Options for Spartina control in Northland

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1. Introduction

Spartina is present in Northland harbours and the lower reaches of the waterways flowing into them. A 1991 survey found *Spartina* at 87 sites in 11 harbours, and further sites have been discovered since that survey was undertaken.

Considerable effort has been invested in control work, with *Sparttna* close to eradication from the Whangarei Harbour. Control in Whangarei has been undertaken using the herbicide Gallant© (haloxyfop).

The Department of Conservation, Kaitaia Area Office is now considering options for *Spartina* control in some of the large northern harbours such as Rangaunu and Parengarenga. These harbours have particularly significant conservation values and *Spartina* poses a major threat to the ecological integrity of the harbour ecosystems.

This report provides a brief overview of the options for *Spartina* control, and a recommended course of action. A brief review is also provided of the known side-effects of the herbicide Gallant.

1.1 PROJECT BRIEF

The following brief was provided by the Department of Conservation.

1. Review control methodologies and recommend a course of action for Northland.

2. Review scientific data on side-effects of the herbicide Gallant, to assist with a resource consent application.

2. Control options

Many methods of *Spartina* control or eradication have been used, with varying levels of success. A brief outline of these methods is provided below.

2.1 GRAZING

Spartina has previously been managed as a cattle crop in Northland (Franko *et al.* 1985). While reducing plant biomass, grazing does not kill plants, and cattle can cause severe negative impacts in estuaries by trampling and nutrient enrichment.

2.2 PHYSICAL REMOVAL

Physical removal has been attempted on many scales, including hand pulling, digging out individual plants using hand implements, and the use of mechanical excavators. Hand removal with tools can be successful but is slow, very labour intensive, and would be prohibitively expensive if attempted on a large scale. However, it has been used successfully for small infestations where there has been substantial mobilisation of community effort (Bertolotoo 1997).

Small-scale hand pulling has been evaluated in the USA (Norman & Patten 1997) and resulted in a high level of control (97-1000, but was very labour intensive. It should be noted, however, that hand digging is not feasible in some situations due to the dense *Spartina* root mat (Bishop 1996).

Large-scale mechanical excavation has also been attempted (e.g. in the Avon-Heathcote Estuary) but was unsuccessful (probably due to the residual root material and the broken root fragments which would remain to be spread further by water movement).

2.3 SMOTHERING

Smothering with plastic sheeting has been trialed in Tasmania (Bishop 1996; Lane 1996). Treatments included cutting and smothering; cutting; and cutting, treatment with glyphosate, and smothering (Bishop 1996). Cutting and smothering has been successful on a small scale, with a success rate similar to effective herbicide control (D. Bishop, unpublished data). However, it is labour intensive, difficult to establish in site with strong tidal flows (lost plastic poses an environmental risk), and is unsuitable for large *Spartina* infestations due to the cost of covering large areas and the logistics of securely fixing large sheets of plastic (Bishop 1996).

There has not been any assessment of non-target impacts of smothering, but this issue previously caused concern in the Willapa Bay (USA) in relation to the possibility of juvenile fish kills beneath plastic sheeting.

Department of Conservation field trials have assessed the cost of this technique at c. $26,700 per hectare, using Taskforce Green subsidised labour (Renwick & Syddall 1998).

2.4 CUTTING

Cutting, with no other treatment, has also been assessed in Tasmania (Bishop 1996; Lane 1996). It prevented seed production but otherwise had little effect.

2.5 STEAM TREATMENT

Steam treatment has received only preliminary and small-scale assessment in one Bay of Plenty trial (Shaw & Gosling 1996, 1997). Results indicated a level of initial impact similar to effective initial herbicide treatment. However, the trial was not continued and few conclusions can be drawn from this work.

The application of the technique at an operational scale is limited by the need to get the bulky and heavy steam-producing equipment close to an infestation. Hose length is limited to c. 20 metres to maintain the steam at or close to boiling temperature (Shaw & Gosling 1996). It may have potential for small infestations on estuary margins with good vehicle access within 20 metres of the site to be treated.

2.6 BURNING

Burning (using an LPG burner) has been used in a small-scale operational trial in the Bay of Islands, and is documented in a very useful report by Darden (1997). An intensive programme was undertaken, with burning undertaken on a weekly or monthly basis over 11 months. Cutting of *Spartina* was undertaken prior to burning for the first 6 weeks, after which only burning was done (Darden 1997).

The technique was successful, killing the *Spartina,* with plants in the "mid-tide area" most susceptible to burning. The technique is labour intensive, achieving 3.75 m^2 of *Spartina* removal per labour hour (Darden 1997). The technique did not kill mangroves, and requires no special training or equipment other than a suitable LPG burner and a fire extinguisher (Darden 1997).

Department of Conservation trials in Northland have estimated costs of c. $28,500 per hectare for burning, using Taskforce Green subsidised labour (Renwick & Syddall 1998). High costs alone preclude the use of burning of anything other than a small scale, probably using volunteer labour.

2.7 BIOLOGICAL CONTROL

Research is currently under way in Washington State to investigate the feasibility of using an insect *(Prokelisia marginata)* to control *Spartina alterniflora* (Anon. 1997). Initial work is investigating host specificity. The project will take many years and no similar work is under way or proposed in New Zealand.

2.8 HERBICIDES

Herbicide treatment has been undertaken for several decades, using a range of herbicides and application techniques, with varying success.

Australia

Herbicides that have been used or assessed in Australian trials include oxygenated bleach - sodium chlorate (Bishop 1996, unpublished data; Lane 1996), Shirpon (2,2-DPA), Glyphosate 360, Fusilade (fluazifop-P), Verdict (haloxyfop), Select (clethodim), and Arsenal (imazapry) (Pritchard 1994).

Various surfactants were trialed. Verdict (haloxyfop), Fusilade, and Select (clethodim) gave the best results, closely followed by Arsenal (imazapry) (Pritchard 1994, 1996).

Further trials were undertaken to determine whether the effect of glyphosate could be enhanced with additives or differing spray concentrations and volumes (Pritchard 1996), but results did not match the four herbicides listed above.

Fusilade has been selected as the preferred herbicide for *Spartina* control in Australia, and its toxicity has been assessed in laboratory and field studies (Palmer *et al.* 1996).

USA

Sparttna alterniflora is native to the east coast of the USA, but was introduced accidentally to the west coast, where it has spread prolifically.

Rodeo (glyphosate) is the only herbicide approved for use on *Spartina* (Crocket 1997), and considerable effort has gone into trying to improve its efficacy. *Spartina* control using glyphosate is very politicised (cf. Perkins 1997). Rodeo is applied from aircraft and to regrowth after cutting (e.g. see Moore 1997; Major & Grue 1997; Norman & Patten 1997). Variable results have been obtained from the application of glyphosate either on the ground or from aircraft. There is considerable interest in the use of other herbicides, but restrictions are so tight it is difficult for US workers to even evaluate alternative herbicides on a trial basis.

A recent study of glyphosate used with alternative surfactants again produced variable results (Patten 1997). This same study did, however, obtain complete control with clethodim and recommended that further research be done on the timing of treatment and application techniques.

New Zealand

Many herbicides have been used or evaluated in New Zealand, and *Spartina* control with herbicides has perhaps been undertaken here for longer than anywhere else in the world. A summary of the herbicides used between 1968 and 1985 is provided in Franko *et al.* (1985) (and in Shaw & Gosling 1996).

A range of herbicides were evaluated in trials in Ohiwa Harbour in the early 1990s - Zero (quizalofop), Roundup (glyphosate), Gallant (haloxyfop), Fusilade (fluazifop-P-butyl), Weedazol/Dalapon, Touchdown (glyphosate + trimesium) and Arsenal (imazapry). The best results were obtained with Gallant and Arsenal, but Arsenal was not considered further due to its toxicity to a wide spectrum of plants (Shaw & Gosling 1996). The Ohiwa infestation has since been eradicated using Gallant.

Roundup (glyphosate) has been used widely but with variable results. These results also led to other control trials in the Manawatu Estuary (Lovelock 1993) and Gallant also gave the best results. Centurion (clethodim) was also assessed in the Manawatu trial but surviving stems were left throughout the trial plot (Lovelock 1993).

Other New Zealand and Australian control operations

Recent control work is summarised in Shaw & Gosling (1996 and 1997). Nearly all operations now use Gallant, including those undertaken in the Whangarei Harbour, near Auckland, Waikato, Tauranga Harbour, Manawatu estuary, Waimea Inlet, and Southland. The Manawatu Estuary control programme resource consent has been changed from Roundup to Gallant. Dalapon/Weedazol is still used in the Avon-Heathcote estuary, and Roundup in Otago.

The effectiveness of Gallant has enabled *Spartina* to be eradicated from Ohiwa Harbour, with near eradication from the Waimea Inlet, some of the Southland estuaries, and Whangarei Harbour.

Fusilade is now being used for *Spartina* control on an operational basis in Victoria and Tasmania.

3. Selection of a control/ eradication technique

Various techniques have been used for *Spartina* control in New Zealand and other countries, with varying degrees of success. Some basic principles need to be established for the selection of preferred techniques:

1. The technique(s) must be capable of achieving a consistently very high level of mortality, preferably within a short period.

2. The technique(s) must be safe - both for the operator(s) and the receiving environment.

3. They must be cost-effective.

Eradication of *Spartina,* as opposed to sustained control, requires that all of these criteria be met. It will also require very careful planning, execution, monitoring, and follow-up over many years (at least 3-5, maybe longer).

3.1 OPTIONS FOR ERADICATION

The choice of technique(s) to achieve eradication will depend on the scale of the infestation.

For small discrete infestations it may be feasible to use burning or plastic sheeting. The use of plastic sheeting will only be useful for small discrete clumps (say up to 20 x 20 m) and will not be practical for exposed sites, or amongst mangroves (a common situation in Northland harbours). For any other scenarios the only viable option is to use a herbicide with a known high level of efficacy and acceptable level of side effects (note that all techniques will have some side effects).

The only herbicide currently known to meet the criteria outlined above in New Zealand is Gallant (haloxyfop).

3.2 ENVIRONMENTAL EFFECTS OF GALLANT

The environmental effects of Gallant have been assessed in two New Zealand field studies. The first was undertaken in the Waimea Inlet, Nelson, by the Nelson-Marlborough Regional Council (Roberts 1992). Three small trial plots were initially assessed, followed by an operational trial involving treatment of several hectares. Monitoring assessed impacts on sediment-dwelling invertebrates, native fish, and non-target plants (Roberts 1992). The following paragraph from Roberts (1992) summarises the results of the monitoring programme.

> "Invertebrates and plants were sampled before spraying, and 1, 11 and 100 days after spraying. Several kinds of fish were held in cages adjacent to sprayed areas for the 24 hours after spraying to test for toxic effects. During the 1992 spray programme Gallant did not affect a variety of non-target plants, even where they were directly sprayed. Caged eels, inanga, cockabullies and shrimps all survived in water adjacent to sprayed areas. Common invertebrates did not appear to be affected by the spraying."

No bioaccumulation assessments were made in this study.

Note that the Nelson assessment of environmental effects was based on spraying high-intertidal *Spartina* at an application rate of c. 14 litres of Gallant/hectare. More recent work indicates that 9 litres/hectare is adequate for successful control.

The only other study of the effects of Gallant in New Zealand was undertaken by Roper *et al.* (1996) for the Department of Conservation. This study included the following components:

- a review of Gallant's toxicity based on existing information;

- an assessment of Gallant's toxicity based on standardised laboratory toxicity tests;

- a field study to look at loss of spray from a site in Whangarei Harbour, Northland; and

- an assessment of bioaccumulation of Gallant's active ingredient, haloxyfop, in shellfish.

Results of this study are summarised by the following extract from Roper et al. (1996).

> "Gallant contains the active ingredient haloxyfop-ethoxyethyl (etotyl) ester at a concentration of 100g l^{-1}. On application the haloxyfop-ethoxyethyl ester breaks down to the parent acid: haloxyfop. Haloxyfop-ethoxyethyl is practically non-toxic to birds, although it is regarded as being moderately to highly toxic to fish. By comparison, haloxyfop acid is low in toxicity.
>
> Laboratory toxicity tests showed that a 1% Gallant solution (the strength at which Gallant may be applied) is strongly toxic. However, at the assumed application rate of 9 litres of Gallant per ha (i.e. 0.9 ml m^{-2}) lower levels of toxicity were seen.
>
> In a field application some toxic effects are likely for benthic organisms, especially where spray ponds on the sediment surface. With the dilution by tidal flushing, however, toxic effects will be reduced. While spraying may cause a temporary decline in densities of some species, toxicity will not persist and benthic communities will recover.
>
> Field measurements showed that measurable quantities of haloxyfop were washed off an inter-tidal site following spraying with Gallant. The resulting concentrations in the water column were well below those known to be toxic.
>
> Shellfish could accumulate haloxyfop residues up to about twice the ambient water concentrations. However, the levels in the shellfish would diminish very rapidly (by about 50% per day). As a precaution, a 5-day ban on harvesting of shellfish within a specified distance (say, 500 m) of an intertidal area sprayed with Gallant is recommended."

Only limited analysis of shellfish tissue was undertaken and the analytical technique used did not provide reliable results, although it did indicate only very low levels of accumulation (Roper *et al.* 1996). It may be warranted to undertake further field assessments of shellfish in the vicinity of a Gallant treatment operation.

Felsot (1997) has compared the toxicity levels of carbaryl (an insecticide used to control burrowing shrimp in American estuaries), glyphosate, fluazifop-butyl (Fusilade), haloxyfop-ME (Gallant), clethodim (Select), and imazapyr (Arsenal) to mammals, rainbow trout, and daphnia. All of the herbicides were less toxic than carbaryl to micro invertebrates, and human health hazards seem to be particularly low for all of the herbicides (Felsot 1997). Felsot (1997) considered that haloxyfop has a low toxicity to fish (rainbow trout) and to micro invertebrates. He also commented that:

> "Laboratory and field studies indicate rapid dissipation in soil and water, suggesting safety may be enhanced by lack of opportunity for long-term bioconcentration."

The only other study that I am aware of is an MSc thesis under way at Auckland University assessing the effects of Gallant on invertebrates in control trials in Tauranga Harbour and near Auckland. The study is still in progress and no definitive results are yet available (P Nicholls pers. comm.).

4. Summary and conclusions

Spartina is an aggressive and persistent invader of intertidal mudflats that is difficult to control and eradicate. Control techniques used to date have included grazing, physical removal (on a range of scales), smothering, cutting, steam treatment, burning, and various herbicides. Combinations of techniques have also been used such as cutting followed by herbicide treatment of regrowth. Bio-control is being investigated in America but this research has only just been initiated.

Burning and smothering may be viable for small infestations but are both labour intensive and expensive, and are not cost-effective.

The most successful herbicides with least environmental side effects are the grass selective herbicides haloxyfop (Gallant), fluazifop (Fusilade), and clethodim (Centurion).

Best results to date in New Zealand have been obtained with the herbicide Gallant.

Assessments of the environmental effects of Gallant have been undertaken and these have indicated an acceptable level of impact. Gallant is now used widely in New Zealand for *Spartina* control, under resource consents issued by various regional councils. Levels of control have been very high, with *Spartina* eradicated from one estuary and close to eradication in others.

Any negative environmental effects of Gallant can be minimised or avoided by maximising the time the *Spartina* is exposed between tides after treatment, use of an appropriate surfactant, careful application of the chemical to target plants, and the use of correct dilution rates and application rates. Restrictions on shellfish harvesting close to treatment sites will further minimise any risk, say a 5-day ban within 500 m, as suggested by Roper *et al.* (1996).

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