Rotorua lakes weed cordons – a freshwater biosecurity tool

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Summary Invasive plants represent a significant biosecurity threat to our pristine environments. To reduce this threat, weed cordons have been installed at boat ramps in lakes Rotomā and Ōkataina. This has been undertaken as these lakes house minimal invasive species but have a high risk of incursion from other lakes in close proximity such as Lake Rotoehu. A two-part trial was undertaken on the netted weed cordons that have been installed in lakes Rotomā and Ōkataina — two of Rotorua's cleanest lakes. This trial was designed to test the effectiveness of the weed cordons *via* a simulated incursion from a boat and trailer or fishing equipment. This trial was also repeated in an un-netted area next to the weed cordon, called a 'ghost' cordon. This was designed to test what would happen if there was no weed cordon present. The trial was undertaken during all wind directions to gain an accurate understanding of what would happen to the released fragments in all conditions. The results of this report revealed that overall, the boat ramp weed cordons in the three locations retained 84.9% of all fragments released in all wind conditions. This was in contrast to not having a weed cordon present, which resulted in 85.2% of all fragments released being either not found or found to be present outside the ghost cordon range. Some of the results were surprising with regard to wind direction and the effect on fragment transportation. More studies may need to be undertaken to determine what lake currents do to weed fragment transportation and whether future weed cordons may need to be altered to combat this. Overall, it was concluded that weed cordons in these lakes appeared to be working effectively as a biosecurity tool but should be complemented with other initiatives such as portable wash-down facilities, public awareness, pest surveillance and lake weed spraying. Recommendations for future research include continued trial work to test which areas of the weed cordons are the most vulnerable. Monitoring of lake currents around the weed cordons could also be undertaken in future trials to determine the extent (and strength) of lake currents and their potential to affect fragment transportation.

Keywords Weed cordon, ghost cordon, fragments, lake weed.

INTRODUCTION

Plants are an important ecological component of both natural and man-made water bodies. Native aquatic plant communities are a unique and endangered resource in New Zealand (Holm *et al.* 1997). There is interest in the culture of water plants in aquaria and ornamental ponds, and in the possibility of using water plants for wastewater treatment and aquaculture (Stodola 1967). Aquatic weeds can however be serious impediments to applied water users. The aesthetic and recreational value of New Zealand's lakes and rivers can be seriously compromised by specific waterweeds (Wood and Mason 1977).

A significant threat to the biosecurity of New Zealand's freshwater habitats comes from plants that have been intentionally introduced (Thomson 1922). Over 70 freshwater aquatic plants introduced into New Zealand have now established here and many have become problem weeds, with most New Zealand lakes, rivers and streams affected by at least one of these species (Parsons *et al.* 1997). Impacts are significant, including reduction in indigenous biodiversity and economic losses. Over 75% of these weeds were deliberately introduced as plants suitable for the aquarium or ornamental pond trade, and several other species for fodder or culinary plants (Mühlberg 1982). The deliberate nature of introductions is probably not surprising given the geographic isolation of New Zealand and the barriers to accidental or natural spread of freshwater plants (Williamson 1996). As the aquarium or ornamental pond trade has served as the source of such weeds in the past, it is reasonable to assume there may be other potential weeds still waiting to establish (Pheloung 1996).

A number of Bay of Plenty lakes now contain some of New Zealand's most undesirable and damaging aquatic weed species. Aggressive aquatic weed species are progressively degrading native plant communities in our most heavily weed-infested lakes (Lakes Rotorua, Rotoiti, Rotoehu, Tarawera and Ōkāreka's) (Champion *et al*. 2002).

Some of Rotorua's lakes (including Lakes Rotomā, Tikitapu, Ōkataina and Rotokakahi) contain relatively intact native plant communities and/or plant communities with few of the most serious aquatic pest weeds. Some of these lakes are close to the region's most heavily weed-infested lakes and are critically vulnerable to pest weed introduction. Hornwort (*Ceratophyllum demersum*) is one of the most invasive aquatic weeds as it is not as depth-limited as other invasive species. It can spread easily and rapidly displacing native vegetation in shallow and deep water. The concept of weed cordons as a biosecurity tool for freshwater management was tabled during discussions with the Aquatic Pest Technical Advisory Group (APTAG). The APTAG group is continually looking at new and innovative ways to evolve freshwater biosecurity and the group visualised weed cordons as a means of mitigating and potentially eradicating pest species from particular lakes. The weed cordons consist of three panels, two of which extend 30–70 metres perpendicular from shore, beginning either side of the boat ramp. The third backbone (slightly longer at 80–100 metres) lies at a slight angle across the face of the two lines extending from shore, to form more or less a 3000 m^2 total area with a 15 m wide breach on one side of the net to allow boats to enter and exit the cordon.

The buoyed weed cordon panels support purse seine net 'curtains' and create a physical barrier in an effort to prevent the movement of invasive weed fragments out of the cordon and into the main body of the lake.

Currently there are five weed cordons in three lakes in the Rotorua district. These are Lake Rotomā (2), Rotoehu (1) and Ōkataina (2). The first weed cordon to be installed in 2008 was Lake Rotomā (Merge Lodge).

METHODS

The aim of the free-floating trial was to test the effectiveness of the cordons in relation to a simulated incursion where the weed was still floating on the surface and able to move about freely within the cordon.

This trial was undertaken over three weed cordons that are currently installed in lakes Rotomā (2) and Ōkataina.

During the trial the cordons were tested in four differing wind directions (i.e. north, south, east and west) and at differing times of the day. The sizes of the fragments (*Lagarosiphon major*) released in different locations within the weed cordon(s) were between 25 mm and 250 mm.

The fragments were usually left overnight and collected the next day to ensure that no fragments were 'cleaned up' by the public. The fragments were released using an ocean kayak. The fragments were collected along the weed cordon edge *via* scuba/snorkel divers and along the beach on foot. The entire length of the cordon was also searched along the buoyed top line *via* an ocean kayak to collect fragments caught within that area.

The trial work simulated three differing types of incursions and 480 fragments were released per trial within each cordon. The incursions trialled were typical of the type of incursions one would encounter at a boat ramp. Trial 1 simulates a fragment release that occurs when invasive weed species are caught on a propeller or hull of a vessel. Trial 2 simulates an incursion on a boat's propeller and also *via* a shore-based fisherman. Trial 3 simulates an incursion *via* a shore-based fisherman. The release of fragments over the three incursion types were spread over these differing areas within the cordons to fully test the cordon on all sides i.e. north, south, east, west and shoreline. The 480 fragments released per trial, per cordon were distributed by releasing 120 fragments during the four different wind directions i.e. north, south, east and west. This trial was repeated in the 'ghost' cordon area which was an area marked *via* GPS which mirrored the actual boat ramp weed cordon. This was used to determine what free floating fragments would do without the cordon in place and to track where those fragments went to. The weed fragments used were *Lagarosiphon major* which had pink marker tape attached near the base of the fragment. *Lagarosiphon major* was used as it is currently present in the two lakes (Rotomā, Ōkataina) where the trial was undertaken. *Lagarosiphon major* acts typically like the other weed species (e.g. hornwort) when it enters the water and will give an accurate picture of fragment dispersal without compromising the biosecurity of the lake. The pink tape that was attached to the fragments during the trial was used to give the researcher the ability to detect the fragments during collection.

RESULTS

Lake Rotomā weed cordon and ghost weed cordon trial work (Merge Lodge) The results from the trial work suggest this current weed cordon is working effectively. 28.5% of the fragments released were washed onto the beach inside the cordon range and 56.7% of the fragments were caught on the cordon. This resulted in 85.2% of all fragments released during this trial being retained by the weed cordon at this boat ramp. This, in return, is emphasised by not having a cordon (ghost) present and this trial only retaining 10% of the fragments released and 90% of the fragments moving outside the ghost cordon range or being lost. The boat ramp weed cordon was most vulnerable during southerly (5.4% not found) and easterly (5% not found) winds. This may have been due to bird species picking up the fragments (which has been noted during previous monitoring) or these fragments may have made their way out into the body of the lake in southerly winds which blow fragments towards the cordon entrance.

Lake Rotomā weed cordon and ghost weed cordon trial work (Matahī Spit) The results from the trial work suggest this current weed cordon is working effectively. 28.5% of the fragments released were washed onto the beach inside the cordon range and 56.5% of the fragments were caught on the cordon. This resulted in 85% of all fragments released during this trial being retained using a weed cordon at this boat ramp. This, in turn, is emphasised by not having a cordon (ghost) present and this trial only retaining 14.2% of the fragments released and 85.5% of the fragments moving outside the ghost cordon range or being lost. The boat ramp weed cordon was most vulnerable during an easterly (6.9% not found) wind.

Lake Ōkataina weed cordon and ghost weed cordon trial work The results from the trial work suggest this current weed cordon is working effectively. 31% of the fragments released were washed onto the beach inside the cordon range and 54% of the fragments were caught on the cordon. This resulted in 85% of all fragments released during this trial being retained using a weed cordon at this boat ramp. This, in turn, is emphasised by not having a cordon (ghost) present and this trial only retaining 21% of the fragments released and 79% of the fragments moving outside the ghost cordon range or being lost. The boat ramp weed cordon was most vulnerable during northerly (5.2% not found) and southerly (4% not found) winds.

Results of combined trial work over the three boat ramp weed cordons and ghost weed cordons Figure 2 indicates that 55.5% of all fragments released during all trials moved outside the ghost cordon range and 29.6% of the fragments were not found. 14.9% of the fragments released were washed inside the ghost cordon range. Figure 1 indicates that 55.6% of all fragments released at the three boat ramp weed cordons were caught on the cordons. This also shows that 29.3% of the fragments released were retained within the weed cordon range.

Related effectiveness of trialled boat ramp weed cordons The results of this trial showed that although the three weed cordons were constructed differently, the effectiveness of these cordons is similar. The results show the three cordons had an overall effectiveness of containing fragments of 85% each.

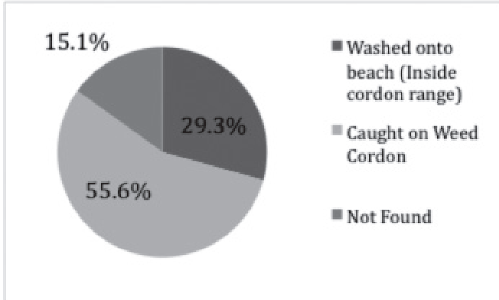

Figure 1. Boatramp weed cordons over 3 sites. Percentage of fragment movement to different locations in all wind directions. N = 1440.

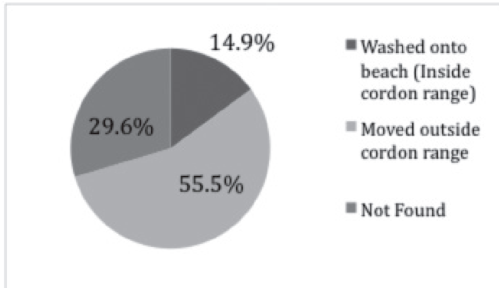

Figure 2. Ghost weed cordons over 3 sites. Percentage of fragment movement to different locations in all wind directions. N = 1440.

Time between release and collection of fragments During the trial, the fragments were released and collected the following day. This was undertaken as the previous trial (2009) at the Lake Rotomā weed cordon (Merge Lodge) resulted in fragments being found in the bin near the boat ramp, affecting the results. During this trial, no fragments were found in or near the bins at the trial sites. To test the cordon further trials would need to be undertaken with fragments left for long periods before being collected.

Wind direction This parameter was tested on the boat ramp cordons (and ghost cordons) as it was thought that particular wind directions would blow potential fragments out the boating entrance(s) of the cordon(s). This did not seem to occur with the boat ramp cordons, with only a small number of fragments lost overall during the trial. The results show that Lake Ōkataina, which would need a westerly wind (cross-wind toward entrance) to blow fragments out of the entrance, has the lowest (2.7%) amount of lost fragments in relation to the other wind directions during the trial. The highest percentage of fragments not found was during an off-shore wind event with 5.2% of the 480 fragments released not found. The Lake Rotomā (Matahī Spit) weed cordon, which would need a westerly (cross-wind toward entrance) wind to blow the fragments out the entrance, had the lowest amount of lost fragments with 2.3% not found during this wind event. The highest amount of fragments (6.9%) not found occurred during an easterly (cross-wind away from the entrance) wind, which would blow fragments to the seaward (westerly) arm of the cordon. The Lake Rotomā (Merge Lodge) weed cordon, which would need a southerly wind (cross-wind toward entrance) to transport fragments out of the cordon entrance, was the highest with 5.4% of fragments not found during this wind event. The results of the wind-related trial work in two of the weed cordons (Matahī Spit and Ōkataina) were surprising as it was thought that wind directions that sent floating fragments toward the cordon entrance would result in most of these fragments being lost. This was not the case for these two cordons and other factors such as lake currents or failure of the particular cordon areas may have attributed to these losses. More trial work will need to be done to test this parameter and to get definitive answers on these particular trials. The effectiveness of the weed cordons in relation to wind direction is surprising with the three weed cordons being slightly less effective during wind events that blow fragments away from the weed cordon entrance. The three weed cordons are most effective at retaining fragments during off-shore winds (24%, 21.7%, 19.8%) which is only slightly higher than cross-shore winds blowing fragments directly toward the cordon(s) entrance (19.6%, 22.7%, 22.3). These results suggest there are other factors affecting the transportation of fragments within the weed cordons and more research will need to be done to determine why this is happening.

Fragment movement in relation to lake currents Although movement of fragments by currents was not tested during the trial work, it is thought that lake currents may have accounted for fragments disappearing. M. Bloxham pers. comm. states that wind, changes in water density, bathymetry and inflow or outflow from the lake would produce currents. Wind can produce lake currents as the air drags over the lake surface and pulls water with it. This usually produces waves, but after the wind dies down, waves could dissipate leaving a current. Water density produces currents as temperature changes cause water to rise or fall. Warm rising and cold sinking waters are what drive the ocean currents. The same can take place in a lake, particularly in autumn or spring. Also, if waters enter the lake with significantly different temperatures or chemistry, then currents would flow to take the more dense water deeper and less dense water shallower. When the waters enter or exit the lake there will be a current. Depending on the rate of flow, the current could extend further than expected. Bathymetry and the underwater topography of the lake bed can help to funnel currents and amplify them. Sometimes currents can show up where they might not be expected, directed by the shape of the unseen lake bed. Blanton (1975) found that upwelling downwelling cycles observed along the north shore of Lake Ontario (USA) had periods of about 12–16 days in length. Currents associated with the downwelling cycle were typically stronger. The cycle periods were at least a factor of two larger than periods expected from cyclone movements across the Great Lakes. Although the upwelling downwelling cycles are generally a response to wind, this discrepancy suggested a tendency for a more wave-like periodic response. These near-shore lake currents may account for the unexplained loss of fragments at Matahī Spit and Lake Ōkataina during wind directions that should have sent the fragments back within the cordon(s). The Merge Lodge weed cordon was the only site where fragment losses were the highest during a wind event that directed the fragments towards the entrance of the cordon. The Merge Lodge weed cordon is a more sheltered site and may not be as susceptible to wind-induced lake currents as the other two sites and therefore is not affected by currents moving fragments. Merge Lodge also has a more gradual bathymetry when compared with Lake Ōkataina and Matahī Spit, which may have also contributed to a decrease in lake currents at that site. During the trial work, the weather patterns were stable as the trial was undertaken over summer. During late January (2011) there was however a period of high winds which could have affected currents around the near-shore of all trial sites. This may have contributed to the mixed results during the trail, particularly at the Matahī Spit cordon which had the most fragments lost during a wind event blowing away from the cordon entrance. Wind speed was not monitored during the trial but is a parameter that could be added to future trials.

Weed cordons as a public awareness tool This report has shown that weed cordons act effectively as a freshwater biosecurity tool and the information gathered needs to be taken to the public and wider scientific community to 'sell' weed cordons as a real way of fighting the battle with invasive species. Other regions and organisations may benefit from having weed cordons installed in areas that need protecting and this report needs to be spread to these areas. The results of this trial show the weed cordons used in the two lakes are working effectively as a biosecurity tool to minimise fragments entering the main body of these lakes *via* boats, trailers and fishing equipment. Not having a weed cordon in place in these three locations could potentially result in new incursions occurring and the results suggest that this would occur and fragments would easily escape into the body of the lake.

DISCUSSION / CONCLUSION

The results of this research show the weed cordons used in the two lakes are working effectively as a biosecurity tool to minimise fragments entering the main body of these lakes via boats, trailers and fishing equipment. Not having a weed cordon in place in these three locations could result in new incursions occurring and the results suggest this would occur and fragments would easily escape into the body of the lake. The results of this study suggest there are other factors affecting the transportation of fragments in near-shore lake environments around boat ramps. More research is needed to determine why the weed cordons are slightly less effective during wind directions, such as wind events blowing fragments away from the weed cordon entrance, to test this parameter more closely. The weed cordons in general should not be seen as the 'silver bullet' with regard to freshwater biosecurity. The cordons should be used in conjunction with other freshwater initiatives such as public awareness programmes, aquatic weed spraying, washdown facilities, rules and penalties for transporting weeds and monitoring and surveillance programmes. The weed cordons also need to be 'adopted' by the local landowners and lake users to ensure that if, for any reason, the cordons are damaged they continue to work effectively.

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