiro, Opouahi and Elands) - all in northern Hawke's Bay. It is a serious problem in those lakes because it smothers native macrophytes (large aquatic water plants). It is a far more serious problem for the nation in that it has the potential to spread to other waterways throughout the country. Once there it would be unstoppable because it is resistant to herbicides registered for use in New Zealand and has the ability to weather adversity through production of masses of tubers and turions (specialised buds). At greatest threat are waterways that retain native aquatic vegetation communities and those where recreation, commercial water-based activities and hydro-electricity generation are major pursuits.

The hydrilla problem has a complex background and solutions to it have been cautiously and erratically approached in the past. This review attempts to unravel the strands of the story, examine the issues and evaluate the options. It concludes that to do nothing or defer action is unacceptable and irresponsible, and that eradication, while possible, is by no means certain if techniques were used that would not destroy the life of the lakes. Containment using existing techniques is certainly feasible, and could lead to eradication.

It is therefore recommended that either eradication be attempted now, using a combination of grass carp (Ctenopharyngodon idella), weed matting and herbicides, or a comprehensive long-term containment programme be implemented as soon as possible, using a combination of the same measures plus restrictions on boat use, net fishing and shellfish gathering, conditions on research and management practices, and education. Built into either eradication or containment should also be provision for ecological compensations for the sudden loss of macrophyte beds, and restoration of riparian vegetation and wildlife communities. So too should strict measures to ensure the impacts are confined as far as possible to the hydrilla lakes.

CONTENTS

PREAMBLE

Picture a lake in Hawke's Bay, busy with birds, fish and insects, fringed with flax and kowhai and nestled within a mantle of dark vibrant forest between sea and mountains. That is Lake Tutira as it probably was a thousand years ago, when the first people arrived. Since then the great forests have gone, and with them most of the animals. The land around has shed much of its rich soil, streams have been diverted, roads have been constructed and bleating sheep now populate the hills.

The lake endures though. It still nurtures birds and fish. It could become again a place of flax and forest. But it harbours a problem: hydrilla, an exotic waterweed that grows in a dense fringe in the shallows.

Hydrilla lurks in Lake Tutira, and also in nearby lakes Waikopiro, Opouahi and Elands. To many it is a great monster, poised to rush from the shadows, to others it is just another plant, just another management issue. Over the last decade it has been confronted in a variety of ways (by a variety of people and organisations), but it still remains to threaten. It is time for a review of those efforts and an examination of the issues and options.

It is the aim of this review to guide us towards informed and co-operative management of the monster in the lakes.

THE SCENE

Exotic introductions

New Zealand is a land of exotic introductions. Not even the mountain crests, the remote islands or the depths of the lakes are now untouched by the creatures people have brought here from abroad and the changes they have wrought. There are now more exotic species of plants resident in this country than native, and their influence gets stronger daily. So if we value the indigenous, the things which make New Zealand special on earth, we need to deliberately nurture them. And if we are to avoid the costly mistakes of the past, such as panicking about gorse, ignoring possums and using stoats in an attempt to control rabbits, then we need to look carefully and objectively at the whole scene before deciding how to act.

Waterweeds

Millions are spent each year on control of exotic waterweeds in New Zealand: in rivers, streams, ponds and lakes valued for recreation, land drainage or power generation. The worst weeds are the oxygen weeds (Hydrocharitaceae family), hornwort (Ceratophyllum demersum, Ceratophyllaceae family) and waternet (Hydrodictyon reticulatum, an alga, Hydrodictyaceae family).

The oxygen weeds and hornwort are macrophytes: large plants you can see individuals of without needing a microscope. They grow submerged in the shallows of freshwater systems, their roots or stem bases in the sediments, their long leafy stems reaching towards the surface. In New Zealand, if left unchecked, they form luxuriant beds that extinguish the native vegetation there: their natural checks are lacking. They reproduce here asexually, mainly by stem fragments and buds taking root, and can proliferate phenomenally. So far none have been recorded producing viable seeds in New Zealand. All appear to have arrived as imports for use in aquaria and garden ponds. They are now spread by water flows or - usually unintentionally - on boats, on fishing gear and with discarded aquarium contents. Oxygen weeds are so named because they can be used to demonstrate production of oxygen gas during photosynthesis. The four oxygen weeds in New Zealand are Canadian pondweed (Elodea canadensis) native to North America, lagarosiphon (Lagarosighon major) native to South Africa, egeria (Egeria densa) native to South America and Hydrilla (Hydrilla verticillata) native to Europe, Africa, Asia and Australia.

Hydrilla

Hydrilla is a perennial plant though it may have a seasonal dieback. It can grow in water at least 6 m deep, the depth limited primarily by light levels. Its vertical stems branch profusely and can form very dense exclusive communities just below the water surface. It can grow in still or flowing water, and on a range of substrates. It can tolerate a wide range of temperatures (it can even keep growing when surface water freezes - Swarbrick et al 1981), and nutrient regimes (from nutrient-rich to nutrient-poor), and can grow in brackish conditions as well as in freshwater. Just how it would compete with the other oxygen weeds and hornwort in New Zealand is not clear, though it has effectively displaced Canadian pondweed, the only other oxygen weed it has so far encountered here.

Overseas, hydrilla is used medicinally, and as fish food and manure. It is recognised for its benefits to wildlife but in many places - particularly in southern USA and in northern Australia - is seen as an enormous problem. Huge amounts are spent on research and control.

What sets hydrilla apart and creates special management problems is its ability to produce vegetative structures that can tide it over tough times. It produces underground tubers and stolons, and turions (stem thickenings produced as swollen buds at the bases of leaves). From all of these, new plants can grow. Tuber and turion production is stimulated by adversity (extremes of weather, physical damage, chemical attack). Recent studies have shown that up to 2800 turions per cubic metre can be produced, for subsequent dispersal by water currents (Thullen 1990). Tubers and turions are resistant to drying out, which means that control of hydrilla by water draw-down is not often feasible and hydrilla can be inadvertently transported long distances out of water. Tubers remain viable for up to 4 yrs, whilst turions last one or two years. Hydrilla has a tremendous growth rate in temperate conditions, producing many times its initial bulk in a single growing season. So even a single turion or tuber can produce a weed bed in a couple of years.

Internationally, hydrilla is a tremendously genetically diverse plant. It is not known just what strain is in New Zealand - the genetic stock could be quite limited - nor what range of conditions it can tolerate.

The lakes

The four lakes in which hydrilla occurs in New Zealand are all in northern Hawke's Bay. They are close to one another geographically (the greatest distance between lakes is 20 km), in altitude (160-480 asl), in aspect, and in general climate. All are in similar landscapes: gentle hill country on calcareous limestones, mudstones and sandstones. The prime land use is pastoral farming.

Lake Tutira

Lake Tutira is largest by far of the lakes (180 ha), and the deepest (maximum depth 42 m). At most 160 m above sea level (a.s.l.) it is also the lowest, along with Lake Waikopiro. Most of it falls within Tutira Recreation Reserve, administered as a public facility by Department of Conservation, Hawke's Bay. The northern 16 ha is owned by hapu within Ngati Kahungunu.

Only vestiges of native forest and flaxlands remain around the lake and now weeping willows fringe much of the shoreline. The lake is home to a considerable waterfowl population, notably black swans, various ducks, dabchicks, Australasian coots, shags and pukeko. Rainbow and brown trout have been stocked to provide a recreational fishing resource since shortly after the turn of the century, and tiger trout have been introduced more recently. There is a large eel population, and beds of kakahi (freshwater mussels) in places. The main public use of Lake Tutira is for picnicking, fishing, boating and casual camping. It is also an integral part of outdoor education programmes for children. Much research has been done on water quality, sediments, waterweeds, birds and fish. In recent years, the main inlet, Papakiri Stream (Sandy Creek), has been artificially diverted into the outlet, Mahiaruhe Stream, to control flooding and diminish eutrophication.

The first discovery of hydrilla in the wild in New Zealand was in Lake Tutira. Although its presence was known in the early 1950's, it was not until 1963 that it was officially identified. Then it was not abundant, and was patchily distributed around the lake margins (Grant 1965). It now forms a dense fringe in the shallows of the lake along with Canadian pondweed. This fringe is approximately 10% of the area of the lake and has been estimated to occupy about 3.3% of the total water volume.

Swans browse the oxygen weeds to about a metre below the water surface. Control methods to prevent the spread of hydrilla have so far been limited to small-scale mechanical control near boat haul-out sites, banning of boat motors, restriction of eeling using nets and erection of warning signs.

Lake Waikopiro

This small lake, 11 ha in area, is virtually joined to the south end of Lake Tutira: they are separated only by a narrow piece of land and sometimes their waters mingle. Maximum depth is 15 m. Lake Waikopiro is within Tutira Recreation Reserve and in terms of ecology and human use is part of the same system, although for most people the larger lake is the main attraction.

Hydrilla and Canadian pondweed form the same kind of dense fringe in the shallows of Lake Waikopiro as in Lake Tutira, and occupy about 20% of the lake area. They have probably both been there almost as long as they have in Lake Tutira.

Lake Opouahi

In terms of remaining natural values, Lake Opouahi is the pick of the four lakes. It is the highest (480 m a.s.l.) and second smallest (6 ha). It is steep-shored and surprisingly deep (maximum depth 24 m).

The lake is fringed with dense reedlands of raupo and sedges, backed by vigorously regenerating native bush and scrub containing a wide range of plants.

People used to come here for eels. Now they mostly visit for picnics, to walk the track around the lake, to look for birds or to fish for rainbow trout. The lake is within Opouahi Scenic Reserve, administered by Department of Conservation, Hawke's Bay.

Hydrilla was first detected in the lake in 1984. It may have arrived from Lake Tutira in an eel net, although this is not known for sure. From an initial patch near the jetty at the south-western end it has now spread and forms colonies around much of the lake's margins. In total, hydrilla probably occupies less than 5 % of the lake area. Motorised boats are banned, as is eeling with nets. An attempt has been made to smother the hydrilla near the jetty with a weed mat, with partial success. A sign warning about the presence of hydrilla has been erected.

Elands Lake

Elands Lake, privately owned, is the smallest of the four lakes (4 ha) and the shallowest (maximum depth 7 m). At 260 m a.s.l. it is between lakes Tutira and Opouahi in altitude. It is land-locked, being spring-fed and having no outlet. Sheep and cattle graze to its edge. Rainbow trout were established and stocked there until 1960, but have now gone.

Hydrilla was first detected in Elands Lake in 1987, but may have been there for many years. It is possible it might have been transported with bullies (Gobiomorphus cotidianus) introduced as a food source for trout from Lake Tutira. By late 1988 it was estimated that hydrilla occupied 25 % of the area of the lake, forming a dense continuous submerged band (Clayton et al 1992).

In September 1988, virtually the entire area of hydrilla was treated with the herbicide diquat, which is used to successfully control other oxygen weeds in New Zealand. However, it had no discernable effect. In November 1988, 400 sterile (triploid) Chinese grass carp (Ctenopharyngodon idella) were introduced to the lake. Within 17 months, the hydrilla biomass had been reduced by over 99% and by April 1991 the beds had gone. Now only a few plants remain beneath logs and branches and in shallow water amongst native turf communities. It is planned to use smaller carp to reach these, and to maintain carp in the lake for at least a further 5 years to ensure no regrowth from remaining turions, tubers or stolons.

This trial in Elands Lake has taught us much about how to tackle hydrilla in New Zealand. It has answered numerous questions and posed others, and provides a platform from which to plan the management of the weed in the other lakes.

People of the lakes

A look at the files on hydrilla and the lakes reveals a fascinating history of people, debate, ideas, research, knowledge and action. But it is a glimpse into only a small and recent piece of history. What is starkly lacking is a further and wider look - a consideration of the wisdom, knowledge and perspectives of the people who have lived with these lakes and the land around more intimately and for far longer.

People have lived around and relied on these lakes in northern Hawke's Bay for hundreds of years. At Lake Tutira there were permanent dwellings and seasonal camps, gardens, orchards and managed wild crops long before Pakeha arrived. The lake was renowned for its eels, its birds and kakahi (mussels). The flax that grew in the water was famous as rongoa (medicine), and that which grew on dry land was good for ropes, nets and weaving. The aruhe (bracken root) was sought after and managed. Other bush foods and materials were harvested seasonally. The use on the lake of mokihi (rafts) made of raupo by Ngati Kurumokihi is renowned.

Lake Opouahi was also famed for its eels. Nearby were pa (fortified retreats) and kainga (settlements), gardens of kumara and taro and areas of good aruhe. Further uphill were the forests of Maungaharuru, which at certain seasons abounded with birdlife, and the high ridges where titi (muttonbirds) had their burrows.

There are old trails threaded through this countryside. Elands Lake must have been close to the route through the saddle of Titiokura to the Mohaka River. People moved seasonally along these trails for the harvests. The lakes were between the sea and the mountain hinterland, and must have been much visited.

This was obviously a land rich in resources, and there were many battles for possession. Each lake has its stories. So too each peak and each valley. The sites of the old kainga, pa, urupa (burial grounds), gardens and harvest areas are known. The key times for the seasonal harvests are known too, but most of those traditional harvesting opportunities, with the exception of the eels, have now gone. Nevertheless, the traditional knowledge can guide future management and restoration.

Hapu within Ngati Kahungunu now have authority over the lakes area. Several hapu are involved.

There is Pakeha wisdom of the area to be acknowledged and guided by too. Land in the area has been in the management of pioneer families for generations. Most notable though is the association of Herbert Guthrie-Smith with the area, and with Lake Tutira in particular. He saw the lake and its hinterland through unprecedented changes, and carefully documented his natural history observations. He made a bathymetric survey of the lake in 1925 and made detailed notes on birdlife, fish and vegetation. His book on Tutira (Guthrie-Smith 1921) is his most famous, and a tremendous reference source for the lake and its surrounds.

Who is responsible?

There is legislation to clarify just who has responsibility for hydrilla in the lakes of northern Hawke's Bay.

Hydrilla is currently classified as a Class B aquatic noxious plant, under the Noxious Plants Act (1978). This means that it is regarded as a national nuisance, but that owners of places where it occurs are not obliged to control/eradicate it at present. However, there are controls on deliberate export, transfer or sale. In mid 1993, the Biosecurities Act (1992) is due to replace the Noxious Plants Act (1978). Hydrilla is seen by MAF Regional Authority as a plant of national concern and would require eradication or control as declared under this new Act.

Department of Conservation are the main owners involved, and the Ngati Kahungunu owners and Elands Station to a lesser extent. The Hawke's Bay Fish and Game Council, as lessees of the Maori land at Lake Tutira, also have responsibility. The Hawke's Bay Regional Council is the local noxious weed control authority and has this and various other responsibilities under the Resource Management Act (1991).

The Reserves Act (1977) places responsibility on Department of Conservation to control and if possible eradicate weeds in areas reserved for conservation purposes under the Act. This applies to Tutira Recreation Reserve and Opouahi Scenic Reserve.

The responsibility then lies most firmly with the Department of Conservation, hence its initiation of this review to guide future management. That management though can only proceed with the co-operation of all landowners.

Those whose operations are potentially threatened by hydrilla also have a stake in the issue and clearly stand to benefit from eradication or containment of the weed in the sense of not incurring costs in the future should it spread into the waterways they use. They could therefore be reasonably expected to contribute towards the costs of eradication and containment operations and of research. The most obvious agency in this situation is Electricity Corporation of New Zealand Ltd.

Research agencies that possess knowledge and experience of most aquatic systems, waterweeds and their control are National Institute of Water and Atmospheric Research Ltd. (NIWAR) and Ministry of Agriculture and Fisheries (MAF Qual). Electricity Corporation of New Zealand Ltd and Manaaki Whenua-Landcare Research New Zealand Ltd also have considerable expertise.

Who cares?

Many people care about the issue of hydrilla in our lakes, some passionately. There has been a whole spectrum of responses to it ranging from indifference to hysteria, from parochialism to holism, from timidity to bullishness. There's no doubt it is a complex issue, and whatever the outcome people with particular interests will be affected in different ways.

There is urgency in the situation, generated both politically and from the rampant nature of the hydrilla itself. It is a time for clarity of vision rather than myopia and for informed decisiveness rather than dithering.

A quick listing of those most concerned follows:

Owners/authorities

Department of Conservation
Hapu within Ngati Kahungunu
Elands Station
Hawke's Bay Regional Council
Hawke's Bay Fish and Game Council

Recreation groups and individuals

Fishers (for eels and trout)
Picnickers
Tramping clubs and other walkers
Bird watchers (including Ornithological Society of NZ)
Royal Forest and Bird Protection Society
Guthrie-Smith Trust
Small-boat users

Industries
Electricity Corporation of NZ Ltd
The tourism industry

Researchers
Historians
Archaeologists
NIWAR
MAF Qual
Department of Conservation
Manaaki Whenua-Landcare Research New Zealand Ltd

THE ISSUES

1. How much of a problem is hydrilla?

This is a vexed and complex issue. Various effects balance each other, or work both ways. The issue can be clarified by looking at the benefits of hydrilla and what it threatens, both in the lakes where it occurs and elsewhere.

The analyses of the benefits and threats from hydrilla and other oxygen weeds of Clayton and Wells (1989), Froude and Richmond (1990), Henriques (1987) and Hill and Hoddle (1991), along with information from a range of other sources, form the basis of the following evaluation.

Benefits of hydrilla

Most of the benefits of hydrilla are in common with those provided by oxygen weeds and other macrophytes in general. Such plants play constructive ecological roles in every waterway in New Zealand, and may have other values as well. First of all is the provision of habitat diversity, which results in an increase in the biomass and diversity of animals. Food is provided for herbivores such as swans, coots, koura (freshwater crayfish), snails and some fish. No doubt the large number of swans at Lake Tutira owes a lot to the presence of hydrilla. Detritus feeders get the benefit of dead plant material. Animals such as dabbling ducks, dabchicks, eels and trout feed on the smaller animals (mainly invertebrates and little fish) that shelter among the plants.

Eels and trout may themselves use the hydrilla beds for shelter, especially whilst young when the risk of predation is greatest. Just how important exotic oxygen weeds are to these fish is not clear. There have been various studies of the relationship, especially relating to trout, but these give contradictions and a confused picture. Overall, the value of these weeds to the trout fishery, especially for rainbow trout that primarily feed in open water, has been regarded as slight (Fish 1963).

Oxygen weeds act as nutrient pumps in the aquatic system, absorbing large quantities of important elements and compounds such as carbon dioxide, nitrogen, phosphorus and calcium from the water and substrate, whilst providing significant local quantities of oxygen. They can also accumulate substances such as arsenic. On decomposition, the nutrients are released back into the water and sediments. So the hydrilla is obviously contributing to a cycling of nutrients within the lakes of northern Hawke's Bay, and could do so elsewhere.

Macrophytes filter suspended solids from the water, slow water flow and trap sediments, thereby improving water clarity and helping ameliorate the effects of sudden increased sediment inflow or mobilisation. They also stabilise unstable substrates and cushion the effects of wave action, thereby reducing lakeshore erosion. Hydrilla, with its good root system and much-branched stem structure, undoubtedly does these jobs quite well, and provides greatest benefit to the most wave-prone shores (such as the south-eastern shores of Lake Tutira), although it is not tolerant of high wave action.

All the plants in an aquatic system compete somewhat for the available space, nutrients and sunlight. Therefore the presence of macrophytes such as hydrilla can have a regulating effect on other plants such as planktonic and bottom-dwelling algae. Because the relationship is not as direct and simple as all that though, just how important this effect is in the hydrilla lakes is not known. A suggestion has been made (Johnstone 1985) that hydrilla could exclude hornwort, which is one of the worst weeds of hydro lakes in New Zealand, though experimental culture of both species together showed no evidence of that effect (J. Clayton pers comm).

Finally, hydrilla and other macrophytes have many uses in other countries: as fertilisers, stock food, fish food, compost and mulch, in biogas production and in medicine. They can be readily harvested, and contain at least as much crude protein and mineral matter as terrestrial forage crops. Classification as a noxious weed would prevent hydrilla being used for such purposes in New Zealand.

Threats posed by hydrilla

The threats posed by hydrilla come from a variety of its attributes. Overseas it can tolerate a wide range of growing conditions: from cool-temperate to tropical temperatures; from nutrient-rich (eutrophic) to nutrient-poor (oligotrophic) situations (it has nitrogen-fixing bacteria in its roots to cope with the latter); from neutral to alkaline pH; in estuarine (brackish) or freshwater systems; in water up to and perhaps more than 6 m deep. It could potentially therefore colonise most freshwater systems throughout New Zealand.

Hydrilla has very rapid growth rates and a prolific nature, giving it the ability to rapidly colonise available sites and out-compete other vegetation. It can disperse readily within water bodies and can cope well with adversity, responding to attacks on it by production of masses of turions and tubers that can ride out hard times.

Added to this is its resistance to the chemical herbicides that are used to most readily and cheaply control other waterweeds.

These features combine to make hydrilla one of the worst waterweeds in this country. What it threatens is elaborated on next.

(a) Actual: threats to the lakes where it occurs

Native aquatic vegetation communities are threatened directly by hydrilla, especially in sites sheltered from much wave action. The hydrilla simply smothers them, totally excluding the natives. This has consequences for the fauna there, not only providing a radically changed habitat, but reducing habitat diversity. Native fish, invertebrates and diving birds are most affected (Williams 1984). Most of the shallows of lakes Tutira, Waikopiro and Elands have been smothered by hydrilla like this. Lake Opouahi is less affected so far: it still has most to lose.

Water circulation and shore wave action are reduced by dense weed beds, enhancing deoxygenation of water and sediments locally. This, coupled with the process of weed decomposition, can lead to lowering of water quality and conditions unsuitable for fish and invertebrates. Such local deoxygenation has recently been recorded in Lake Tutira.

In lakes with rich sediments and nutrient-poor waters, dense weed beds can 'pump' nutrients from the sediments into the water, promoting eutrophication (Clayton and Wells 1989). All four hydrilla lakes fall into this category, but again the extent of the effect is not certain.

Hydrilla beds are of direct nuisance value to bathers, divers, anglers and boaties, especially in Lake Tutira. There is a risk of accidental drowning through entanglement, especially for children, and possibly for diving birds. Plant material cast ashore following storms not only impairs access to the water and beaches but is unpleasant while it lies there putrefying: this is only a minor problem in the hydrilla lakes though.

Hydrilla, like other waterweeds, supports snails of the variety that host the water-borne protozoa that cause "duck itch" or "swimmers itch". It follows that if these snails and protozoa are present, then the presence of large beds of hydrilla will greatly increase their abundance.

Activities that are curtailed most by the presence of hydrilla are eeling and boating. Because of the risk of spread of hydrilla on eel nets, use of them could only be countenanced at present if the nets never left the lakes where they were used. Motor boats are banned from the lakes, partly because of the potential disturbance to wildlife, but because of the great risk of fragmentation of the weed and transfer on or in motors.

(b) Potential: threats to water bodies elsewhere

All of the threats outlined in (a) above are potential problems for water bodies that could be colonised by hydrilla. Because other water bodies have different attributes and uses than the limited ones of the northern Hawke's Bay lakes, the range of potential threats and their magnitude is far greater.

The systems at greatest ecological threat are the few remaining waterways not already have oxygen weeds and other exotic macrophytes. These include lakes like Waikareiti and Rotomahana. Their native plant communities would be devastated by hydrilla. In other systems, like Lake Taupo, there are areas free of exotic macrophytes: these too would be radically modified by hydrilla.

Even for waterways already invaded by other exotic macrophytes, hydrilla is a threat. Because of its resistance to chemicals routinely used to control the other weeds, hydrilla would be very difficult and costly to control. This is a huge and looming issue for hydro systems, drains and waterways where tourism is based around commercial boating, fishing and shore-front accommodation.

Typical problems encountered overseas where hydrilla is a weed include (Hill & Hoddle 1991):

- interference with water use (fishing, boating and general recreation, including water-skiing, diving and tourism). Weeds become entangled on yacht keels, outboard motors and fishing gear, and access to open water from beaches, jetties and boat ramps is impaired.

- impaired drainage, causing flooding and eutrophication.

- blockage of water intakes, including hydro schemes, causing big power generation losses.

- devaluation of properties on waterfronts from the masses of storm-wrecked and putrefying weeds.

- aesthetic impairment from the trapping of floating litter in surface weed.

Most of these effects are already caused by the other exotic macrophytes that have become prolific in New Zealand, so it is reasonable to expect them of hydrilla should it spread. The difference is that whilst the other exotic macrophytes can be fairly readily controlled at present, hydrilla cannot, so the potential scale of the problems and control costs is much greater.

The verdict

Hydrilla has already done most of the ecological damage that could be expected of it in lakes Tutira, Waikopiro and Elands. It poses a continuing impediment to restoration of natural aquatic features there. Lake Opouahi though still retains significant communities of native aquatic vegetation and associated fauna: these are being progressively overcome by hydrilla right now.

Because of its ability to grow in a wide range of conditions, its tolerance of adversity and its resistance to chemical control, hydrilla could potentially establish in virtually every other water body in New Zealand. The benefits that are likely from this are:

- increased food for wildlife, especially exotic birds.
- increased shelter for some aquatic fauna.
- increased nutrient cycling (though this could also be a threat).
- increased water clarity through filtering of suspended solids, stabilisation of unstable substrates and reduction of wave action.
- some regulation of other aquatic plant life.
- provision of material for use as fertilisers, stockfoods, mulches, composts and medicines.

These benefits though are minor, and only apply if other macrophytes are not already providing those functions. Major threats are posed to:

- ecological values, especially of water bodies that retain native aquatic vegetation but also to fish and wildlife in modified ecosystems.
- water-based recreation, in many of its forms and including human safety and health.
- shore-front values, including property values.
- tourism based an commercial use of water systems and shore-front accommodation.
- land prone to flooding if drains and other water channels become clogged.
- hydro schemes.

It is obviously a matter of opinion, but overall the benefits appear slight, whilst the threats are huge. Like it or not, hydrilla is a serious potential problem for the nation and we cannot pretend otherwise.

2. Tangata whenua perspectives and concerns

Local Maori knowledge, hopes, fears and wishes have been consistently left out of the equation in past evaluations of the issues and options regarding the hydrilla situation in the northern Hawke's Bay lakes. The following is a brief listing of the main concerns of the Ngati Kahungunu hapu who have authority over the lakes:

a) The Ngati Kahungunu hapu are uncomfortable with the continued presence of hydrilla in the lakes because:

- it constitutes a threat to other waterways in the region and in New Zealand as a whole.
- it prevents eeling, for which lakes Tutira and Opouahi have been traditionally renowned.
- it prevents restoration of the famous rongoa (medicinal) flax beds that used to grow in the shallows of Lake Tutira.

The hapu lament the loss of their traditional eel fishery and rongoa flaxes, and would dearly like to see them restored.

b) The Ngati Kahungunu hapu lament the loss of other useful plants, especially the valuable flaxes that used to grow on the land around the lakes, ti kauka (cabbage trees) and other native plants that were valuable for food, for rongoa and for native wildlife. They would like to see them used in revegetation efforts on the lake margins.

c) The Ngati Kahungunu hapu would like the urupa, fighting pa, kainga and other historic sites at the lakes properly looked after.

d) The Ngati Kahungunu hapu place a high value on the history of the lakes and the region. They primarily request that their history, that of the tangata whenua, be respected. They also request that the history of the Pakeha in the region be respected.

3. Conservation perspectives

In this review of the issues and options surrounding hydrilla in New Zealand, it is acknowledged that all parts of the scene are connected and interdependent. Also, the emphasis is firmly on protecting and nurturing that which makes New Zealand special on earth. In other words, where choices have to be made, conservation of the indigenous is regarded as more important than conservation of the exotic, and the rarest plants and animals take precedence. Furthermore, things of national value, or at risk nationally, must take precedence over those of local value, or at risk locally.

With that firmly in mind, basic issues relating to conservation of plants, animals, landscapes and waterways are outlined to make sure they are included in helping shape management of the hydrilla problem.

Plants

Hydrilla is an exotic plant. So too are Canadian pondweed, willows and wattles. By definition, these and the other exotic plants in and around the hydrilla lakes are unwelcome unless they are of particular value to such things as native wildlife, water quality and land stability.

Conversely, plants such as red pondweed (Potamogeton cheesemanii), raupo, flaxes, kowhai and ti kauka (cabbage tree) are native to the hydrilla lakes and should be fostered.

To be consistent with conservation principles, management of the hydrilla problem ought to reflect this distinction. So options should be designed or chosen to benefit or favour native vegetation where possible, if not in the short term then certainly in the long term. Any restoration work in particular should encourage or use primarily native plants.

Animals

Exactly the same principles apply as with plants: management should aim to favour native animals. In the hydrilla lakes, trout, swans, mallard ducks and cattle are exotic intruders in the ecosystem, whereas eels, koura, kakahi, grey ducks, dabchicks and bitterns are natives at threat. Paradise shelducks, though native, are not threatened, either nationally or locally.

Water

Is water a commodity, to be manipulated, restrained and modified to conform to human desires? Or does it have a nature of its own, that ebbs, flows, surges and runs when it has the freedom to do so? With the exception of Elands Lake, the hydrilla lakes have definite and active inflows and outflows, and all have beaches and wave-cut shores that have formed from fluctuations in water level and the action of waves.

To conform with conservation principles, management options should aim to go with and accommodate the flows and fluctuations rather than attempting to confine or manipulate them.

Land

The landscapes around the hydrilla lakes have been radically modified - native forests have been mostly replaced by exotic trees and pasture. Even the landforms have been altered with roads, stock tracks and accelerated sheet erosion.

If management is to mesh with conservation principles, it should aim to enhance the indigenous character of the land around the hydrilla lakes: to foster clothed stability rather than naked erosiveness, and to work with natural contours rather than impose those that clash with them.

4. Social issues

Who uses the hydrilla lakes, what do people think of water weeds, what are their attitudes to various proposed control options, how do they perceive local bodies and government departments? These questions require some unravelling before the perspectives they reveal can be included in forming an approach to the hydrilla problem.

Lake classification and use

Lakes Tutira and Waikopiro are classified reserves catering primarily for recreation. Although they and their surroundings are highly modified, they have significant natural values and provide strong conservation and restoration opportunities. They lie beside a busy highway. They are probably used by more people than any other Hawke's Bay lakes. People mainly visit for (in alphabetical order):

- angling
- artistic inspiration
- bird watching
- boating
- camping
- conservation management
- diving
- farm management
- outdoor education
- picnicking
- research
- roadside rest
- spiritual reasons
- swimming
- traditional food
- traditional medicine
- walking

A minority of users will live locally, but they will probably feel most strongly about any proposed management. Most others are probably Hawke's Bay residents who regard the lakes as part of their heritage and accessible hinterland.

There is a wide spectrum of human use then, with potential for conflict between user groups. There is a clear need to recognise this in approaching the hydrilla problem, and to attempt a harmony in choosing options for management.

Lake Opouahi is within an area that still retains important natural features and is set aside primarily for conservation. It is relatively small and off the beaten track. People visit mainly for:

- angling
- artistic inspiration
- bird watching
- conservation management

- diving
- farm management
- picnicking
- research
- spiritual reasons
- traditional food
- traditional medicine
- walking

The range of uses is a little less than for lakes Tutira and Waikopiro, but the degree of use is far less. Nevertheless there is still potential for conflict.

Elands Lake is essentially a large private farm pond that is very little visited by the public. People mainly use it for:

- angling
- duck hunting
- farm management
- research

Because of the restricted range of use and inaccessibility to the general public, the likelihood of conflict is relatively low.

Public perceptions

The files reveal as wide a spectrum of opinion as there are users of the hydrilla lakes, and as many attitudes to hydrilla and potential management methods as there are writers on the subject. Talking with people confirms and embellishes this. The most reasoned approaches come from impartial observers, but there are few of them: everyone has an opinion, a vested interest, a personal bias.

In general, people value the lakes for their own chosen use. They love trout, ducks and swans. They are frightened by the spectre of hydrilla, and other waterweeds. They are even more frightened by some of the proposed management tools, notably herbicides and grass carp. They are suspicious of local authorities, research agencies and government departments, whom they suspect of having hidden agendas. They want to be consulted before decisions are made.

Despite a massive flow of paper and numerous meetings, there is a great deal of myth, misinformation and misconception surrounding the hydrilla problem. This is probably because of lack of adequate consultation and publicity in the past. There is a lesson to be learnt from this, and a lot of ground to be made up.

5. Political issues

No consideration of the hydrilla problem can escape the politics of the scene. There are four main aspects.

a) The problem of waterweeds

There is something of a panic over waterweeds in New Zealand at present. This is understandable, because their history so far is one of rampant replacement of native aquatic vegetation and massive impairment of recreational, commercial and industrial use of waterways. The costs of control are escalating. Waternet (Hydrodictyon reticulatum) is a current management nightmare, and on evidence hydrilla could become one too.

Politicians and policy managers see the need then to nip problems in the bud in order to save massive costs later. There is, accordingly, increasing pressure to act on hydrilla.

b) Roles and responsibilities

There are so many agencies and individuals involved in the hydrilla problem, and so many levels of involvement, from on-the-ground managers to central government politicians, that clearly defining roles and responsibilities is not easy.

It is a challenge for consensus and co-operation, which if not met soon must lead to imposition of autonomous action by the leading players.

c) Power struggles

Even a random delving into the files or a brief conversation on the hydrilla problem will give a hint of the struggles of user groups and local authorities to influence the way it is managed. This provides yet another challenge for consensus and co-operation.

d) Science restructuring

The increasing commercialisation of science in recent years has created pressures that directly and indirectly impact on the hydrilla problem. The most conspicuous of these is the situation regarding grass carp. There is a sudden requirement for the grass carp research programme to pay for itself or collapse, with the likelihood of the fish stocks and breeding capability going private in the near future and perhaps being lost altogether. In the light of this situation, the pressure to make a prompt decision about the future use of grass carp in management of hydrilla has been mounting and become less subtle.

Ultimately, just how the hydrilla problem is tackled following this review and the subsequent consultation - in other words who does what, how, when and who pays - may involve political or policy decisions at a national level.

6. Research

The hydrilla problem has had a great deal of research lavished upon it, both in New Zealand and overseas. Aspects covered in detail include:

- the plant and its biology
- what is threatened by hydrilla
- chemical control methods
- mechanical control methods
- biological control methods
- hydrology of the lakes
- wildlife of the lakes (native and exotic)
- aquatic vegetation of the lakes (native and exotic)

So there is now a great deal of technical and environmental knowledge which can be brought to bear on the hydrilla problem, and research continues.

Aspects that are less well researched and for which there are outstanding questions include:

- hydrilla's competitiveness with other oxygen weeds in New Zealand.
- hydrilla's resistance in New Zealand to chemical herbicides that kill it overseas.
- hydrilla potential for growth in waterways of different water and sediment chemistry and climatic regimes in New Zealand.
- exactly how long turions and tubers of hydrilla remain viable in New Zealand conditions.
- precise impact of hydrilla presence on wildlife and water quality.
- precise impact of hydrilla removal on wildlife and water quality.
- statistical data on social impacts and community perceptions of various management options.
- the precise chances of grass carp being able to breed in the wild in New Zealand.

For most of these questions, the answers would not affect the basic situation. There is always the need for more research, and there are always those who will seek more information before making a decision. **However, it is felt that there is sufficient proven knowledge now to confront the major issues of the hydrilla problem and to do an informed analysis of the management options.**

THE OPTIONS

There are three broad options for management of the hydrilla problem:

1. **Do nothing/defer action.**
2. **Eradication.**
3. **Containment.**

Each has attendant costs and benefits. The following is a discussion and analysis of the consequences and practicality of each in turn, in the light of the background and issues already discussed in this review. The focus is deliberately on the principles, because once they are sorted out, the techniques can be chosen and tailored accordingly.

1. Do nothing/defer action option

This is a wait-and-see mode, which bows to the complexity and difficulty of the situation rather than the magnitude and urgency of the problem.

a) The costs

There will be little risk to Lakes Tutira, Waikopiro or Elands. However, in Lake Opouahi, virtually all native aquatic vegetation communities will be replaced with dense hydrilla beds in only a few years, thereby destroying a natural system in a distinctive Hawke's Bay lake.

Eel fishing with nets or hinaki will need to be prohibited in any of the lakes, because of the risk of spreading the weed on nets. Harvesting of kakahi (freshwater mussels) will similarly become prohibited, because of the risk of transfer of tubers and turions. Restrictions on recreational activities will need to be tightened too, for the same reasons.

The longer hydrilla remains in the lakes, the more likely it is to be spread to waterways elsewhere. Natural vectors such as birds and wind are very unlikely to carry plant matter, but humans could, either inadvertantly or deliberately. The analysis by Johnstone, Coffey and Howard-Williams (1985) has shown that hydrilla is not easily transferred far by recreational boat traffic, but live material could be transported much further in damp nets, dive suits, aquaria or containers. Because hydrilla's tubers and turions are so resistant to drying out, they could be picked up in mud, be carried large distances, survive the journey and produce plants once they contacted water.

The fact that hydrilla has been around for 40 years or so in New Zealand and hasn't got far is no cause for complacency. For it has spread in that time, to three other lakes and over a distance of 20km. The pattern of spread of other oxygen weeds, and aquatic weeds in general in New Zealand has been remarkably similar where not deliberately transferred: initial appearance at a site, buildup there to become a local problem, spread to other waterways in the region, then eventual widespread occurrence. All this has taken place in only a few decades. Hydrilla may seem to be a little slower than some, but its eventual spread throughout the country appears inevitable unless some intervention to minimise the risk is taken.

The greatest risk then of doing nothing is of missing the opportunity for eradication or containment, thereby incurring huge future costs to the nation of hydrilla management once it becomes widespread. This is enormously heightened when the potential for what might happen were other strains of hydrilla to be introduced to the country is taken into account. The strain now in New Zealand has been crossed in overseas experiments with other strains, to produce new plants that grow prodigiously and produce masses of seeds that can be spread by wind, birds or people.

b) The benefits

The benefits of no intervention lie in lack of immediate disruption to the status quo and in buying time for future developments.

The macrophyte beds of the hydrilla lakes would not be disturbed, thereby retaining existing waterfowl populations, recreational fishing and shore structure. This should please most recreationists, who would continue to be able to see large numbers of swans, to catch trout reliably and to picnic and boat as at present.

The risk of deliberate malicious spread of hydrilla to other waterways by those strongly interested in perpetuation of the status quo would be minimised. Threats along these lines have been issued in the past, and should not be underrated.

In time, new techniques for dealing with hydrilla may be developed. These are most likely to be along the lines of more effective herbicides, alternative biological control agents and integrated systems of control. Research into them continues apace overseas, but no startling new developments seem on the immediate horizon.

The other obvious benefit of doing nothing is that it is very cheap in the short term.

c) Practicality

This option is certainly practical in the short term, but it carries an element of explosive danger. In the longer term, the time-bomb is bound to go off, and some sort of action will be essential.

2. Eradication option

For those who see hydrilla as a looming and urgent problem, eradication of the weed as soon as possible is imperative. They are right, but it would be costly and disruptive, and may not be feasible as yet.

There are various potential techniques available at present:

1. **Lake-level draw-down (lowering of water level).**
2. **Chemical methods: herbicides.**
3. **Mechanical methods: harvesters, mats.**
4. **Biological methods: grass carp.**
5. **Light-absorbing dyes.**

These could be used either alone or in combination. Their feasibility and consequences are examined in relation to the whole principle of eradication.

a) The costs

Whatever technique or combination of techniques was used, there would be major disruption of the lake systems, for as long as it took for eradication of hydrilla and the subsequent re-establishment of native plant communities.

All would have to totally eliminate the macrophyte beds of the lakes to be effective, which would lead to temporary loss of swans, other herbivorous waterfowl, and those that feed on the fish and invertebrates that rely on the plants (Williams 1984). There would probably be some decline in the trout fishery too, brown trout and tiger trout being affected more than rainbow trout. Eels would be affected too, since they are known to prefer some sort of cover for shelter from the light in the daytime, and are far more abundant in enclosed waterways that have rank marginal vegetation (Jellyman & Todd 1982; McDowall 1990). Loss of macrophytes would lead to increased wave action on exposed shores, particularly south-eastern Lake Tutira, with a consequent increase in erosion and water turbidity there.

Stringent precautions would have to be taken to ensure hydrilla was not inadvertently transported during the operation. The greatest risk would be during mechanical operations.

There has been much alarm expressed at the prospect of algal blooms following macrophyte removal, but so far the local evidence suggests it is unlikely in the hydrilla lakes. Removal of the macrophytes from the relatively small and shallow Elands Lake, Parkinsons Lake and Waihi Beach Reservoir has not resulted in algal blooms or major changes in water quality (Clayton et al 1992, Mitchell 1980). Lakes Tutira, Opouahi and Waikopiro are bigger and deeper than those lakes, and proportionately less occupied by macrophytes, so might reasonably be expected to respond even less. Should algal blooms occur though, there would be control costs, for example in the use of fish such as silver carp (Hypophthalmichthys molitrix), in herbicides or in mechanical methods.

Wildlife would also be directly affected by most of the possible eradication methods. Mechanical harvesting, smothering (with opaque material such as weed-matting, concrete or light-absorbing dyes) and lake-level draw-down would displace all waterfowl, fish and invertebrates from the areas affected, and is likely to kill at least some of them. This would be especially severe on those that could not go elsewhere, such as freshwater mussels and koura, and those that would be made more vulnerable to predation, such as small fish.

Non-target plants in or near the macrophyte zones would also be harshly affected, if not eliminated. This would be most so in Lake Opouahi, which still retains a healthy fringe of native aquatic vegetation.

There would be major disruption to virtually all the water-based recreation pursuits on the lakes: directly through the effects of the operations themselves and indirectly through impacts on wildlife and aesthetic quality.

There is also the risk of pollution through substances such as petroleum products from machinery being spilt into the lakes and through escape of substances used into nearby waterways and onto nearby land. Careful operation could minimise these risks.

The only biological method currently on offer for eradication of hydrilla is the use of grass carp (also known as white amur, and not to be confused with other kinds of carp). It carries all the costs of destruction of the macrophyte beds, but is most environmentally acceptable in that it minimises the risks of pollution, aesthetic detraction and direct impact on wildlife. It carries two further risks through: those of escape or deliberate transfer of carp to other waterways where they might cause damage, and of potential breeding in the wild. Some people, including Department of Conservation staff, are consequently uneasy about the use of carp.

Grass carp are used extensively in the USA, Europe and Asia to control waterweeds (oxygen weeds, reeds, pondweeds etc. - de Kozlowski 1991, Gangstad 1986, Santha et al 1991). They have been used in this way for decades, and are now the prefered control agent in many countries. In so doing, they provide a major industry, are the subject of much research and in places have commercial fisheries founded on them.

There would be an initial release of enough carp to ensure the hydrilla beds in the lakes would be quickly consumed (2-3 years). The densities of fish required are known. It would then be necessary to annually restock with carp to recoup losses and ensure sustained pressure on the hydrilla until its tubers and turions were exhausted (a further 5-7 years).

Escape of carp into the outlet stream of Lake Tutira, Mahiaruhe Stream, is their only really likely unaided spread, with attendant risks to the vegetation values of the stream. Carp could certainly be caught and transferred elsewhere, and would put most at risk those waterways that still retain native vegetation. They are a large long-lived fish (up to 25 years) and even one could do local damage. It would take a lot though to do damage on large scale.

No breeding of grass carp has yet been observed in the wild in New Zealand and is rare in countries overseas where they are used for weed control. Their primary requirements for breeding are that the fertilised eggs stay suspended in a warm and turbulent current for long enough (24-40 hours) that they can develop and hatch, then for the larvae to find sheltered ponds or margins for protection for the next two days before they can fend for themselves. Specifically, water temperature must be between 19 and 30°C, average water velocity must be greater than 0.8 metres/second at spawning and at least 0.23 m/sec for development, there must be abundant zooplankton and sheltered water for larvae (Stanley et al 1978; Leslie et al 1982). Overseas, spawning occurs only in large rivers or canals having these conditions, and eggs are carried 50 to 180 km before hatching. In this country, it is considered that only the lower Waikato River system could provide these conditions, but so far no evidence of breeding has been found, despite their presence there for over a decade (McCarter 1992, McDowall 1984, Rowe & Schipper 1985; C.Richmond pers com). Diploid carp (those with two sets of chromosomes) could breed, but triploid carp (with three sets) cannot. It is now possible to produce large quantities of triploid carp reliably in New Zealand, and use of them in the hydrilla lakes would not only eliminate the chances of them breeding in the wild but would also eliminate the chances of people using them as breeding stock. Testing whether fish are triploid or not can be done either individually, which is expensive but guaranteed, or in batches, which is much cheaper but carries a statistical risk of some diploid fish being undetected. Overall, it is considered that the risks of carp breeding in the hydrilla lakes are extremely low, even if diploid, and pale into insignificance beside the risks from hydrilla itself.

There is not much evidence of negative impact of grass carp on other native or exotic fish in Europe: no effect on commercial catches, water quality improved if anything, algal blooms do not occur (Gangstad 1986). It seems reasonable to expect that to also be the case in New Zealand.

There are techniques available for removing carp from the lakes once they have done their job. These include the use of nets and traps of various types and varying efficiency, electric fishing that would have an inevitable bycatch of other fish and the use of rotenone, a paralysing chemical that would also affect other fish. If carp were not removed, most would starve to death once their food supply ran out (2-3 years) and the rest would eventually die out too. The most negative effect of their continued presence would be to hamper restoration of native aquatic vegetation because as general herbivores they would eat native as well as exotic plants.

Other costs of restoration would present themselves. These are discussed along with benefits.

The eradication option would undoubtedly be the most disruptive and expensive in the short term, no matter what techniques were used. The duration of the operation would vary considerably according to technique: from a few months if radical chemical application were used, to up to a decade if grass carp were used.

b) The benefits

The greatest obvious benefit of eradication would be to eliminate the hydrilla problem:

- from the lakes where it is now,
- from the country.

Thereby, the huge costs of control that are foreseen should hydrilla remain into the future would be saved to the nation. There would be a one-off cost, rather than on-going costs, that must be far cheaper in the long term.

Eradication of hydrilla would open up all sorts of possibilities for restoration of natural and traditional values at the lakes.

Eel populations would be restored quite soon without intervention, thereby allowing resumption of traditional eel fishing, so long as it was compatible with conservation objectives for the lakes. Koura and kakahi could be harvested again too.

Native submerged aquatic vegetation would probably re-establish itself, but the process could be enhanced and speeded by broadcasting of plant material from nearby waterways at relatively minor cost.

Loss of the filtering, nutrient sink and wave cushioning benefits provided by the hydrilla could be compensated for by restoration of reedlands, flaxlands and shrublands on the lake shores. These would have the advantages of providing shelter for invertebrates, fish and birds, of providing materials for traditional medicine and weaving, of regulating sediment and nutrient flow from the land into the lakes and of controlling lakeshore erosion. These benefits would be enhanced if native plants were used. The costs of such revegetation are also regarded as being relatively minor.

Eradication of hydrilla would also allow restoration of the recreational trout fishery. There is no reason to believe that the restored fishery should be particularly costly to achieve or lower in quality than it is now.

Waterfowl would largely replenish themselves. Birds most dependent on macrophytes, such as swans, would probably not become as numerous as before, but others now rare, such as bitterns, crakes, rails and fernbirds, would benefit from restoration of lakeshore reedlands, flaxlands and shrublands.

Should grass carp be used, they would furnish a new recreational fishery at the lakes. By all accounts they provide an angling challenge and are good eating.

c) Practicality

No-one appears to know for sure how practical eradication of hydrilla from the four lakes really is.

In the Elands Lake trial using grass carp, hydrilla biomass has been rapidly diminished to a minute fraction of its original, but plants persist beneath fallen trees, where carp can't reach them, and amongst shallow-water turf-forming vegetation growing on consolidated substrates (Clayton et al 1992). These problems would be much greater in lakes Tutira and Opouahi. If a practical method of dealing with the hydrilla under snags and in shallow-water turf communities were found, (the best prospects lie with grappling hooks or divers to shift the snags, effective herbicides and weed mats) then use of them in conjunction with carp would be quite feasible. It would have to be kept up for at least five years, perhaps a decade, because of the longevity of hydrilla's tubers and turions.

Weed mats have been tried on a small scale on hydrilla - in Lake Opouahi. There, the attempt was to eliminate a solid patch of the weed, then the main one in the lake. It has succeeded in killing the bulk of the patch, but fragmentation of the weed during the operation has served only to help spread it around the lake. Regarding this as a learning experience, such mats could be used on a large scale, blanketing the entire shallows of each of the lakes. They would have to be in place for at least four years to kill the tubers and turions, but would be vulnerable to tearing, lifting during storms and deliberate damage. Their best prospect for use in eradication is in conjunction with grass carp, at sites where carp aren't effective.

At present there are no selective herbicides registered in New Zealand that are effective on hydrilla. Trials have been done here with those effective on the weed oveseas, both in the laboratory and in the hydrilla lakes. The cause of their lack of success is not obvious at this stage. There are undoubtedly non-selective chemicals available that could be used, including common salt. However, these are so unselective, and would have to be in sufficient concentration and for sufficient time to eradicate hydrilla - tubers and turions and all - that the lakes would be effectively killed in the process.

Light-absorbing dyes would have the same problem: they'd have to be so concentrated for so long that they too would destroy virtually all lake life.

Lake-level draw-down is simply not realistic. It would require a large pump and siphon installation to lower levels rapidly and keep them low even in times of heavy rainfall. The lake levels would have to be lowered by 9m to make sure of exposing all hydrilla habitat. The exposed sediments would have to dry out completely to kill the tubers and turions, which would take years, if it happened at all. Mechanical removal of the exposed sediments, concreting them over or saturating them with herbicides might work, but probably wouldn't and would definitely create the possibility for inadvertent transfer of hydrilla material. In addition, draw-down could simply shift hydrilla temporarily into deeper water.

Mechanical harvesting of hydrilla until its tubers, stolons and turions are exhausted is also not practical at present. No machine or person can do the job nearly as effectively as grass carp, and they carry the attendant risk of inadvertent transfer of weed. If a dredge could be devised that could suck up weeds, stolons, tubers and turions without scattering them, that would provide real prospects.

No other water plant is known to be able to totally out-compete hydrilla. Hydrilla can grow as deep and as shallow as other oxygen weeds, and much deeper than plants such as water lilies which could shade it out.

The basic problem with hydrilla eradication is that the last little turion or stem fragment must be killed. If any remains, hydrilla is still there to flourish all over again.

3. Containment option

Containment falls between do-nothing and eradication. It acknowledges the need to act, recognises the difficulties of eradication and seeks to diminish the risks of hydrilla spreading. The costs, benefits and practicality will depend on the level of containment aimed at. Most disruptive and costly will be management to minimise the risk of hydrilla spread, but this is also the most attractive and holds greatest overall benefit.

Because containment is long-term, more techniques are needed than for a hard-hitting eradication programme. Techniques that could be used include:

- knockdown of hydrilla biomass, using:
  - grass carp
  - herbicide
  - shading (mats, other water plants)
- targeting sites presenting most transfer risk (boat haulouts, picnic areas, diving and fishing areas)
- restriction of boat use to hire boats kept at the lakes
- ban on eel fishing using nets or hinaki until hydrilla beds have gone
- ban on shellfish (kakahi) gathering
- education through signs and notices
- stringent conditions for research and management.

a) The costs

Containment is probably the most financially expensive option overall in the long run, because although the yearly expenses would be less than for eradication, they would have to continue.

Otherwise, the impacts could be quite small, if the minimalist management as at present in Lakes Tutira, Waikopiro and Opouahi were continued. There, a ban on eel fishing using nets or hinaki is in place, which has as its major effect in prevention of a renowned traditional fishing activity. All motor boats are banned, which prevents some forms of aquatic recreation. Educational signs are in place advising of the restrictions and the presence of hydrilla. There is a partially effective weed mat in place over one patch of hydrilla in Lake Opouahi.

These management techniques have significantly diminished the chances of hydrilla spreading, but the risk of spread from the three lakes remains high. Clearly then these techniques are a mere short-term holding operation and are totally inadequate in lowering the chances of hydrilla spread to acceptable levels.

Current management of hydrilla in Elands Lake points the way to the kind of containment that could lead to the risks becoming acceptable. There, the macrophyte beds of the lake have been virtually eliminated, leaving hydrilla only as small plants under snags and in shallow-water turf vegetation (Clayton et al 1992). To transfer hydrilla from there now, it would be necessary to dig up and transfer sediments or shore-turf containing tubers or turions, or to seek out and transfer wet foliage: very unlikely inadvertently, not very likely deliberately.

Grass carp have been used in Elands lake, and remain to keep the hydrilla down. Should they be used in the other hydrilla lakes, those opposed to their use have threatened to deliberately spread hydrilla around, so that is a risk that must be considered.

Other techniques that could be used include shading with weed mats or other waterplants, using herbicides and periodic water-level draw-down. However, mats are vulnerable to damage, shifting during storms and being covered by algae and sediments. Water plants such as water lilies do not grow in as great a range of water depths as hydrilla. Herbicides either have little effect on hydrilla or kill almost everything. Water-level draw-down is expensive, damaging and risky. All these techniques cause major disruption to the macrophyte beds, with the costs described earlier in relation to eradication prospects - except the costs are permanent. Numbers of birds, fish, invertebrates and native aquatic plants would be forever lowered, and could never be fully restored.

b) The benefits

The obvious benefit of any containment programme is the lowering of the risk of inadvertent hydrilla spread. That by deliberate malicious means is lowered in a practical sense once the hydrilla becomes difficult to find, but remains high if there is passionate opposition to the management measures. Minimising the risks of hydrilla being transfered would make those concerned for the waterways of the Hawke's Bay region and the nation as a whole breathe a lot easier.

Techniques that radically lower the levels of hydrilla would provide some restoration opportunities. Should grass carp be used, eel fishing could resume once the hydrilla beds had gone (within a couple of years). Comprehensive and careful use of weed mats might also achieve this, though it is less certain. Restrictions on boating and diving could be lifted. Restoration of shore vegetation such as flaxlands and shrublands could take place, to the benefit of birds and invertebrates in particular and to provide traditional materials for medicine and weaving.

Grass carp would provide a new sustained fishery, offering both the challenge and the edible reward. It would complement the trout and eel fisheries.

Another obvious benefit of containment is that, unlike the do-nothing option, it retains the possibility of eventual eradication.

c) Practicality

Containment at the current low management level is certainly practical. Containment to significantly lower the hydrilla transfer risk would require much greater management input.

The only feasible techniques on offer right now are the use of grass carp, weed mats and herbicides. Of these, weed mats have never been used on the kind of scale required and the small trials have not been successful, so they are unproven, and the selective herbicides currently available here simply don't work. That leaves grass carp as the best available single option, and the trials to date - both overseas and in New Zealand - show that they can quite practically be used to virtually eliminate hydrilla from lakes the size of Waikopiro, Opouahi and Elands. What is not certain is how they would perform this function in a lake the size of Tutira, but there is scientific confidence that stepping up the scale of the operation to this level would be just as successful. Overseas, far larger lakes than Tutira have had successful hydrilla control using grass carp (de Kozlowski 1991, Gangstad 1986, Klussman et al 1988).

Use of a combination of techniques would undoubtedly be more likely to succeed than reliance on a single one. The most practical and most likely combination to succeed of all would seem to be: grass carp to knock the hydrilla down and keep it down, and weed mats and herbicides to control it where carp can't. This would be enhanced further by continuing existing containment measures of restriction of boat use, restriction of net fishing and kakahi gathering, conditions on research and management practices, and education.

4. The choices

Appendix I is a tabulation of the options and their potential costs, benefits, resources required and practicality. It allows ready comparisons of the options. Rankings of potential costs, benefits and required resources are made on the assumption that the measures would actually work; rankings of practicality are assessments of whether in fact they would work or are sensible.

In summary, the **do nothing/defer action** option is a short-term cost saver that so heightens the risk of hydrilla spread that it is totally unacceptable. **Eradication** is of greatest potential benefit and undoubtedly cheapest in the long term, but at this stage no-one knows whether it could actually succeed. **Containment** is definitely the most practical by far, but carries costs into the indefinite future.

Of the **eradication** options, **a combination of grass carp, selective herbicides and weed matting** holds the most promise of success and benefit for the least cost and damage. In the future there may be developments of more effective herbicides, less clumsy mechanical harvesters that could extract plant material including tubers and turions without disseminating them, and alternative biological agents that do not have the drawbacks of grass carp. So even if eradication looks unlikely now, it could be achievable in future.

The immediate requirement though is to ensure the risk of hydrilla spread is minimised: ie it is kept contained in the lakes where it now occurs. Of the **containment** options, **a combination of grass carp, weed matting, boat restriction, restriction on eel fishing using nets or hinaki, restriction on shellfish gathering, conditions on research and management practices, and education** looks highly likely to succeed for moderate cost overall. Of these, only grass carp are not being adequately used at present, and the risk, of hydrilla spread, whilst considerably lower than if no action had been taken, still remains high. The additional use of grass carp would diminish the risk radically - to very low levels indeed. With better use of weed matting and selective herbicides as well, the risk would be lowered to almost zero, and the goal of eradication would be very close.

Continue to next file: casn71a.pdf