Assessment of the Environmental Effects – the efficacy of caged grass carp (*Ctenopharyngodon idella*) at removing the aquatic weed hornwort (*Ceratophyllum demersum*) in Lake Karapiro

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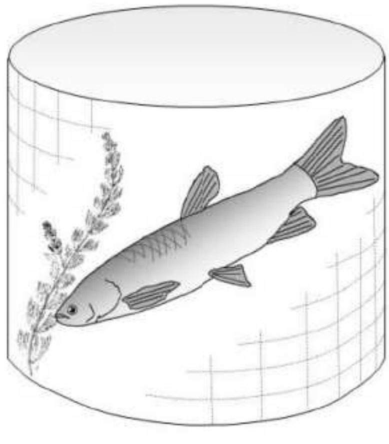

4. Grass carp effectiveness for aquatic weed eradication

Grass carp are herbivorous fish, which were imported into New Zealand with the intent that they would be used to manage aquatic weeds (Rowe and Schipper 1985). They have been used successfully overseas for the control of hydrilla (*Hydrilla verticillata*), and in New Zealand for the eradication of other submerged aquatic macrophytes (Rowe and Hill 1989). In New Zealand grass carp have successfully eliminated *Egeria densa* from Lake Parkinson, *Elodea canadensis* from Lake Waingata and hydrilla from Lake Eland (i.e., no plants have been found since 2003, known tuber viability indicates that eradication cannot be declared until 10 years after the last plant). They have also eliminated submersed weed species from a large number of ponds and private dams.

Grass carp are warm-water fish (Rowe & Schipper 1985) and feeding on macrophytes begins at temperatures over ca. 15ºC, when the young fish reach a length of ca. 150 mm and feeding activity increases with both fish size and water temperature up to at least 30ºC. Grass carp feeding in New Zealand waters is therefore maximal during summer months and minimal during winter with the feeding season being largely determined by water temperatures. This means that stocking densities need to be higher in New Zealand waters than in locations where water temperatures remain high (>20ºC) all year round. It is clear from the use of this fish both overseas and in New Zealand to date, that grass carp will eat most aquatic plants (native and introduced species) and, at the right stocking density, have the capacity to eradicate the introduced 'oxygen-weed' species (Hofstra 2011).

4.1 Case study - Lake Eland

Lake Eland (Hawke's Bay) is a 4 ha spring fed shallow dam (max depth 7 m) lake on a privately owned farm (Champion unpublished data 1988). In the 1980s when it was first reported, hydrilla covered ca 1 ha of the lake growing down to ca 4.5 m depth. Following confirmation that hydrilla had established in Lake Eland, a trial commenced in 1988 to determine the effectiveness of grass carp to control, and potentially to eradicate, hydrilla (Neale 1988). As it has no inlet or outlet streams and is isolated from public access, Lake Eland was ideal for the grass carp trial.

The trial design included an assessment of water quality, invertebrates, vegetation, fish and birds (Neale 1988). Water quality and invertebrates were monitored by the Hawkes Bay Catchment Board. Triploid grass carp were supplied by Ministry of Agriculture and Fisheries, birds counts were undertaken by the Department of Conservation, and vegetation was monitored by the Aquatic Plants Section MAF Tech (now NIWA) (Neale 1988).

An aquatic plant survey in 1987 included five emergent species (*Typha orientalis, Schoenoplectus tabernaemontani, Juncus edgariae, Bolboschoenus fluviatilis, Eleocharis acuta*), four marginal species (*Persicaria decipiens, Ludwigia palustris, Lobelia perpusilla, Callitriche stagnalis*) and twelve submerged species (*Glossostigma elatinoides, Glossostigma submersum, Lilaeopsis ruthiana, Elatine gratioloides, Potamogeton crispus, Potamogeton cheesemanii, Potamogeton ochreatus, Chara corallina, Nitella cristata, Myriophyllum propinquum, Elodea canadensis* and hydrilla) (Clayton et al. 1995). Amongst the submerged species all but hydrilla occurred in less than ca 1 m of water, 5 species had less than 5% cover, the *Glossostigma* species and elodea had 76-95% cover and the hydrilla had 100% cover to 4 m and occurred to depths of 4.5m (Neale unpublished report ca 1988). Hence the native plants that were present in the lake had a limited distribution and abundance with hydrilla dominating the littoral zone of the lake bed (Neale unpublished report ca 1988).

Triploid grass carp were stocked by MAF Fish in December 1988. Initially 100 fish/ha of ca 270 mm in length were stocked in November 1988 (Clayton et al. 1995). An assessment of vegetation in April 1990 revealed a major reduction in hydrilla, 17 months after grass carp were released. At this time the native plants *Glossostigma* and *Typha* were not visibly reduced, however in April 1991 evidence of grass carp browsing on *Typha* was first noted, whilst the dense beds of *Glossostigma* and *Lilaeopsis* remained to a depth of ca 2 m and were abundant to 1 m (Clayton et al. 1995). In November 1991 extensive searches at depths of 1-1.5 m revealed occasional hydrilla plants re-growing from tubers or buried stems, predominately in areas supporting low growing turf plants and amongst fallen tree branches (Clayton et al. 1995). Sediment sampling down to 3 m water depth also revealed viable tubers. However no plants or re-growth occurred in areas of the lake deeper than 1.5 m down to 4.5 m, the predominant depth range of hydrilla before grass carp (Clayton et al. 1995). An annual (April) vegetation survey of Lake Eland has continued since then, with a single hydrilla plant last found in 2003, and more recent surveys reporting only the continued presence of the turf plant community (Hofstra et al. 2008), and young raupo (Hofstra et al. 2004).

As a landlocked lake, Eland had no fish of any intrinsic value in the absence of migration pathways to the sea (eg., no self-sustaining eel population). However, trout had previously been stocked along with common bullies as a food source for the trout. Common bullies were present in low numbers at the time of the grass carp introduction (Neale unpublished report ca 1988), and more recently were recorded as being abundant (Hofstra et al. 2008). Bird surveys conducted over the years have indicated that the species present now are comparable with those present pre-grass carp and hydrilla eradication (Champion, unpublished survey sheet dated April 1989). The number of invertebrate taxa found in the lake has remained similar, however there has been a shift in diversity - i.e., snails were not found in the 2008 survey, but mites were (Hofstra et al. 2008).

Although stocked with trout at one time, the lake was considered more suitable for wildfowl than recreational or fishery purposes, receiving high nutrient loads from its ca 26 ha pastoral catchment (Sander 1994). Lake Eland is eutrophic, as indicated by summer mean chlorophyll values (chl-a) and phosphorus concentration and is subject to algae blooms. A thermocline forms occasionally at ca 2m depth, with bottom waters becoming anoxic in the late summer. Water quality results indicate little change as a consequence of the introduction of grass carp to Lake Eland. However, determination of water quality changes over time is difficult based on the data available as sampling was irregular (Sander 1994).

The Lake Eland grass carp trial has demonstrated the effectiveness of grass carp at removing hydrilla, while a turf plant community is retained and so too is the habitat for a range of macroinvertebrate taxa, common bullies and waterfowl.

4.2 Case study – Contained grass carp in Lake Opouahi

Lake Opouahi is the smallest (ca. 6ha) and highest (480 m a.s.l.) of the currently hydrilla affected lakes and is located in the hills north and inland of Lake Tutira. It is situated in the Department of Conservation administered Opouahi Scenic Reserve, which has, under a joint venture arrangement with ECOED (Environment, Conservation and Outdoor Education Trust) also become home to the Opouahi Pan Pac Kiwi Crèche following the construction of predator proof fencing by ECOED.

Lake Opouahi has high scenic values and is surrounded by native bush and swampland with ca. 20 to 30% of the lake's catchment (44 ha) in farm land (Hooper 1987). There are several small inlet streams that pass through the northern wetland and the main inflow to the lake from the swamp is the Waipapa Stream. The lake outflow on its southern side is the Awatamatea Stream which eventually joins the Waikoau River (Hooper 1987). Hydrilla was first noted in Lake Opouahi in 1984 (Walls 1994), and is likely to have established at some time between 1970 and its first record, because it was not reported in a lake vegetation survey in 1970 (Department of Lands and Survey 1981). At the outset of the MAF hydrilla eradication response hydrilla formed discrete clumps of vegetation within the lake littoral zone, as well as a dense weed bed near the jetty (Hofstra et al. 2008).

The lake and its surrounds are visited for hiking, bird watching and picnicking, and the lake itself provides water for adjoining properties. Water takes from the lake were problematic for the proposed use of herbicide to reduce hydrilla near the jetty. As a result, an alternative solution was devised. A containment fence was constructed around the hydrilla at the jetty and a number of the grass carp scheduled for release into the wider lake for hydrilla control, were released inside the fence. The intention was to retain the fish within the fence for four months, by which time it was anticipated that the hydrilla would be reduced to an acceptable level. However, the grass carp acted more quickly than expected and were released into the rest of the lake in two months, as all vegetation within the contained area had been consumed. This result highlighted the potential for grass carp to be used for aquatic weed control and/or eradication through a contained or 'mob-stocking technique'.

5. Potential environmental effects of grass carp

The potential impacts of grass carp in New Zealand waters were addressed by Rowe & Schipper (1985). Predation on other fish is not an issue as grass carp have no teeth and once over about 150 mm in length are herbivorous. Furthermore, as they only breed in rivers that meet stringent conditions on flow, river length, juvenile rearing habitat, and water temperature, they will not breed in New Zealand waters. Stocked populations will eventually die out unless restocking is undertaken to replenish populations. Their life span in the wild is likely to range from 10-20 years.

Research in both New Zealand and overseas during the past twenty years has shown that the main impacts arising from the use of the grass carp in lakes is related to their removal of all aquatic and marginal vegetation and the consequences of this on the lake ecosystem (Rowe 1984; Mitchell 1980; Mitchell et al. 1988; Rowe & Schipper 1985; Rowe & Hill 1989; Rowe et al. 1999). As the amount of aquatic vegetation varies greatly between lakes, any impacts need to be considered on a case-by-case basis.

Where fish are released in sufficient numbers to control aquatic pest plants in a body of water, small shallow lakes where vegetation is a major component of the ecosystem will be more affected than large deep lakes where the vegetation is a relatively minor component. Stocking densities would need to approximate 100 fish per vegetative hectare to achieve biological control.

Lake Karapiro

Lake Karapiro occupies some 770ha, within which the weed hornwort is able to grow down to ca 5m water depth. Approximately 210ha of the lake area are less than 5m in water depth and so the potential area that could be occupied by weed growth is about 27%.

At the recommended stocking rate of 100 grass carp per vegetated hectare that area of weed would equate to ca 21,000 grass carp to achieve effective weed control in Lake Karapiro. This is not contemplated, but the number of grass carp required to have an impact on the current weed biomass of this lake is clearly very large and well in excess of the number required for this trial.

In the proposed study there will be a total of about 60 fish in cages, for a period of two months after which the grass carp will be removed from the lake. During the study it is expected that hornwort within the cages will be reduced or eliminated. Once the fish and cages are removed the weed will return.

However, in the event that the fish were accidentally or deliberately released, the grass carp will be contained (by the hydro-dams) and the resulting stocking density within the lake will be less than a third of a fish per vegetated hectare, well below the level required to achieve weed control. No effect would be perceptible.

In the unlikely event that the grass carp remained in a school, and resulted in localised higher stocking density, hornwort may be reduced locally, and could even result in temporarily improved habitat for low growing native plant species that grass carp are unable to graze on account of their low stature of the plants.