



ENVIRONMENTAL MANAGEMENT GROUP

Technical report

INTERNAL



SAFEGUARDING YOUR ENVIRONMENT + KAITIAKI TUKU IHO



Whakaki Lagoon Ecological Monitoring 2007

April 2008
EMI [0809]
HBRC Plan Number [4022]



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Environmental Management Group Technical Report

Internal

Environmental Monitoring Section

Whakaki Lagoon Ecological Monitoring 2007

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INTRODUCTION

Regular monitoring of ecological condition and trend is built into the planned management of Whakaki Lagoon, northern Hawke's Bay, by the Hawke's Bay Regional Council (Hawke's Bay Regional Council Draft Plan No. 2783, April 1999).

In December 1999, a regime for monitoring the ecological condition and trend of the lagoon was set up on contract for the Hawke's Bay Regional Council by Geoff Walls. This was done using the experience gained in establishing a similar monitoring regime in Pekapeka Swamp, Hawke's Bay, a year earlier. It also had the benefit of the local knowledge of Trustees of Whakaki Lagoon, adjacent landowners and Department of Conservation staff. Baseline surveys of vegetation and fauna were carried out at the same time.

That work was reported upon (Whakaki Lagoon Ecological Monitoring, 1999). A companion report provides more background information and forms a monitoring plan (Whakaki Lagoon Ecological Monitoring Plan, February 1999).

In early December 2001, the monitoring programme was repeated as planned. Overall, the lagoon water levels were higher in 2001 than in 1999, due to recent heavy rain. That made some of the monitoring more difficult, particularly around the immediate lagoon margins.

In December 2003, the monitoring was repeated once more. Conditions were similar to those in 2001.

In October 2005, the monitoring was repeated once more. Conditions were similar to those in 2003, indicating that the increased lagoon water levels are now normal rather than ephemeral.

In December 2007, the monitoring was repeated once more and found that the conditions were similar to 2005. This document reports on the findings.

1. VEGETATION

1.1 Terrestrial vegetation

Historically there has been three aspects to monitoring of the terrestrial vegetation of the lagoon: mapping of the current vegetation cover; establishment of photopoints; establishment of permanent vegetation monitoring plots.

1.1.1 Vegetation map

Method:

The patterns of terrestrial vegetation were re-mapped in ArcMap 9.2 using 2003 rectified arial imagery.

Observations:

Seven major vegetation types were identified in 1999 and mapped. The observations made then were found to be valid in 2001, 2003, 2005 and 2007:

- W** Low herbfield-sedgeland in zone of wave action and periodic inundation; contains turfs of *Mimulus repens* and *Lilaeopsis ruthiana*, much used by waterfowl.
- SR** Lagoon shore fringe of dense sedges and rushes; dominated by *Juncus kraussii* and *Bolboschoenus fluviatilis*; shore ribbonwood (*Plagianthus divaricatus*) present in places.
- MG** Mosaic of rushes, sedges, blackberry and grazed pasture; mainly backing the shore fringe on the west, north and east sides of the lagoon.
- MR** Mosaic of rank grasses, rushes, sedges, pohuehue, lupin, blackberry and other shrubs (including gorse and boxthorn); backing the shore fringe on the south side of the lagoon.
- Ra** Sparse vegetation containing cushions of *Raoulia* aff. *hookeri* and various exotic grasses on open sand-shingle flats at the rear of the dunes. The presence of *Raoulia* aff. *hookeri* is of significance: this species is at the northern end of its geographic range.
- Sp** Spinifex grassland on foredunes; one of the best populations of this native sandbinder left on the East Coast of the North Island (strangely virtually free of marram grass).
- Ma** Marram grassland; two eradicable patches near the south-west corner of the lagoon.

The low wet turfs, *Raoulia* aff. *hookeri* cushion fields and spinifex grasslands are the most natural vegetation types; the others are the product of considerable past modification through burning, mechanical clearance and the impact of farm stock. In the distant past (before people arrived), there is likely to have been a relatively narrow shore fringe of rushes, sedges, harakeke (lowland flax) and cabbage trees. Behind this would have been coastal forest featuring pukatea, tawa, kahikatea and nikau. On the strip between the lagoon and the sea may have been low forest of totara, akiraho, ngaio, kohuhu, kanuka and manuka. Pingao and sand tussock would have accompanied the spinifex.

The low wet turfs are expected to persist, although heightened water levels since 1999 have diminished their extent. The *Raoulia* aff. *hookeri* cushion fields appear to be vulnerable to invasion by exotic grasses. The spinifex grasslands are vulnerable to invasion by marram grass. The existing marram grass patches are expected to spread unless controlled. The shore fringe sedges and rushes are likely to contain increasing amounts of shore ribbonwood as stock are progressively fenced out. Cabbage tree and harakeke may make a reappearance too. In the grazed mosaics, nothing is likely to change much in the foreseeable future. By contrast, in the ungrazed (rank) mosaics various native and exotic shrubs, trees, rushes, sedges and grasses (including weeds) are likely to proliferate according to the management regime (planting, weed control, rabbit control, etc.).

Next monitoring:

General observations in November-December 2009; re-mapping of the vegetation then (if sufficient change has occurred)

1.1.2 Photopoints

Method:

12 photopoints were set up the length and breadth of the wetland in December 1999. Each was marked with an aluminium label attached to a post, mostly an existing fence post. The photopoints were chosen to represent the spectrum of terrestrial vegetation types and situations around the wetland. They were also selected to be readily relocated. Photos were taken from the standing position at each photopoint: mostly panoramas of the vegetation; some more localised and specific. A SLR camera with a 50mm lens was used. Film was Kodak colour print, 200asa. The photopoints were revisited in early December 2001 and again in early December 2003, when an additional photopoint was added. The photopoints were revisited again in October 2005, when digital photography was used. The 2005 prints, in order, are in the album that accompanies this document, and the images have also been supplied on CD.

The location of each photopoint is marked on the map (Appendix 1). It is also described on the photopoint recording sheet (one for each photopoint, Appendix 2). Also on each sheet is a description of the vegetation and the ecological patterns and processes occurring there.

Observations:

Photopoint 1:

Sited at the main inlet channels, overlooking an expanse of dense marsh clubrush (*Bolboschoenus fluviatilis*) sedgeland. In 2001, since the cattle were fenced out (c.1999), the marsh clubrush had grown noticeably taller, and the previously small raupo patch had expanded significantly. Mercer grass (*Paspalum distichum*) and annual beard-grass (*Polypogon monspeliensis*) had proliferated in more open damp pasture sites. In 2003 it was much the same. The raupo had continued to expand. In 2005, it was earlier in season so the *Bolboschoenus* was still brown (hadn't yet grown back from its winter die-off). The paddocks were more flooded from recent rain (the entire wetland system water level was raised). Raupo had continued to bulk up. There was much waterfowl and bitterns were booming.

In 2007 the Raupo had continued to expand and there was new growth of *bulboschoenus*. The water level was low due to an extensive dry period prior to the survey. Blackberry had thickened considerably but had been sprayed in an attempt to control the spread. A skylark was observed at this photopoint

Photopoint 2:

Sited at the mouth of the artificial inlet channel, to observe the shore vegetation that includes low turf of *Mimulus repens* and *Lilaeopsis ruthiana*, scattered rushes fringing grazed pasture and dense *Bolboschoenus fluviatilis* sedgeland. Domestic stock still use the site. Higher water levels in 2001 made it difficult to assess the condition of the low turf, but it was evident that the *Bolboschoenus fluviatilis* had grown in both height and density. In 2003, silver poplar, karamu and blackberry had expanded somewhat near the stile. Pressure from cattle had resulted in the *Bolboschoenus fluviatilis* being grazed down. Otherwise, things were similar. There was a wealth of waterfowl present. In 2005, silver poplar and blackberry had expanded much near the stile. The water level was high; waders required to reach the lake edge photopoint! At the lake edge there had been a considerable loss/retreat of *Bolboschoenus*, because of cattle impact and high water level.

In 2007 the vegetation was essentially as 2005. Silver poplar and blackberry continue to expand around the stile. The lake edge appeared also to be as 2005 but the water level was considerably lower and there was evidence that cattle have grazed the vegetation down. Sea rush was thriving and seemed to have expanded a little.

Photopoint 3:

Sited in an embayment on the northern lagoon shore. Chosen to follow the processes within grazed grassland with rushes and the ungrazed strip of *Bolboschoenus fluviatilis* sedgeland backing it. The grassland is heavily used by waterfowl. In 2001, silver poplars had grown rapidly alongside the railway line, beginning to obscure the view. Otherwise the vegetation appeared similar to how it was in 1999. In 2003, the silver poplars had continued to bulk out and the paddocks were grazed more (the *Bolboschoenus fluviatilis* was lower). In 2005, *Bolboschoenus* had more or less gone because of cattle and inundation. The cattle impact was evident from dense *Bolboschoenus* where cattle were absent, right up to the fence. Sea rush hadn't really changed. Silver poplar had bulked out much.

In 2007 the most noticeable change was the lessened impact of cattle which has allowed the sea rush and *bulboschoenus* to bulk up. Silver poplar also looked as though it had thickened further

Photopoint 4:

Two photopoints in the same locality on the north-eastern shore of the lagoon. Chosen to observe the broad fringe of rushes and sedges dominated by *Bolboschoenus fluviatilis* and *Juncus kraussii*. Grazed by stock. In 2001, the *Bolboschoenus fluviatilis* had grown up and thickened. Silver poplars had grown massively by the railway line. In 2003, the silver poplars had grown to virtually obscure the vista and on the lagoon shore *Juncus kraussii* had increased whilst the *Bolboschoenus fluviatilis* had decreased (probably the result of higher water levels in recent years). In 2005, silver poplar had much grown up, otherwise there was little change though the water level was higher.

In 2007 the water level was further raised which made access to the photopoint difficult. There did not seem to be much change in the vegetation from observations in 2005.

Photopoint 5:

Sited at the lagoon exit, the beginning of Rahui Channel. Low wet turfs backed by fringes of rough pasture, sedges and rushes, grow here. Used by domestic stock on the true left (west) of the channel; fenced off (in 2000) on the true right. Since fencing, grasses and rushes (including *Bolboschoenus fluviatilis*) had grown and thickened on the true right bank of the channel, despite the presence of a mob of goats. In 2003, these processes had continued. Goats were still present and pampas had appeared (should be controlled). In 2005, things were more or less as in 2003. Goats were present and *Bolboschoenus* had diminished through grazing. Pampas was larger and should be killed. The 'delta' area was more vegetated, but the turf was inundated. Channel banks were eroding through wave action and cattle impact where not fenced; they would re-grow *Bolboschoenus* if fenced off.

In 2007 the goats were still present and the channel banks downstream still were evident of the impact that the stock is having on them. Upstream there was a matrix of rank grass, rushes, *bulboschoenus* and saltmarsh ribbonwood. There has been no attempt to control the Pampas that still proliferates.

Photopoint 6:

Sited at the south-eastern corner of the lagoon at a fence tie-off. To the north-east is the best area of shore ribbonwood on the lagoon shore, currently used by stock in 1999 but fenced off in 2000. To the south is an ungrazed fringe of rushes and sedges and an area of dunes particularly vulnerable to invasion by lupins and boxthorn. Since fencing, the *Bolboschoenus fluviatilis* had thickened somewhat, as had the shore ribbonwood. In 2003, there had been some recent wave-driven shore erosion. Gorse had been killed but pampas was still thriving (should be controlled). In 2005, it was similar. *Bolboschoenus* and three-square were holding the shore together in the face of wave action. Regeneration of shore ribbonwood was continuing (it was becoming more dominant). Pampas had burgeoned and should be killed.

In 2007 there was little change from 2005 although there has been an effort to control the Pampas.

Photopoint 7:

Sited on the southern lagoon shore at a planted area fenced to exclude rabbits and hares. Chosen to follow the progress of the revegetation programme and the anticipated proliferation of shrubs and vines in the shore fringe of rushes and sedges. Since 1999, the planted native plants had grown substantially, the most successful being ngaio, flax and pohutukawa. Since there were many hares in the vicinity, the fence was clearly doing a good job of protecting the plantings. Pohuehue (*Muehlenbeckia complexa*) and tree lupins had also grown much on the site, both inside and outside the fenced area. In 2003, the plantings had continued to flourish. The netting, no longer necessary, had been removed. Blackberry was present but not yet a problem. In 2005, the plantings had continued to flourish. The wetland vegetation looked similar to 2003. Pohuehue and blackberry were abundant but not impeding the planted trees and shrubs.

In 2007 The plantings have grown well and are dominant of the Pohuehue and blackberry which is still present but not proving to be a problem.

Photopoint 8:

Sited on the dune crest at the south-western corner of the lagoon system. Chosen to observe the important communities of spinifex and *Raoulia* aff. *hookeri*, both

vulnerable to invasion by exotic grasses (including nearby marram grass). In 2001, the spinifex and *Raoulia* aff. *hookeri* were much as they were in 1999. However, in the dune slack zone there was more ground cover of sheep's sorrel, flatweeds and Indian doab, all exotic invaders of some concern as competitors to the native plants. Lupins and *Bolboschoenus fluviatilis* had grown up nearer the lagoon. In 2003, the same processes had continued, and spinifex and *Lagurus ovatus* were flowering heavily. Spinifex and *Raoulia* appeared to be holding their own. In 2005, it was pretty much as in 2003, but changing in places. The spinifex population was very healthy. Lupins were increasing. Bare sand was being clothed in shore convolvulus, Indian doab and herbaceous exotic plants, indicating that the habitat for *Raoulia* is becoming poorer.

In 2007 the spinifex is still looking very healthy and has advanced shoreward. The bare sand still being invaded by Indian doab and shore convolvulus. Although it seems to be less of a problem than previous years it still needs to be monitored closely to ensure that there is sufficient habitat for *Raoulia*.

Photopoint 9:

Sited on a rise on the new fenceline at the south-western corner of the lagoon system. Chosen to observe the marram grass areas here (expected to rapidly spread unless controlled) and the mosaics of vegetation either side of the fence erected to keep stock out of this part of the lagoon system. A 360-degree panorama was observed and photographed at this strategic site. In 2001, marram grass had significantly advanced, blackberry had thickened, lupins had much expanded and *Bolboschoenus fluviatilis* had thickened. On the sand, the ground cover of exotic flatweeds and grasses (especially Indian doab and haretail) had increased notably. In 2003, marram had continued to spread unchecked, and an ecological warning about the consequences of not eradicating it was issued. Lupins had spread further and small exotic herbs were now abundant on the sand. The shore vegetation had continued to thicken. In 2005, marram was still advancing fast. North of the fence it had been sprayed, but it was unimpeded south of there (**desperately necessary now to eradicate, see 1.3 Weeds**). Lupins were spreading fast also. Evening primrose had much increased in the *Raoulia* zone and may pose a considerable threat. Bare sand was becoming vegetated. In the wet zone, there had been much increase in *Isolepis prolifer*.

In 2007 Lupin continues to advance and Marram seems to have spread eastwards. The Evening primrose still poses a threat in the *Raoulia* zone and the bare sand continues to be invaded by the exotic grasses and flatweeds, particularly Indian doab and haretail.

Photopoint 10:

Sited just north of Photopoint 9, at the fence corner. Chosen to follow the changes expected in the fringe of rushes and sedges following recent (c.1999) exclusion of stock. In 2001, *Bolboschoenus fluviatilis* had grown up and thickened, blackberry had grown up and pasture grasses (especially Yorkshire fog) had grown rank. Nearby cabbage trees had sprouted from their bases and a clump of pampas grass required control before it spread. In 2003, pohuehue had nearly engulfed the tagged post. Blackberry had grown, the cabbage trees were healthy and the pampas had been killed. At the shore, *Juncus kraussii* appeared to be increasing at the expense of *Bolboschoenus fluviatilis*, due to increased water levels. In 2005, things were much as in 2003. *Juncus* could be expanding at the expense of *Bolboschoenus*, but it was not clear at this stage. Fernbird and bittern were heard.

In 2007 vegetation composition was essentially as in 2005 although the vegetation had thickened markedly with the exclusion of cattle from this area and it was very difficult to get to the exact site. Blackberry had grown and there was an increase in pohuehue.

Photopoint 11:

Sited on the lagoon shore at the south-western corner (also aquatic sampling site 4). A complement to Photopoint 10, right at the lagoon shore. The water level was too high in 2001 to reach this spot. It was evident though that *Bolboschoenus fluviatilis* had thickened and grown taller since 1999. In 2003, the water levels were still too high to reach the photopoint. In 2005, water levels were still too high to reach the photopoint and the vegetation appeared much as previously.

In 2007 water levels were lower than previous years but the photopoint could not be visited due to the thickness of the vegetation which appeared essentially as in 2005.

Photopoint 12:

Sited along the new fenceline on the western side of the lagoon, among a great expanse of rushes and sedges. *Bolboschoenus fluviatilis* had thickened and grown taller on both sides of the fence, but more so on the lagoon side where stock were totally excluded. The site was in standing water in 2001. In 2003 it was decided not to revisit this photopoint because of the water. The *Juncus kraussii* had increased and the *Bolboschoenus fluviatilis* was tall and dense. In 2005, the photopoint was again not visited because of high water levels. The vegetation looked essentially as in 2003. In 2007 water levels were lower than previous years but the photopoint could not be visited due to the thickness of the vegetation which appeared essentially as in 2005.

Photopoint 13:

A new photopoint established in December 2003. Sited at the seaward corner post of the western fenceline and chosen to follow the well-being of the spinifex on the raised foredune and the *Raoulia* aff. *hookeri* in the dune hollow. Exotic plants like Indian doab, sheeps sorrel and flatweeds appeared to threaten the *Raoulia*, whilst the spinifex looked dense and healthy. In 2005, open sand was more clothed with vegetation: shore convolvulus, *Carex pumila*, haretail and herbaceous plants. *Raoulia* had definitely retreated. Spinifex was very healthy. 3 photos were taken.

In 2007 the spinifex was still dense and healthy and seemed to be advancing down the dune system. There is cause for concern with the disappearance of established *Raoulia* plants possible due to vehicular disturbance of the open sand. The *Raoulia* plants at the base of the dune seem to be holding their own but the habitat continues to be invaded by exotic plants, most commonly Indian doab, sheeps sorrel and flatweeds.

Next monitoring:

November-December 2009; thence every second year. Photos to be repeated; recording sheets to be used.

1.1.3 Permanent vegetation plots

Method:

In 1999 six permanent vegetation monitoring plots were established in sites chosen to represent the main parts of the lagoon edge. Sites locations are marked on the map in Appendix 1.

In 2007 it was found that the vegetation monitoring plots are rather difficult and time consuming due to how much the vegetation has grown. A decision was made to abandon these and to continue monitoring through photopoints which has proved to have equal value. Results from previous years surveys can be found in the ecological reports prepared by Geoff Walls for those years.

1.2 Aquatic vegetation

Method:

The composition of the aquatic vegetation was assessed at four sites, chosen to represent the main parts of the lagoon shore. Macroinvertebrate sampling and fish survey was done at these sites too. The site locations are marked on the map (Appendix 1) and described on the combined aquatic vegetation and macroinvertebrate recording sheets (one for each site, Appendix 3).

Sampling at each site was done by hand-pulling aquatic vegetation and "washing" it in white plastic trays for examination. The aquatic macrophytes present were identified, and their relative abundances were recorded. Macroinvertebrates were searched for in each sample (see 2.4), and their standard sensitivity scores recorded to give a measure of water quality.

Observations:

In 1999, the aquatic macrophytes were dominated by the natives *Ruppia polycarpa* and *Potamogeton pectinatus*. Floating plants were also natives: *Lemna minor* and *Azolla filiculoides*. The only weeds found were *Potamogeton crispus*, common at Site 1, and crack willow at Site 3 (Rahui Channel). In 2001, there was little change. Mercer grass had increased at Sites 1 and 3, *Myriophyllum propinquum* had decreased at Site 1 and the exotic floating pondweed *Spirodela punctata* was detected at Site 1. At Site 3, *Potamogeton pectinatus* and *Ruppia polycarpa* were not seen (in 1999 floating mats had drifted to the site). Site 4 was too submerged to assess changes in turf plants. In 2003, surprisingly, *Potamogeton crispus* and *P. suboblongus*, formerly obvious at Site 1, had vanished. *Spirodela punctata* was not detected. At Sites 2 and 3, *Ruppia polycarpa* and *Potamogeton pectinatus*, previously drifted on the shore in masses because of swan activity, were absent. Those changes may have been due to the heightened water levels. Site 4 was again too submerged to visit and sample. In 2005, *Potamogeton crispus* and *Spirodela punctata* were found again at Site 1, but *P. suboblongus* had not reappeared. At Site 2 sea rush had been largely replaced by marsh clubrush and creeping bent, probably as a result of increased freshwater levels. At Site 3 there was less marsh clubrush but more creeping bent and floating plants. Site 4 was inaccessible as before. Overall, there appears to have been a significant shift in macrophyte composition since the lagoon has been less open to saline influence and has retained more freshwater.

In 2007 *Azolla filiculoides*, *Spirodela punctata* and green algae were not found at site 1 but had not been there in 2005. *Potamogeton crispus* was present but *Potamogeton suboblongus* was still not sighted. Sites 2 and 3 had the same species present as in 2005 although at site 2 *Juncus kraussii* had increased as had *Azolla filiculoides* and *Bulboschoenus fluviatilis* at site 3. Site 4 was again not sampled as it was again inaccessible due to difficulty in getting through the Raupo stands and mud.

Next monitoring:

November-December 2009; thence every second year. Sampling to be repeated; recording sheets to be used.

1.3 Weeds

Method:

Weeds were searched for during the survey and monitoring of both the terrestrial and aquatic vegetation (1.1, 1.2). Their presence and impact were noted.

Observations:

The following terrestrial weeds are regarded as requiring surveillance or **control**:

- **Crack willow (*Salix fragilis*)**, established in Rahui Channel and capable of spreading around the lagoon shores; also considered an aquatic weed; **should be controlled**;
- **Weeping willow (*Salix babylonica*)**, in vicinity and could spread on shores, inlets and outlet channel, but not considered particularly invasive;
- **Silver poplar (*Populus alba*)**, well established on the north-eastern shore; **expanding fast and should be kept in check**;
- **Gorse (*Ulex europaeus*)**, a minor threat to the rear dune areas; **readily controlled at present**;
- **Sweet brier (*Rosa rubiginosa*)**, present in small quantities, **readily controllable at present**; could aggressively invade the dunes;
- **Pampas grass (*Cortaderia selloana*)**, becoming increasingly established in places on the rear dunes and elsewhere; **readily controlled now but likely to spread rapidly if left**;
- **Marram grass (*Ammophila arenaria*)**, in two controllable patches at the south-western corner of the lagoon system; another smaller patch (11m x 8m) found on the rear dunes to the north (E2904774 N6228923) in December 2003; **a major threat to the native dune communities; some control has been done, but requires extension and follow-up as a matter of urgency**;
- **Boxthorn (*Lycium ferocissimum*)**, invading the dunes; **controllable at present; should be kept in check**;
- **Lupin (*Lupinus arboreus*)**, invading the dunes; not a serious threat as susceptible to disease and defoliation but could be a problem for *Raoulia* aff. *hookeri* cushion fields;
- **Indian doab (*Cynodon dactylon*)**, a creeping grass rapidly invading the dunes; a definite threat to *Raoulia* aff. *hookeri* cushion fields; **may be difficult to control, but trials of grass-specific herbicide use should be carried out in preparation for a bigger control effort if required**;
- **Iceplant (*Carpobrotus edulis*)**, a patch near Vegetation transect 5 and more planted by the hut there; **a potentially serious threat to the dune**

vegetation, especially the *Raoulia*, and should be controlled as a matter of urgency;

- **Blackberry (*Rubus fruticosus* agg.)**, common in mosaic communities; not considered an ecological problem; provides habitat for fernbirds;
- **Bone-seed (*Chrysanthemoides monilifera*)**, a small patch found on the rear dune near the SE corner of the lagoon (E2905427 N6228921) in December 2003; **a potentially serious threat to the dune vegetation, newly established, and should be eradicated as a matter of urgency;**
- **Japanese honeysuckle (*Lonicera japonica*)**, not yet present, but in the vicinity and capable of invading shrubby areas;
- **Bindweeds (*Calystegia silvatica* and *Convolvulus arvensis*)**, abundant around the margins; not a serious ecological threat at present.

The following aquatic weeds are regarded as requiring surveillance:

- **Purple-backed duckweed (*Spirodela punctata*)**, that could displace the native floating species;
- **Curly pondweed (*Potamogeton crispus*)**, found at the main inlet in the past but seems to have diminished recently.

Next monitoring:

November-December 2009, along with other vegetation monitoring; thence every second year.

1.4 Notable flora

Method:

Plants of note were searched for during baseline survey and monitoring.

Observations:

To date, no rare native plants have been recorded from Whakaki Lagoon. However, the colony of the cushion plant *Raoulia* aff. *hookeri* between the lagoon and the sea is significant. It is a large thriving population at the northern end of the geographical range of this species, which is classified as nationally threatened (de Lange et al 2004, Hitchmough 2002). However, the population is very isolated from any other and there are several threats (mainly weeds) that require monitoring. Three of the photopoints (Photopoints 8, 9 and 13) and three of the vegetation transects (Transects 4, 5 and 6) cover that requirement. There are three additional photoplots that focus on the issue at Transect 4. Indian doab, an exotic grass, looks poised to become a serious problem for the *Raoulia* aff. *hookeri* in the near future, so now is the time to be considering control methods (see 1.3 above). Photographs of *Raoulia* aff. *hookeri* are in the photo album that accompanies this report, along with the photopoint and vegetation transect photos.

No other notable flora was detected in 1999, 2001, 2003, 2005 or 2007. Should any other notable plants be detected or introduced in future, extra monitoring will be needed.

Next monitoring:

November-December 2009, along with other monitoring and via Photopoints 8, 9 and 13.

2. FAUNA

2.1 Water birds

Method:

Two methods were used:

1. **Directed searches**, whereby a number of sites around the lagoon were visited to listen and look for crakes, rails and bitterns. Taped calls were played to elicit responses. The search sites are marked on the map (Appendix 1).
2. **General fauna survey**, whereby water birds were searched for during other survey and monitoring activities.

Observations:

Forty-six species of water birds have been recorded from the Whakaki Lagoon catchment (Hawke's Bay Regional Council Management Plan No. 2783, 1999; this survey). Not all may still be present. The list includes NZ Dabchick, an uncommon endemic, and Australasian Bittern, a rare native. Both are listed as threatened by the Department of Conservation (Molloy and Davis 1994, Hitchmough 2002). The list also includes three native wetland birds a little more common nationally but now very rare in Hawke's Bay: Spotless Crake, Fernbird and Banded Rail. The latter species may have now gone from the scene.

No definite detections of crakes, rails or bitterns were made in 1999, despite several hours of searching. Nor were crakes or rails detected in 2001. It was probably too late in the birds' breeding season for strong responses to taped calls to be expected and traffic noise was frequently disruptive to good listening. However, Spotless Crake were heard near the inlet in October 2005 and are reported to be still in good numbers at the lagoon (pers. com. Malcolm Smith, Department of Conservation, Wairoa).

Bitterns were heard booming in several places around the lagoon shores in 2001, 2003 and 2005. In 1999, 2001, 2003, 2005 and 2007, fernbirds were found in several places around the lagoon, especially on the western side and at the eastern end, and the population appears to be reasonably strong at present.

The other wetland birds include swans, ducks, geese, shelducks, shags, herons, Royal Spoonbill (present in 1999 and 2007 but not in 2001 or 2003), Pukeko, Australasian Harrier, NZ Kingfisher, Welcome Swallow and a number of migrant and resident waders. The swans, ducks, geese, shelducks and Pukeko are seasonally hunted in the wetland. Although it is the nature of water birds to be somewhat shy, they are extremely wary, suggesting that hunting is making it difficult for them to feed, roost and breed in safety. Species added to the list during the 1999 survey were Black Shag and Black-fronted Dotterel.

Estimated numbers were similar in 2007 to those of earlier visits, but no terns, oystercatchers or Australian Coot were seen during the survey. Since those birds are highly mobile around the wider landscape, these apparent absences are not regarded as significant.

The full list of birds and their estimated numbers for December 2007 is in Appendix 4.

Next monitoring:

November-December 2009; thence every second year.

2.2 Other birds

Method:

General fauna survey, whereby birds other than water birds were searched for during other survey and monitoring activities.

Observations:

Eighteen other species of birds have been recorded at the lagoon in the past. Four (Pipit, Riroriro, Fantail and Silvereye) are common natives, whilst the remainder are common introduced species typical of the Hawke's Bay rural scene. The only change in 2001 from 1999 was that Pheasant and Riroriro were not detected. In 2003, Pheasant was present but Riroriro was not detected. Both Pheasant and Riroriro were detected in 2005 but not in 2007. The full December 2007 list of birds and their estimated numbers is in Appendix 5.

Next monitoring:

November-December 2009; thence every second year.

2.3 Fish

Method:

Fish were surveyed largely using netting and trapping. Fyke nets, hinaki and minnow traps were set overnight in 1999 at the four aquatic sampling sites (for locations, see map, Appendix 1, and aquatic vegetation and macroinvertebrate recording sheets, Appendix 3). Meat was used as bait in the fyke nets and hinaki; vegemite in perforated film canisters was used as bait in the minnow traps. Fish were also observed in open water sites and caught for identification using a scoop net. Because of practical difficulties, nets were set in only two sites (the inlet and outlet) in 2003 and 2005 and at three sites in 2001 and 2007.

Observations:

The fish in 1999 were:

- Shortfin eel (*Anguilla australis*): caught at Sites 1, 2 and 3; all small (24-53cm long).
- Inanga (*Galaxias maculatus*): seen only at Site 3 (Rahui Channel).
- Goldfish (*Carassius auratus*): erroneously known as carp (McDowall 2000); introduced to New Zealand; a single fish 15cm long caught at Site 1 (inlet to lagoon).
- Common bully (*Gobiomorphus cotidianus*): very common; caught at all sites; 3-6cm long.

In 2001, the results were similar, except that fewer eels were caught, more bullies (2-6 cm long) were caught and goldfish were seen but not caught. Whether these findings are significant or not is not clear; they could have been artefacts of the higher water levels.

In 2003, shortfin eels (20-50cm long) were caught at Sites 1 and 3, and common bullies (including one large individual 150mm long) were caught at both sites and seen elsewhere. No inanga or goldfish were seen, but that is not taken as an indication of their absence.

In 2005, no eels were caught but the remains of shortfin eels (40-50cm long) were found at Site 2 (the results of someone else's fishing), and numerous common bullies were caught at both Sites 1 and 3 and seen elsewhere. Goldfish were seen in several places but not caught. No inanga were seen or caught.

In 2007 nothing was caught at site 1 or 2 and juvenile common bully *Gobiomorphus cotiadanus* (2-3cm) were captured at site 3. There were no eels caught in the survey ,however, shortfinned eels had been reported migrating over the spit bar. (Whakaki trust pers. Robert Walker)

Not recorded during any of the surveys, but reported from the lagoon were:

- Longfin eel (*Anguilla dieffenbachii*), now rare in the North Island.
- Black flounder (*Rhombosolea retiaria*).
- Yelloweyed mullet (*Aldrichetta forsteri*).

Next monitoring:

November-December 2009; thence every second year.

2.4 Aquatic invertebrates

Method:

Macroinvertebrates (invertebrates big enough to see with the naked eye) were sampled along with aquatic vegetation at four representative sites (see 1.2 and 2.3; locations marked on the map, Appendix 1, and described in the aquatic vegetation and macroinvertebrate recording sheets, Appendix 3). Aquatic vegetation samples were gathered by hand, and "washed" into trays to dislodge invertebrates. Water and substrate (mud, etc.) samples were also gathered and examined with the use of trays and a hand lens. Invertebrates were identified using the Taranaki Regional Council guidebook (1997) and Parkinson and Cox (1990). Sensitivity scores, indicative of water quality, were assigned from the Taranaki Regional Council guidebook (1997), but updated from Boothroyd & Stark (*in* Collier and Winterbourn 2000). Species found and their scores are listed in the aquatic vegetation and macroinvertebrate recording sheets (Appendix 4).

Observations:

In all four sites, the invertebrates found had sensitivity scores ranging from 1 (very low water quality) to 5 (moderate water quality; 10 is very high water quality). The ranges and averages of the scores are tabulated below. They show that at none of the sites was the water of very good quality, but neither was it poor. The number of species found ranged from 11-15 in 1999, from 7-18 in 2001, from 7-13 in 2003, from 10-12 in 2005 and from 8-14 in 2007. The changes in numbers of species are not considered important, probably due to the fluctuations in water levels and aquatic vegetation. In 2003, 2005 and 2007, Site 4 was not sampled because of practical difficulties associated with the high water levels.

| | Number of species found | | | | | Range of sensitivity scores | | | | |
|--------|-------------------------|------|------|------|------|-----------------------------|------|------|------|------|
| | 1999 | 2001 | 2003 | 2005 | 2007 | 1999 | 2001 | 2003 | 2005 | 2007 |
| Site 1 | 15 | 18 | 13 | 12 | 14 | 1-5 | 1-5 | 1-5 | 1-5 | 1-5 |
| Site 2 | 11 | 7 | 7 | 11 | 8 | 1-5 | 1-5 | 1-5 | 1-5 | 1-5 |
| Site 3 | 11 | 11 | 9 | 10 | 10 | 1-5 | 1-5 | 1-5 | 1-5 | 1-5 |
| Site 4 | 12 | 9 | - | - | - | 1-5 | 1-5 | - | - | - |

Next monitoring:

November-December 2009; thence every second year. Sampling to be repeated; recording sheets to be used.

2.5 Mammalian pests

Method:

General fauna survey, whereby signs of mammalian pests were searched for during other survey and monitoring activities.

Observations:

Eight mammals that could be regarded as pests in the wetland were detected during baseline survey and monitoring set-up in 1999:

- Domestic cattle: present in many places; fenced out from the south and west of the lagoon but still occasionally penetrating.
- Domestic sheep: present in relatively low numbers on the north and east sides.
- Domestic/feral goats: present in small numbers at the east (outlet) end; should be controlled if feral.
- Rabbit and hare: present right around the margins, but especially on the dunes; require ongoing control.
- Possum: present around the lagoon margins, though not in high numbers; best controlled.
- Hedgehog: present around the lagoon margins.
- Feral cat: present in low numbers around the lagoon margins.

In 2001, all were still present in much the same estimated numbers, with the exception of rabbits, which were in much lower numbers (the result of RCD?). Hares seemed to be more conspicuous, possibly as a consequence. Eaten petrel remains on the beach in 2001 suggested cat predation.

In 2003, the situation was much the same as in 2001, except that sheep were not present at the time of survey. In 2005, sheep were also absent and possums (perhaps also rabbits and hares) were being controlled near the plantings. In 2007 there were no sightings of any pests. Rabbit and Hare were being controlled by the landowners and there were numerous bait stations to control other pest species. Semi feral goats were still present on the South-east end at the outlet. Domestic cattle had been excluded from most of the Lagoon edge apart from a small area on the West side.

Other mammalian pests probably present but not detected include:

- Ship rat and Norway rat: known predators of birds, lizards and invertebrates.
- Mouse: known predator of invertebrates.

- Stoat, ferret and weasel: known predators of birds, lizards and invertebrates; good swimmers.

Next monitoring:

November-December 2009; thence every second year.

2.6 Terrestrial invertebrates

Not deliberately surveyed or included in the monitoring plan, but worthy of separate study. The suite of invertebrates living in driftwood is particularly noteworthy, especially considering the relative intactness of the seashore. Rapid examination showed that many native species were present, including earwigs, termites, weevils, other beetles, sand scarabs, ants and spiders.

2.7 Reptiles and amphibians

Also not deliberately surveyed or included in the monitoring plan, but worthy of separate study. Common skinks (*Leiopisma nigriplantare polychroma*) were seen among dune vegetation. In 1999, frogs were heard on the south-western shore of the lagoon. They were probably the southern bell frog (*Litoria raniformis*), native to Australia and reasonably widespread in New Zealand. In 2001, adult frogs were not heard, but tadpoles were found at the aquatic sample site at the NW corner of the lagoon. Frogs were not found in 2003, but were heard at both ends of the wetland in 2005 but not in 2007. Frogs have rapidly declined recently world-wide (and in New Zealand) through fungal disease. The presence of frogs in this wetland can therefore be viewed as positive, particularly considering that they are not regarded as having a significant adverse impact on the natural ecology.

Next monitoring:

General observation, November-December 2009; thence every second year.

3. CONCLUSIONS AND RECOMMENDATIONS

This section of the report is taken directly from conclusions and recommendations given by Geoff Walls (2007)

The key natural features of Whakaki Lagoon and its surrounds are:

- Lagoon: outstanding habitat for wetland birds, including several rare and iconic species; eels, bullies, inanga and other native fish; beds of native aquatic macrophytic plants; fringes of primarily native vegetation, including saltmarsh ribbonwood, rushes, sedges and wetland turfs;
- Beach/dune system: mat daisy (*Raoulia* aff. *hookeri*) cushion fields; spinifex; native invertebrates and lizards; the potential for restoration of pingao and sand tussock;
- Overall restoration potential: wetland and coastal shrubland and forest, flax, rushlands and sedgeland, sand plants, eel populations, wetland and coastal bird populations.

In addition, there is a strong tradition of customary custodianship, which persists. Therefore there are bright prospects for restoration and enhancement of the natural features of the lagoon system. Already considerable restoration has been done, including fencing to exclude domestic stock, weed and animal pest control and restoration planting. Most of this has been done by the owners in collaboration with the Department of Conservation. My previous monitoring reports, commissioned by the Council, have provided valuable guidance.

The monitoring regime has allowed a series of conclusions to be drawn about various aspects of the ecological condition and trend of the lagoon system, and the efficacy of management. Out of these conclusions flow a consequent series of recommendations. They are split into three sections:

- Monitoring methods
- State of the Environment (SOE) monitoring and reporting
- Management issues

3.1 Monitoring methods

3.1.1 Vegetation

The monitoring regime for terrestrial and aquatic vegetation is practical and meaningful, therefore appropriate in addressing the current management issues. However, the vegetation transects are rather complicated and time-consuming, and can be covered by photopoints.

Recommendation: That the current monitoring regime for vegetation (including weeds) continues, except that transects be covered by photopoints rather than measured.

3.1.2 Notable Flora

Mat daisy (*Raoulia* aff. *hookeri*) is the most note-worthy plant species present, forming remarkable cushion fields in the sand hollows behind the beach. These communities are probably of great antiquity but are threatened by invading exotic grasses, herbs and shrubs. Indian doab, a creeping grass, is the worst of these, although evening primrose also looks to

have troublesome potential. Intensive photographic monitoring has been set up to follow the issue, and shows a deterioration in condition. So now is the time to do some small-scale management trials in preparation for a larger effort that looks likely to be needed in future. Localised grass-specific herbicide application may be all that is needed, although work elsewhere suggests that mat daisies are quite sensitive to herbicides. Trials and monitoring of their efficacy are required, sooner than later.

Recommendation: That Raoulia aff. hookeri cushion fields continue to be monitored intensively, that small-scale herbicide trials be carried out and the results monitored to assess the efficacy of controlling Indian doab without damaging Raoulia.

3.1.3 Fauna

The monitoring regime for most terrestrial fauna and aquatic macroinvertebrates is practical and meaningful, therefore appropriate in addressing the current management issues. It is insufficient to properly determine the condition and trend of rare water bird, lizard, dune invertebrate and fish populations, each of which would require more effort and different timing. Fish population assessment is being carried out by another agency, and the owners have a pretty good handle on the eels and goldfish (Robert Walker, pers com.). Fish & Game and local hunters routinely assess waterfowl.

Recommendation: That the current monitoring regime for terrestrial fauna and aquatic macroinvertebrates continue.

Recommendation: That additional emphasis is given to monitoring rare water birds (see below).

Recommendation: That additional emphasis is given to survey and monitoring of lizards and dune invertebrates (see below).

(a) Rare water birds

The variety and numbers of water birds appear to be holding their own well at present. One nationally rare species - Australasian bittern - may now be resident at the lagoon, and the populations of fernbird and spotless crake (both regionally rare) appear strong. It is not known whether banded rail or marsh crake still persist; they are notoriously hard to detect, especially after the breeding season. A specific search by experts in spring might reveal these birds. What is sure is that the condition of the habitat for these birds is improving with the changes in management in recent years.

Recommendation: That a specific search be mounted biennially in spring for rare water birds, using local expertise.

(b) Land birds

Land birds use the wetland in considerable numbers. Most are exotic (introduced) species, but a few are natives. The native species should progressively benefit from the restoration plantings.

Recommendation: That land birds continue to be monitored routinely.

(c) Lizards and dune invertebrates

The initial ecological survey and subsequent monitoring have only superficially encountered the small native fauna of the dune/bar system that is distinctive and ecologically special to Whakaki Lagoon. This fauna includes lizards (skinks and geckos) and invertebrates such as sand scarab, giant earwig and katipo, mostly associated with the spinifex, mat daisy and

extensive strand zone of storm-tossed driftwood. The small amount of sampling done to date suggests that populations of these native animals are currently low and at risk, but probably beginning to benefit from the predator control regime. Not much extra effort would need to be put in to do justice to this issue; probably a few hours of driftwood turning and some pitfall trapping would be required. Time of year would not be critical, although the cooler months would be best avoided.

Recommendation: That a specific survey of lizards and dune invertebrates be carried out and a routine monitoring programme be established.

(d) Aquatic invertebrates and water quality

Aquatic macroinvertebrates provide a useful measure of water quality and habitat condition. They indicate that the lagoon can support a considerable diversity of small animal life, but that the water quality is compromised by the input of sediment and artificial nutrients. There are limitations to the technique though, because it was primarily developed for stream systems, and other measures of water quality are necessary for comprehensive monitoring of condition and trend. The Ecological Monitoring Plan for Whakaki Lagoon (Walls 2000), adopted by Hawke's Bay Regional Council, proposed regular (monthly or quarterly) sampling of standard parameters. These included pH, conductivity, turbidity, colour absorbances, biochemical oxygen demand, dissolved reactive phosphorus, ammoniacal-nitrogen, nitrate-nitrogen, total phosphorus and total nitrogen. The landowners (Whakaki Trust) have themselves been carrying out extensive water quality surveys so there does not seem to be any need of repetition.

Recommendation: That aquatic macroinvertebrate monitoring continues.

3.1.4 Monitoring Techniques and Frequency

In the light of ten years' experience in Pekapeka Swamp and other wetlands in Hawke's Bay, the suite of techniques being used to monitor the ecological condition and trend of Whakaki Lagoon appear to be appropriate and valuable. The only issues are the redundancy of the vegetation transects, the difficulty of detecting rare water birds, lizards and dune invertebrates, and the lack of monitoring of water quality parameters (see above). In view of the relative stability of the wetland but some pressing management needs, monitoring at two-yearly intervals seems sensible.

Recommendation: That the current ecological monitoring programme - with the suggested modifications - be continued.

State of the Environment (SOE) monitoring and reporting

Parameters used in this monitoring regime are directly applicable to State of the Environment (SOE) monitoring and reporting. Using a basic assessment of status (or condition) and trend for each parameter, they can be used as environmental indicators, and an overall condition and trend rating for the wetland as at December 2007 can be arrived at:

| Indicator | Status/Condition (High, Medium, Low) | Trend (Improving, Stable, Deteriorating) |
|------------------------------|---|---|
| Native vegetation | M | I |
| Threatened native flora | M | D |
| Native birds | H | S-I |
| Native fish | ? | ? |
| Lizards & dune invertebrates | ? | ? |
| Native macroinvertebrates | M | S |
| Water levels | M | S |
| Water flows | M | S |
| Water quality parameters | ? | ? |
| Overall ecology | M | S-I |

The conclusion is that the wetland is in a moderately natural state and is improving in condition in key aspects. There has been a significant improvement in native vegetation and water regime since 1999. It is expected that restoration management will produce further marked improvement in status/condition in future. The only indicator of concern is threatened native flora, notably mat daisy (*Raoulia* aff. *hookeri*): in 2005 its condition was assessed as Stable, but it is now considered to be Deteriorating. Lizards and dune invertebrates could also be in decline, or maybe starting to recover.

Recommendation: That restoration management of threatened native flora be recognised as necessary due to deteriorating condition.

Recommendation: That survey and monitoring of lizards and dune invertebrates be included as valuable ecological indicators.

Recommendation: That a similar tabulation of ecological condition and trend be used as part of the regular monitoring reporting for the wetland.

3.2 Management Issues

Fencing and native vegetation recovery

The fencing that has been carried out has been successful in excluding domestic sheep and cattle from more than half the lagoon shoreline so far. The result has been improvement in the condition and much regeneration of the native wetland vegetation around the lagoon margins there, especially saltmarsh ribbonwood, marsh clubrush, raupo, sedges and rushes. There has also been a proliferation of exotic (introduced) vegetation that was otherwise controlled, to varying degrees, by stock. Among these are blackberry, tree lupin, bindweeds and grasses, particularly creeping bent and Mercer grass. None of these are regarded as being ecological problems for the wetland ecosystem, but the invasion of the dry open sandy areas on the seaward side by exotic lupin, grasses, iceplant and herbs since stock removal is a threat to the mat daisy communities, as outlined above.

The Department of Conservation has overseen the majority of the conservation fencing, largely funded by a private endowment for regional wetland restoration. This has resulted in a secure publicly owned wildlife refuge in the north-west (inlet) part of the wetland, and physical protection of the western, southern and south-eastern sides. The rest of the lagoon - the northern and north-eastern side - is not fenced from stock, and is managed with a grazing regime. There are no serious ecological problems arising out of this at present. The deliberate use of goats to control weeds at the lagoon outlet (south side) is not helpful to the regeneration of native vegetation there, as the goats enter the fenced protected area.

Recommendation: That the Regional Council assist in maintaining existing fences in stock-proof condition and that assistance to fence other parts of the lake margin be offered to the owners if requested.

Restoration planting

Because the native woody vegetation has become so depleted around the lake and in the surrounding landscape, deliberate planting is necessary to create a dominant and self-perpetuating cover of native forest, shrubland and flax for the future. This process has already been successfully started, in collaboration between the owners and the Department of Conservation. The results are impressive, especially given that most planting has been done on dry exposed sites. Already there are substantial areas of native trees, shrubs and harakeke, proof that such vegetation naturally surrounded the wetland. The potential for more such restoration planting is great. It includes restoration of native sand plants formerly present: pingao, sand tussock, sand coprosma and sand daphne. Pockets of these could be planted and are unlikely to threaten the mat daisies.

The only ecological issue is the use of “exotic natives”, plant species native to New Zealand but not natural to Hawke’s Bay. These include pohutukawa and karo, now well established and likely to self-perpetuate and spread. They are currently performing valuable habitat roles and do not threaten any natural ecosystems. The issue is one of naturalness: ideally, planting to restore natural patterns and processes should be of native species from the locality (ecological district).

Recommendation: That the Regional Council encourage the continued planting of native plants in the areas of former pasture from which stock are excluded, species from the ecological district to be used for preference.

Recommendation: That the establishment of native sand plants formerly present, including pingao, sand tussock, sand coprosma and sand daphne, be encouraged.

Water levels, flows and aquatic vegetation

The water level of the lagoon has been lowered in the past by opening an artificial outlet channel through the dune and beach system direct to the sea, much against the wishes of the tangata whenua. This allowed salt water to enter the lagoon, otherwise very much a freshwater system, killing freshwater plants and animals and creating damaging algal blooms. It also denied eels and inanga their traditional migration paths. Fortunately an end was put to this practice of artificial drainage, and the ecological healing process is proceeding well.

Recommendation: That the experience of the disastrous practice of artificial drainage of the lagoon be remembered and never repeated.

Weeds

There are some terrestrial weeds present, but few aquatic ones as yet. Of greatest concern are Indian doab and marram grass, which are threatening the cushion fields and spinifex on

the sand. The marram grass could be eradicated from the whole system quite easily at this stage: small infestations in the south-east have been eliminated but the big patch in the south-west is spreading. Indian doab may be able to be controlled locally without great difficulty. Pampas grass, boxthorn, gorse, sweet brier and bone-seed are also threats to the sand system and should be controlled wherever found as a matter of course. Exotic iceplant has been planted near the huts on the southern side of the lagoon. It is a serious threat to the dune system, especially the cushion (mat daisy) fields, and no matter how attractive it appears now it should be eradicated as a matter of urgency. Consultation with the owners in this matter will be essential. Potentially troublesome terrestrial arrivals could be vines such as old man's beard and Japanese honeysuckle. They should be controlled as soon as they are detected. Willows are present in small quantities; they should be watched carefully as they have the potential to proliferate around the shores of the lagoon and in the channels, as has happened in most of Hawke's Bay's freshwater wetlands. Water net poses a serious potential aquatic threat to this shallow lagoon, and could easily arrive. Uncontrolled commercial eeling is being done in wetlands where it is prolific further south in Hawke's Bay, and it is thought that water net has arrived there by that means, probably from the Bay of Plenty.

Recommendation: That marram grass be eradicated as soon as possible, and that trials be undertaken to assess the practicality and ecological consequences of Indian doab control using grass-specific herbicides.

Recommendation: That gorse, pampas grass, sweet brier, bone-seed and boxthorn be actively controlled wherever found.

Recommendation: That exotic iceplant be eradicated as soon as possible.

Recommendation: That old man's beard, Japanese honeysuckle and other such newly arrived weeds be controlled wherever found in the wetland.

Recommendation: That the existing willows be carefully watched and be controlled if they show signs of spread in the wetland.

Recommendation: That commercial eeling activities be placed under strict surveillance to ensure that water net is not transported to Whakaki Lagoon.

Mammal pests

Herbivorous mammal pests are not now much of a problem in the wetland. Domestic sheep and cattle have been excluded from much of the lagoon surrounds by fencing, and rabbits, hares and possums appear to be at low levels. Goats straying into the protected area near the lagoon outlet are not helpful to native vegetation recovery there, but their impact is local. The main on-going mammal threats are now from predators (cats, ferrets, hedgehogs, stoats, weasels and rats). For the last few years, trapping, poisoning and shooting has reduced predator numbers to quite low levels and active maintenance of a trapping and bait station regime by the owners is keeping their numbers down on the southern side. This must be helping the resident population of spotless crakes, fernbirds and Australasian bitterns, and enhancing the potential for the dune system to become a breeding and roosting haven for shore birds and waders, including NZ dotterel, oystercatchers and terns. If the regime of trapping and bait station use was extended to the other shores of the lagoon, the recovery in bird life and small native fauna would be even more impressive.

Recommendation: That the Regional Council encourage the maintenance and expansion of the programme of mammal predator control for the wetland.

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APPENDIX 1: Map of Whakaki Lagoon, showing vegetation types and monitoring site locations

1. Vegetation types

| | |
|-----------|---|
| W | Low herbfield-sedgeland in zone of wave action and periodic inundation |
| SR | Lagoon shore fringe of dense sedges and rushes |
| MG | Mosaic of rushes, sedges, blackberry and grazed pasture |
| MR | Mosaic of rank grasses, rushes, sedges, pohuehue, lupin, blackberry, etc. |
| Ra | Sparse vegetation of <i>Raoulia</i> aff. <i>hookeri</i> and exotic grasses on rear of dunes |
| Sp | Spinifex grassland on foredunes |
| Ma | Marram grassland |

2. Monitoring sites

- Photopoints
- Vegetation transects
- Aquatic sampling sites

APPENDIX 2: Photopoint recording sheets, December 2007

- Photopoint no. 1
- Photopoint no. 2
- Photopoint no. 3
- Photopoint no. 4
- Photopoint no. 5
- Photopoint no. 6
- Photopoint no. 7
- Photopoint no. 8
- Photopoint no. 9
- Photopoint no. 10
- Photopoint no. 11
- Photopoint no. 12
- Photopoint no. 13

PHOTOPOINT RECORDING SHEET

| | | |
|--|-----------------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 1 |
| Establishment date: 2/12/99 | | GPS reference: E2902212 N6231138 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: Via access track along W end of orchard & across railway line, thence across paddock to bridge across inlet channel. Photopoint on small knoll c. 10m from gate on S side of bridge (material dredged from channel). Direction from marker/post (magnetic bearing): 6-7-photo pan SW-S Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Expanse of dense tall <i>Bolboschoenus fluviatilis</i> with occasional <i>Juncus effusus</i> . Single clump of raupo near fence to S: expanding? A few cattle using area, but essentially now fenced to exclude them. Should show recovery of shrubs in time. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 6/12/01 | G. Walls | Now cattle free. <i>Bolboschoenus</i> expanse looks essentially as in 1999. Raupo patch has expanded in both directions. In absence of grazing Mercer grass and annual beard-grass are growing up in wet open ground (ex pasture). In next-door paddock, <i>Bolboschoenus</i> is poised to take over if grazing is abandoned or eased. 3 extra photos taken to N and W. |
| 8/12/03 | G. Walls | Essentially as in 2001. <i>Bolboschoenus</i> dominant where free of grazing. Raupo has bulked up a little. Next-door paddock is grazed down. This area is now managed by DOC. |
| 10/10/05 | G Walls | Earlier in season so <i>Bolboschoenus</i> still brown (hasn't yet grown back from its winter die-off). Paddocks more flooded from recent rain (entire wetland system water level raised). Raupo continuing to bulk up. Much waterfowl. Bittern booming. |
| 03/12/07 | G Walls F. Cameron | <i>Bulboschoenus</i> dominant and showing new growth. Raupo has continued to expand. Blackberry has thickened but is being sprayed in an attempt to control it. The water level is very low due to the extensive dry period. |

PHOTOPOINT RECORDING SHEET

| | | |
|--|-----------------------|--|
| Location/Area: Whakaki Lagoon | | Photopoint no: 2 |
| GPS reference: E2902946 N6231036, E2902883 N6230833 | | |
| Establishment date: 5/12/99 | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: From corner of road at small bluff, across railway line. Tag on stile post, from which 1 photo taken. 4 photos taken from lake edge where artificial inlet channel meets lagoon. | | |
| Direction from marker/post (magnetic bearing): 1 photo SW; 4 photos SW-E | | |
| Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Shore turf of <i>Mimulus repens</i> and <i>Lilaeopsis ruthiana</i> . <i>Azolla</i> dominant in channel mouth and around shore. Backed by dense <i>Bolboschoenus fluviatilis</i> with scattered <i>Juncus kraussii</i> . Heavy use by cattle, swans, geese & ducks, so heavily grazed. <i>Bolboschoenus fluviatilis</i> tall and dominant on S side of channel. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer/ | Comments (changes, processes, etc) |
| 6/12/01 | G. Walls | From stile: looks to be little change except karamu has grown up and blackberry has expanded slightly. From lake edge: little change except water level at least 30cm higher than in 1999 and <i>Bolboschoenus</i> has grown in both height and density. Because of the water, photos taken from about 20m north of 1999 spot; angle difference makes it look like a change in <i>Juncus kraussii</i> , but not so. |
| 8/12/03 | G. Walls | From stile: silver poplar and blackberry have expanded somewhat. From lake edge: pressure from cattle has increased, knocking down the <i>Bolboschoenus</i> especially. Otherwise similar to 2001. Amazing abundance of waterfowl. |
| 10/10/05 | G. Walls | From stile: silver polar and blackberry have expanded much. Water level high. From lake edge: a considerable loss/retreat of <i>Bolboschoenus</i> , because of cattle and higher water level. Waders required to reach photopoint! |
| 05/12/07 | G Walls F. Cameron | From stile: Silver poplar and blackberry have continued to expand From lake edge: much as 2005, but water level is much lower and cattle have grazed the vegetation down. Sea rush has expanded a little. |

PHOTOPOINT RECORDING SHEET

| | | |
|---|----------------------|--|
| Location/Area: Whakaki Lagoon | | Photopoint no: 3 |
| Establishment date: 2/12/99 | | GPS reference: E2903756 N6230777 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: | | |
| Base of bluff on NW shore of lagoon. 2 photos taken from railway line, near yellow-painted upright piece of railway iron (tag on sleeper nearby) | | |
| Direction from marker/post (magnetic bearing): 2 photos, SE & SW, from 20m apart | | |
| Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): | | |
| Shore fringe of very dense <i>Bolboschoenus fluviatilis</i> , grazed and browsed by cattle and waterfowl. Very damp. Behind is pasture in which <i>Bolboschoenus fluviatilis</i> is a major component. <i>Juncus kraussii</i> is scattered in pasture, sometimes in a substantial shore fringe but elsewhere sparse. Chosen to follow changes where there is continued stock use on lagoon shore. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer/ | Comments (changes, processes, etc) |
| 6/12/01 | G. Walls | Lagoon water level much higher than in 1999; paddocks inundated. Paddock vegetation looks similar though. Silver poplars have rapidly grown up along railway line and will soon obscure the view! |
| 8/12/03 | G. Walls | Little different from 2001 except paddocks grazed harder (<i>Bolboschoenus</i> lower) and silver poplar has bulked out considerably. |
| 10/10/05 | G. Walls | <i>Bolboschoenus</i> more or less gone: cattle and inundation. Cattle impact evident from dense <i>Bolboschoenus</i> right up to fence. Sea rush hasn't really changed. Silver poplar has bulked out much. |
| 05/12/07 | G Walls F Cameron | Silver poplar has bulked further. Cattle impact less now, so <i>Bolboschoenus</i> and sea rush have both bulked out |

PHOTOPOINT RECORDING SHEET

| | | |
|---|----------------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 4 |
| GPS reference: E2904965 N6230304, E2905006 N6230158 | | |
| Establishment date: 2/12/99 | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: Pull-off at NE of lagoon, with lots of silver poplar. Access track at E end of pull-off, across railway line thence down to lagoon shore at maimai. 1 photo (4a) from railway line, marked with tagged batten; 3 photos from maimai. | | |
| Direction from marker/post (magnetic bearing): 1 photo SSE; 3 photos W,N,E | | |
| Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Shore fringe of <i>Bolboschoenus fluviatilis</i> and <i>Juncus kraussii</i> in varying proportions. Inland of this, pasture of grasses and buttercup, grazed by cattle and sheep. <i>Ruppia polycarpa</i> and <i>Potamogeton pectinatus</i> in drifts on shore (pulled up by swans). Chosen because is a representative lagoon fringe system used by stock. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 6/12/01 | G. Walls | 4a: <i>Bolboschoenus fluviatilis</i> has grown up and thickened much in the <i>Juncus kraussii</i> zone. Flooded cf 1999. Silver poplar has grown massively by the railway line and will soon obscure the vista. 4b: As 4a. More flooded than in 1999, so can't see lower plant tiers. |
| 8/12/03 | G. Walls | 4a: silver poplar has grown to virtually obscure the vista now. 4b: As 2001; little change except <i>Bolboschoenus</i> has decreased amongst <i>Juncus</i> which seems to have increased in standing water. Probably the effect of higher water levels in recent years. |
| 10/10/05 | G. Walls | |
| 05/12/07 | G Walls F Cameron | 4a: silver poplar much grown up. 4b: Little change from 2003, though water level higher. Water level raised and very sticky mud. Hard to reach photopoint. Vegetation essentially as 2005 |

PHOTOPOINT RECORDING SHEET

| | | |
|---|----------------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 5 |
| Establishment date: 3/12/99 | | GPS reference: E2906128 N6229875 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: Outlet, where Rahui Channel leaves lagoon. S side, at fence tie-off. | | |
| Direction from marker/post (magnetic bearing): 3 photos, NW, NE, SW Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Rank rough pasture with sedges and rushes (<i>Bolboschoenus fluviatilis</i> , <i>Juncus kraussii</i> , <i>J. gregiflorus</i>) and lots of exotic herbs and grasses. On shore, areas of <i>Schoenoplectus pungens</i> and turf of <i>Mimulus repens</i> , <i>Lilaeopsis ruthiana</i> and <i>Cotula coronopifolia</i> . Chosen to follow changes with varying regimes of stock exclusion, water level fluctuation, revegetation, etc. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 8/12/01 | G. Walls | Water level significantly higher than in 1999, so can't see turfs. Since fencing of the right bank of channel mouth and east shore of lagoon, grasses, rushes, <i>Bolboschoenus fluviatilis</i> and <i>Schoenoplectus pungens</i> have all increased in density and height. Expect marsh ribbonwood to appear and flourish on shore in future. Goats on channel bank just downstream. |
| 8/12/03 | G. Walls | Water level as 2001. Portion to SE of system fenced now and regenerating well in <i>Bolboschoenus</i> , <i>Juncus kraussii</i> and <i>Schoenoplectus</i> . A lone pampas has appeared and should be killed. To N, where not fenced, grazed harder than in 2001 and channel banks cut down and exposed more. A few goats present. |
| 11/10/05 | G. Walls | More or less as in 2003. Goats present. <i>Bolboschoenus</i> has diminished through grazing. Pampas is larger and should be killed. The 'delta' area is more vegetated, but the turf is inundated. Channel banks are eroding through wave action and cattle impact where not fenced; would regrow <i>Bolboschoenus</i> if fenced off. |
| 05/12/07 | G Walls F Cameron | Goats present (c.20). Channel banks downstream still with stock impact. Upstream going back is rank grass, rushes, <i>Bolboschoenus</i> and saltmarsh ribbonwood. Pampas proliferating and should be killed. |

PHOTOPOINT RECORDING SHEET

| | | |
|---|-----------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 6 |
| Establishment date: 3/12/99 | | Grid reference: X19/055292 |
| Observer/Photographer: Geoff Walls | | |
| Photopoint relocation notes: SE corner of lagoon, at old fence tie-off where it enters water. Photos taken standing on big log. | | |
| Direction from marker/post (magnetic bearing): 4 photos NE, W, S. Also one to E. Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Mix of <i>Juncus kraussii</i> , <i>Bolboschoenus fluviatilis</i> and shore ribbonwood to NE of fence; little of these to S, instead a mix of <i>Bolboschoenus fluviatilis</i> , rushes, occasional shore ribbonwood, pohuehue and grasses, and <i>Carex pumila</i> by shore. Shore ribbonwood expected to increase, along with other woody natives, when fenced to exclude stock. To S, boxthorn and lupin are spreading along the dune system from the east, and require surveillance. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 8/12/01 | G. Walls | Lagoon levels higher than in 1999. Still, lots of drifted <i>Potamogeton</i> and <i>Ruppia</i> washed up on shore. <i>Bolboschoenus fluviatilis</i> has thickened up a bit since shore fenced off in 2000. Shore ribbonwood likewise. Otherwise looks similar; perhaps a bit more <i>Carex pumila</i> on beach to S. Extra photo taken to E of gorse and pampas grass that need to be eliminated. |
| 8/12/03 | G. Walls | Similar to 2001. Has been some shore erosion in recent times (wave-driven). Regeneration process continuing. Gorse has been killed but pampas is thriving and should also be killed. |
| 11/10/05 | G. Walls | Similar to 2003. <i>Bolboschoenus</i> and three-square are holding the shore together in the face of wave action. Regeneration of shore ribbonwood continues (it is becoming more dominant). Pampas has burgeoned and should be killed. |
| 10/12/07 | F Cameron | Similar again to 2005. <i>Bolboschoenus</i> and three square are still protecting the shore from erosion. Pampas has been sprayed in an attempt to control. |

PHOTOPOINT RECORDING SHEET

| | | |
|--|-----------------|--|
| Location/Area: Whakaki Lagoon | | Photopoint no: 7 |
| Establishment date: 3/12/99 | | GPS reference: E2903926 N6229166 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: Northwards of hut with black header tank to fenced revegetation area. Photopoint at NE corner of fenced area. Netting removed (2003). | | |
| Direction from marker/post (magnetic bearing): 4 photos, E, SE, S, W Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Mosaic of pohuehue, blackberry, convolvulus, lupin, grasses and flatweeds on dry sand; wet hollows dominated by <i>Baumea articulata</i> ; shore fringe of <i>Juncus kraussii</i> and <i>Bolboschoenus fluviatilis</i> . Plantings of taupata, ngaio, karo, cabbage tree, pohutukawa, flax. Single boxthorn nearby: should be controlled. Some cabbage trees and clumps of pampas to the E. The area should show recovery of native shrubs in time. The plantings are likely to change the face of the locality. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 7/12/01 | G. Walls | Planted plants have survived and grown, especially ngaio, flax and pohutukawa. Netting is successfully preventing hare damage to them. Tree lupin has grown much, as has <i>Muehlenbeckia complexa</i> . Boxthorn dead (has been controlled). Cabbage tree has new basal shoot. |
| 9/12/03 | G. Walls | Plantings have flourished: ngaio, karo, flax, pohutukawa, taupata and cabbage trees. Those responsible can be justifiably proud. Although some plants are exotic, and others 'exotic natives', the plantings show what can be done by local communities, and also that forest must have grown on the spit in the past. Pohuehue and blackberry a bit weedy but not yet threatening. <i>Raoulia</i> looks much as before. |
| 10/10/05 | G. Walls | Plantings have continued to flourish. The wetland vegetation looks similar to 2003. Pohuehue and blackberry are abundant but not impeding the planted trees and shrubs. |
| 10/12/07 | F Cameron | Plantings are looking very healthy. Blackberry and Pohuehue similar to 2005 – have not impeded plantings. |

PHOTOPOINT RECORDING SHEET

| | | |
|--|-----------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 8 |
| GPS reference: E2902824 N6226874 (post), E2902777 N6228904 (photopoint) | | |
| Establishment date: 3/12/99 | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: SW of lagoon on top of foredune, c. 40m SW of a huge old strainer post just behind the foredunes. | | |
| Direction from marker/post (magnetic bearing): 4 photos, E, NE, NW, W Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Spinifex dominant on foredunes, with accumulations of driftwood to seaward. On sand flats, scattered <i>Raoulia hookeri</i> patches with sparse flatweeds and exotic grasses. Both communities at threat from nearby marram grass. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 7/12/01 | G. Walls | Spinifex still healthy. In dune slack zone, more ground cover of sorrel, flatweeds and exotic grasses (including Indian doab) than in 1999. Less bare sand. Lupins and <i>Bolboschoenus fluviatilis</i> have grown up nearer lagoon. |
| 9/12/03 | G. Walls | As before: processes have continued. Spinifex and <i>Lagurus</i> flowering heavily this year. Much pumice in with the driftwood on the strand zone. |
| 10/10/05 | G. Walls | Pretty much as in 2003, but changing in places. Spinifex population is very healthy. Lupins are increasing. Bare sand is being clothed in shore convolvulus, Indian doab and herbaceous exotic plants, indicating that the habitat for <i>Raoulia</i> is becoming poorer. |
| 10/12/07 | F Cameron | Spinifex is healthy – advanced shoreward. Bare sand invaded by Indian doab and convolvulus although not advanced from 2005. |

PHOTOPOINT RECORDING SHEET

| | | |
|---|-----------------|--|
| Location/Area: Whakaki Lagoon | | Photopoint no: 9 |
| Establishment date: 3/12/99 | | GPS reference: E2902583 N6229239 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: SW corner of lagoon, on new fenceline. Tag on 6 th post S of gate at top of small but strategic rise. | | |
| Direction from marker/post (magnetic bearing): 360-degree panorama (13 photos) | | |
| Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Sparse vegetation of <i>Carex pumila</i> , <i>Raoulia hookeri</i> patches and various exotic grasses and herbs on dry sand. Areas of marram grass, threatening to expand, on either side of the fence. Rushes and sedges in damp hollows. Patches of blackberry and some gorse, lupins and pampas grass. Control of marram, gorse and pampas proposed. Fate of <i>Raoulia</i> is significant. Regeneration of native shrubs is likely in rushland-sedgeland where stock now excluded. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 7/12/01 | G. Walls | Marram grass has significantly advanced in places. <i>Bolboschoenus fluviatilis</i> has thickened on the lagoon shore. Blackberry has expanded. Ground cover on sand of exotic flatweeds and grasses (especially haretail and Indian doab) has increased notably. |
| 9/12/03 | G. Walls | Marram continuing to advance: <u>desperately necessary to eradicate it asap</u> . Lupins spreading, flowereing heavily. <i>Lagurus</i> abundant, flowering heavily. Herbs on sand now abundant. <i>Bolboschoenus</i> still abundant by shore; looks like <i>Juncus kraussii</i> is increasing with it. Fernbirds present. |
| 10/10/05 | G. Walls | Marram is still advancing fast. North of the fence it has been sprayed, but it is unimpeded south of there. Lupins spreading fast also. Evening primrose has much increased in the <i>Raoulia</i> zone and may pose a considerable threat. Bare sand is becoming vegetated. In the wet zone, much increase in <i>Isolepis prolifer</i> . |
| 10/12/07 | F Cameron | Lupin and Marram have increased. Marram is advancing Eastwards. Evening primrose still poses a threat to the <i>Raoulia</i> zone and bare sand invaded by Indian doab, haretail and flatweeds. |

PHOTOPOINT RECORDING SHEET

| | | |
|--|-----------------|--|
| Location/Area: Whakaki Lagoon | | Photopoint no: 10 |
| Establishment date: 3/12/99 | | GPS reference: E2902601 N6229378 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: SW corner of lagoon; corner of new fence, 130m S of shore. | | |
| Direction from marker/post (magnetic bearing): 4 photos, NW, NE, S | | |
| Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Dense rushland-sedgeland of <i>Juncus kraussii</i> and <i>Bolboschoenus fluviatilis</i> . Blackberry well established; some pohuehue. With grazing relief, shore ribbonwood and cabbage tree expected to expand in time. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 7/12/01 | G. Walls | Blackberry has grown much. <i>Bolboschoenus fluviatilis</i> has grown up and thickened. Pasture grasses (especially Yorkshire fog) have grown up rank. Cabbage trees nearby have resprouted from their bases. The pampas grass clump should be killed. |
| 9/12/03 | G. Walls | <i>Muehlenbeckia complexa</i> has completely smothered tagged post. Blackberry has grown. Cabbage trees looking healthy now, and pampas has been killed. <i>Juncus kraussii</i> appears to be expanding at the expense of <i>Bolboschoenus</i> . |
| 10/10/05 | G. Walls | Much as in 2003. <i>Juncus</i> could be expanding at the expense of <i>Bolboschoenus</i> , but not clear at this stage. Fernbird and bittern heard. |
| 10/12/07 | F Cameron | Cannot get to the exact site. Blackberry and pohuehue grown much. |

PHOTOPOINT RECORDING SHEET

| | | |
|---|------------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 11 Grid reference: X19/026295 |
| Establishment date: 3/12/99 | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: SW corner of lagoon, at shore. Access from new fence corner. Site marked by dual posts with iron tacked between them on water's edge. | | |
| Direction from marker/post (magnetic bearing): 3 photos, N, W, SSW Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Expanse of dense <i>Juncus kraussii</i> and <i>Bolboschoenus fluviatilis</i> around shore. Also short turf, mostly submerged, of <i>Mimulus repens</i> and <i>Lilaeopsis ruthiana</i> , possibly maintained by waterfowl. Regeneration of shore ribbonwood is likely now that stock are excluded. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer/ | Comments (changes, processes, etc) |
| 7/12/01 | G. Walls | Water levels too high to reach, so did not photograph. <i>Bolboschoenus fluviatilis</i> has thickened much and is taller since relieved of grazing. |
| 9/12/03 | G. Walls | Water levels too high to reach. <i>Juncus kraussii</i> appears to be expanding at the expense of <i>Bolboschoenus</i> . Standing water appears to have pushed back the <i>Bolboschoenus</i> , favouring the <i>Juncus</i> . Mercer grass is very dense in places. |
| 10/10/05 | G. Walls | Water levels too high and vegetation too dense to reach. Appears essentially as in 2003. |
| 10/12/07 | F Cameron | Vegetation too dense to reach so this photopoint not re-done. Vegetation has grown but not composition essentially as in 2005 |

PHOTOPOINT RECORDING SHEET

| | | |
|---|-----------------|--|
| Location/Area: Whakaki Lagoon | | Photopoint no: 12 |
| Establishment date: 3/12/99 | | GPS reference: E2902402 N6229783 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: W side of lagoon, on new fenceline. Photopoint is at gate (photos taken standing on gatepost). | | |
| Direction from marker/post (magnetic bearing): 4 photos, NNW, ENE, SSE, WSW Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Admixture of <i>Juncus kraussii</i> (evergreen) and <i>Bolboschoenus fluviatilis</i> (summer green). <i>Bolboschoenus fluviatilis</i> coming away where cattle are excluded; may overcome the <i>Juncus kraussii</i> . Much small fathen and <i>Cotula coronopifolia</i> on ground. With exclusion of cattle to E of fence, there may be regeneration of shore ribbonwood, cabbage tree, flax, etc. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 7/12/01 | G. Walls | Reached after a long exhausting wade through deep water! Main change is that <i>Bolboschoenus fluviatilis</i> has grown up in height and density on both sides of fence (stocking levels are down on the SW side), but especially on the lagoon side where stock are excluded. |
| 9/12/03 | G. Walls | Not visited because of high water levels. Viewed from the fence at Transect 6. <i>Bolboschoenus</i> now dense and tall (released from grazing); <i>Juncus kraussii</i> has increased also. |
| 10/10/05 | G. Walls | Not visited because of high water levels. Essentially as in 2003. |
| 10/12/07 | F Cameron | Not visited as unable to reach due to thickness of vegetation. Looks essentially as in 2005. |

PHOTOPOINT RECORDING SHEET

| | | |
|---|-----------------|---|
| Location/Area: Whakaki Lagoon | | Photopoint no: 13 |
| Establishment date: 9/12/03 | | GPS reference: E2902554 N6228972 |
| | | Observer/Photographer: Geoff Walls |
| Photopoint relocation notes: Seaward end of the fence that constitutes Transect 6 at the western end of the dune system. | | |
| Direction from marker/post (magnetic bearing): 2 photos, N & S | | |
| Camera info (lens, film, etc): 50mm, 200asa colour | | |
| Vegetation (composition, structure, patterns, processes): Sparse vegetation on sand: <i>Raoulia</i> mats with <i>Lagurus ovatus</i> , <i>Carex pumila</i> , Indian doab and a few flatweeds; dense spinifex on the raised foredune. | | |
| REPHOTOGRAPHY DETAILS: | | |
| Date | Observer | Comments (changes, processes, etc) |
| 9/12/03 | G. Walls | New photopoint. Chosen to monitor the <i>Raoulia</i> and spinifex. Invasion of Indian doab (just arriving) affecting the <i>Raoulia</i> is the current concern. The spinifex looks very healthy at present. |
| 10/10/05 | G. Walls | Open sand is more clothed with vegetation: shore convolvulus, <i>Carex pumila</i> , harestail and herbaceous plants. <i>Raoulia</i> has definitely retreated. Spinifex very healthy. 3 photos taken. |
| 10/12/07 | F Cameron | Adult <i>Raoulia</i> plant have disappeared from around the fence line. Evidence of vehicular disturbance. Open sand remains clothed in vegetation. Spinifex doing well. |

APPENDIX 3: Aquatic vegetation and macroinvertebrate recording sheets, December 2007

- Site no. 1
- Site no. 2
- Site no. 3
- Site no. 4

AQUATIC VEGETATION AND MACROINVERTEBRATE RECORDING SHEET

| | | |
|---|---------------------|--|
| Location/Area: Whakaki Lagoon | | Site no: 1 |
| Establishment date: 5/12/99 | | GPS reference (post): E2902207 N6231140 |
| | | Observer: Geoff Walls |
| Site notes (location details, vegetation, etc): NW of lagoon at inlet channels, where crossed by bridges. Also Photopoint 1 site. Tag on gatepost just across first bridge from railway access. | | |
| SAMPLING DETAILS | | |
| Date: 05/12/07 | | Observer: Geoff Walls, Fiona Cameron |
| Sampling methods/notes: Tray and handlens; samples from southern channel; fish traps set at same site. | | |
| AQUATIC VEGETATION PRESENT | | COMMENTS |
| Species | Relative abundance* | |
| Lemna minor | s | Azzolla filiculoides not found |
| Mercer grass | m | Spirodella punctata not found |
| Creeping bent | s | Green algae not found |
| Bolboschoenus fluviatilis | m | Potamogeton suboblongus not found. |
| Raupo | m | |
| Potamogeton crispus | s | Pulled up by swans |
| Myriophyllum propinquum | s | Pulled up by swans |
| MACROINVERTEBRATES PRESENT | | SENSITIVITY SCORE (1-10) |
| Isopod (estuarine) | | 5 |
| Dytiscid beetle | | 5 |
| Microvelia bug | | 5 |
| Anisops backswimmer | | 5 |
| Water boatman | | 5 |
| Copepod | | 5 |
| Paratya shrimp | | 4 |
| Potamopyrgus snail | | 4 |
| Physa snail | | 3 |
| Oligochaete worm | | 1 |
| Chironomus midge larva | | 1 |
| Flatworm | | 3 |
| Damselfly larvae | | 5 |
| Mosquito larvae | | 3 |
| | | Many |
| | | Abundant |
| | | Abundant |

- estimated % or: u = uncommon/rare s = some m = much

NB Fernbird heard here in the Raupo.

AQUATIC VEGETATION AND MACROINVERTEBRATE RECORDING SHEET

| | | |
|---|-----------------|---|
| Location/Area: Whakaki Lagoon | | Site no: 2 |
| Establishment date: 5/12/99 | | GPS reference: E2905006 N6230158 (mimai) |
| | | Observer: Geoff Walls |
| Site notes (location details, vegetation, etc): NE of lagoon at lagoon edge. Also Photopoint 4 site. Near mimai, within edge of <i>Juncus kraussii</i> and <i>Bolboschoenus fluviatilis</i> fringe. | | |
| SAMPLING DETAILS | | |
| Date: 05/12/07 | | Observer: Geoff Walls, Fiona Cameron |
| Sampling methods/notes: Tray and handlens; samples from shore at mimai; fish traps set at same site. | | |
| AQUATIC VEGETATION PRESENT | | COMMENTS |
| Species abundance* | Relative | |
| Juncus kraussii | m | In standing water, has increased |
| Bolboschoenus fluviatilis | m | |
| Creeping bent | m | |
| MACROINVERTEBRATES PRESENT | | SENTITIVITY SCORE (1-10) |
| Dytiscid beetle | | 5 |
| Water boatman | | 5 |
| Anisops backswimmer | | 5 |
| Microvelia bug | | 5 |
| Potamopyrgus snail | | 4 |
| Physa snail | | 3 |
| Chironomus midge larva | | 1 |
| Unidentified fly larva | | |

* estimated % or: u = uncommon/rare s = some m = much

AQUATIC VEGETATION AND MACROINVERTEBRATE RECORDING SHEET

| | | | |
|--|----------------------------|---|-----------------|
| Location/Area: Whakaki Lagoon | | Site no: 3 | |
| Establishment date: 6/12/99 | | GPS reference: E2907128 N6229973 | |
| | | Observer: Geoff Walls | |
| Site notes (location details, vegetation, etc): Road bridge across Rahui Channel, E of lagoon. | | | |
| SAMPLING DETAILS | | | |
| Date: 05/12/07 | | Observer: Geoff Walls, Fiona Cameron | |
| Sampling methods/notes: Tray and handlens; samples from near bridge; fish traps set at same site. | | | |
| AQUATIC VEGETATION PRESENT | | COMMENTS | |
| Species | Relative abundance* | has increased margins | |
| Azolla filiculoides | m | | |
| Lemna minor | s | | |
| Bolboschoenus fluviatilis | m | | |
| Crack willow | u | | |
| Raupo | m | | |
| Mercer grass | m | | |
| Creeping bent | m | | |
| MACROINVERTEBRATES PRESENT | | SENSITIVITY SCORE (1-10) | COMMENTS |
| Isopod (estuarine) | | 5 | Many |
| Amphipod | | 5 | Many |
| Copepods | | 5 | |
| Microvelia bug | | 5 | |
| Freshwater shrimp | | 5 | |
| Potamopyrgus snail | | 4 | |
| Oligochaete worm | | 1 | |
| Mayfly larva (unidentified) | | ? | |
| Physa snail | | 4 | |
| Midge larvae | | 1 | |
| Fly larva (unidentified) | | ? | |
| Mosquito larvae | | 3 | |

* estimated % or: u = uncommon/rare s = some m = much

AQUATIC VEGETATION AND MACROINVERTEBRATE RECORDING SHEET

| | | | |
|---|----------------------------|---|--------------------------------------|
| Location/Area: Whakaki Lagoon | | Site no: 4 | |
| Establishment date: 6/12/99 | | Grid reference: X19/026295 | |
| Observer: Geoff Walls | | | |
| Site notes (location details, vegetation, etc): SW corner of lagoon. Also Photopoint 11 site. Tag on dual post at water's edge. Not measured in 2003 or 2005 because water level too high to reach site. | | | |
| SAMPLING DETAILS | | | |
| Date: 6/12/99, 7/12/01 | | Observer: Geoff Walls, Erna Zimmermann | |
| Sampling methods/notes: Tray and handlens; samples from shore; fish traps set at same site. | | | |
| AQUATIC VEGETATION PRESENT | | COMMENTS | |
| Species | Relative abundance* | | |
| Azolla filiculoides | s | Floating | |
| Potamogeton pectinatus | s | Floating; pulled up by swans | |
| Mimulus repens | m | Submerged, so couldn't see | |
| Lilaeopsis ruthiana | s | Submerged, so couldn't see | |
| Bolboschoenus fluviatilis | s | | |
| Juncus kraussii | s | | |
| | | Not measured in 2003, 2005 or 2007 | |
| MACROINVERTEBRATES PRESENT | | SENSITIVITY SCORE (1-10) | COMMENTS |
| Isopod (estuarine) | | 5 | Not measured in 2003 2005 or 2007 |
| Amphipod | | 5 | |
| Potamopyrgus snail | | 4 | |
| Physa snail | | 3 | |
| Microvelia bug | | 3 | |
| Anisops backswimmer | | 3 | |
| Hydrudinea leech | | 3 | |
| Sandfly larva | | 3 | |
| Chironomus midge larva | | 1 | |
| Unident. fly larva | | - | |

* estimated % or: u = uncommon/rare s = some m = much

APPENDIX 4: Bird lists, Whakaki Lagoon, December 2007

| Water birds | | | Other birds | | |
|----------------------------------|-----------|-------------------|----------------------------------|-----------|-------------------|
| Species | Est. Nos. | Breeding (yes/no) | Species | Est. Nos. | Breeding (yes/no) |
| <u>Native species</u> | | | <u>Native species</u> | | |
| Australasian bittern | 5+ | ? | Fantail | - | ? |
| Black shag | 30 | n | Riroriro | - | ? |
| Little shag | 20 | y | Shining cuckoo | - | |
| Grey duck | ? | y | Silvereye | 20 | y |
| NZ shoveler | 20 | y | NZ pipit | ? | y |
| Paradise shelduck | 50 | y | | | |
| Grey teal | 30 | ? | <u>Introduced species</u> | | |
| Pied stilt | 30 | y | Skylark | 20 | y |
| White-faced heron | 20 | ? | Starling | 100+ | ? |
| Pukeko | 50+ | y | Blackbird | 20 | y |
| Welcome swallow | 30+ | y | Thrush | 20 | y |
| NZ kingfisher | 10 | ? | Redpoll | 100+ | y |
| Australasian harrier | 10 | ? | Greenfinch | 100+ | y |
| Spur-winged plover | 30+ | y | Goldfinch | 50+ | y |
| Banded dotterel | 10+ | ? | Chaffinch | 20 | y |
| NZ dabchick | - | | Yellowhammer | 30 | y |
| Australian coot | - | | House sparrow | 30 | y |
| Variable oystercatcher | - | | Dunnock | 30 | y |
| White-fronted tern | - | | Magpie | 20 | y |
| Caspian tern | - | | Myna | 30 | ? |
| Black-backed gull | 20 | ? | Pheasant | - | ? |
| Red-billed gull | 20 | n | | | |
| Fernbird | 20 | y | | | |
| Spotless crane | 10+ | ? | | | |
| <u>Introduced species</u> | | | | | |
| Mallard | 150+ | y | | | |
| Black swan | 200+ | y | | | |
| Canada goose | 100+ | y | | | |
| Royal Spoonbill | 4 | | | | |

APPENDIX 5: Other animal lists, Whakaki Lagoon, December 2007

| Species | Est. Nos. | Breeding (yes/no) | Species | Est. Nos. | Breeding (yes/no) |
|---|------------------|--------------------------|--------------------------------|------------------|--------------------------|
| <u>Introduced mammals (detected)</u> | | | <u>Native reptiles</u> | | |
| Cattle | adjacent | | Common skink | ? | |
| Goat | adjacent | y | <u>Introduced frogs</u> | | |
| Rabbit | 20 | y | Southern bell frog | ? | |
| Hare | 30 | y | <u>Native fish</u> | | |
| Hedgehog | 20 | y | Shortfin eel | - | |
| Feral cat | 10 | y | Longfin eel | - | |
| Possum | 20 | y | Common bully | Some | |
| <u>Introduced mammals (probably present)</u> | | | Inanga | - | |
| Stoat | | | <u>Introduced fish</u> | | |
| Ferret | | | Goldfish | - | |
| Weasel | | | | | |
| Ship rat | | | | | |
| Norway rat | | | | | |
| Mouse | | | | | |