

Northland Lakes - Annual Report 2012

Prepared for Northland Regional Council

June 2012



Lake Omapere

Version

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NIWA Client Report No: HAM2012-069
Report date: June 2012
NIWA Project: NRC12205

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Contents

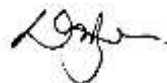
Executive summary	5
1 Introduction	8
2 Methods	9
2.1 Ecological assessments.....	9
2.2 Pest Plant Surveillance.....	13
2.3 Grass carp assessment.....	14
2.4 Management recommendations.....	14
3 Results and Discussion	16
3.1 Ecological assessments.....	16
5 Surveillance	58
5.1 Lake Ngatu.....	58
5.2 Lake Waiporohita.....	58
5.3 Lake Kai-iwi.....	58
5.4 Lake Taharoa.....	58
5.5 Lake Waikere.....	59
5.6 Lake Humuhumu.....	59
6 Grass carp assessments	60
6.1 Lake Roto-otuauru (Lake Swan).....	60
6.2 Lake Heather.....	61
7 Acknowledgements	63
8 References	64

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Executive summary

The Northland Regional Council engaged NIWA to update the Wells and Champion 2011 Northland Lakes Status report by providing the following assessments of lakes and water bodies:

Ecological assessment

Endangered species identification, wetland extent and species composition, submerged vegetation abundance and composition including LakeSPI assessment, water bird, fish and aquatic invertebrate presence and abundance, and processing findings to assign a Lake Biodiversity Assessment ranking.

Central Northland

Lake Kaiwai and Lake Omapere

Pouto

Lake Humuhumu; Lake Kahuparere; Lake Karaka; Lake Mokeno; Lake Rotokawau; Lake Roto-otuauru / Swan; Lake Rotopouua; Lake Rototuna; Lake Whakaneke

Grass carp assessment

The abundance of aquatic vegetation lake wide was assessed for Lake Heather and Lake Roto-otuauru / Swan (using sonar, scuba observations and shoreline searches) to describe the level of progress grass carp had made towards eradicating the target pest plant species.

Weed surveillance

Surveillance was carried out in Lake Humuhumu, Lake Kai-iwi, Lake Ngatu, Lake Taharoa, Lake Waikere, and Lake Waiporohita. Surveillance involved, visually inspecting sites for new pest incursions where introductions would be most likely, such as known access points and popular anchoring spots. The areas were inspected thoroughly using scuba and snorkel at depths where weed colonisation was likely to occur. The lake margins were walked and checked for drift of weed fragments on shore and marginal vegetation also checked for emergent and sprawling wetland weeds.

Lake Kaiwai ecological assessment was carried out for the first time. It was given a “High” Lake Biodiversity Assessment ranking as although it had a sparse submerged vegetation, it had a wide emergent vegetation zone grading into indigenous forest on surrounding western hills with rare plants and animals, making it a regionally important lake.

Lake Omapere margins have been found to support populations of two nationally critical plants (*Centipeda minima* subsp. *minima* and the fern *Ophioglossum petiolatum*) that require further monitoring and conservation effort. Hypereutrophic conditions have been an issue with cycles of *Egeria densa* forming excessive weed beds leading to anoxia, nutrient release, vegetation collapse and toxic algal blooms in the past. To manage this situation grass carp were introduced and feedback has been positive from local iwi regarding improved water quality. Re-establishment of mussels across the lake is also a good indicator of improved conditions without anoxia. Continuing activities such as fencing and planting of indigenous vegetation around lake margins is recommended. Initiating a programme to restore the

critically endangered *Isoetes* (*Isoëtes kirkii* var. *flabellata*) to its last known locality is also suggested.

Lake Humuhumu remains ranked an “Outstanding” lake. It is a large, relatively deep, clear lake with diverse biota including nationally rare plants, fish and birds, with no major pest species. Surveillance of margins for alligator weed needs to be undertaken and this weed removed if deemed practical to achieve.

Lake Kahuparere is ranked as a “High” value lake. It is a medium-sized lake with native vegetation, but is nutrient enriched. Livestock access to margins has recently been stopped. Consideration of sources of nutrients such as from forestry fertiliser use is a priority to safeguard this lake.

Lake Karaka is a “High” ranked lake with an indigenous vegetation and fauna and much of the margin surrounded by wetland including nationally endangered plants, fish and birds. The lake had a dense algal bloom at the time with symptoms of dying submerged plants. Fencing off the eastern shoreline to prevent cattle access to the lake would help. A consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be self-evident.

Lake Mokeno remains ranked as an “Outstanding” lake being large with an all-native vegetation, functioning as an integral part of a wetland / scrub / dune complex covering the south-western Pouto Peninsula. It contains nationally significant populations of endangered biota, but goes through regular heavy algal blooms. Algal blooms threaten in-water values in this lake, so analysis of water quality monitoring and investigation of ground water nutrient fluctuations is required to determine the nutrient sources and potential to manage these.

Lake Rotokawau is a “High” ranked lake The lake supports extensive turf communities dominated by the nationally endangered *Trithuria inconspicua*, charophyte meadows with tall-growing native species, with a good population of nationally rare dwarf inanga. The submerged weed *Egeria densa* is established however, but the good news is it has markedly declined recently and native plant bottom limits have increased.

Lake Roto-otuauru / Swan has a “Moderate” ranking and was previously highly degraded by presence of invasive plant pests *Egeria densa* and *Ceratophyllum demersum*. It is now de-vegetated while grass carp are being deployed to eradicate pest plant species. It has the rare fish *Galaxias gracilis*, and several threatened birds utilise the lake margins.

Lake Rotopouua is an “Outstanding” ranked lake with a good intact native emergent margin and submerged vegetation with some endangered biota. Analysis of annual monitoring of water quality should be undertaken to determine the extent of nutrient enrichment and consideration of sources of nutrients to the lake may find a means of mitigating the threat of nutrient enrichment.

Lake Rototuna is a “High” ranked lake with retired margins, native vegetation and endangered biota. It is threatened by pest fish and nutrient enrichment. A consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be possible. Forestry fertiliser use may be impacting on the lake.

Lake Whakaneke is a “Moderate” ranked lake, near Lake Mokeno. It is isolated and set within indigenous vegetation with dense emergent margins with good populations of several

endangered birds, but with no submerged vegetation and very poor water clarity. A consideration of nutrient sources for Lake Mokeno might also reveal why this lake is so eutrophic and mitigations measures might be self-evident.

Weed surveillance

No new weed incursions were found in the six high-risk lakes monitored.

Grass carp results

Lake Heather After 2 years of grass carp in the Lake Heather the egeria (*Egeria densa*) has nearly all gone and about 50% of the hornwort (*Ceratophyllum demersum*) has been removed. The hornwort was up to 2.2 m tall although there were bare patches. The rate of removal of the weed beds is slower than Lake Swan.

Lake Roto-otuauru / Swan Progress with hornwort and egeria eradication has been rapid with no traces of these weeds found (after 3 years of grass carp). There is now no risk of transfer of these weeds to neighbouring high value lakes. The grass carp should be left in the lake for at least another 3 years until it is certain no vestiges of hornwort or egeria remain.

Recommendations

Weed management issues identified needing consideration were alligator weed at Lake Humuhumu and reed sweet grass at Lake Rototuna.

Algal blooms indicating a threat to lake ecology were noted in lakes Whakaneke, Mokeno, Karaka, Rotopouua, and Rototuna. A consideration of nutrient sources might reveal why these lakes are so eutrophic and mitigation measures might then evident.

1 Introduction

Northland Region has some of New Zealand's highest ranked examples of intact natural aquatic ecosystems. However, they are being lost at an alarmingly rapid rate as invasive species continue to be spread as a result of human activities, and land use practices impact on lake integrity. Often pristine lakes are limited to remote areas with difficult human access and lower land use development. With adequate recognition, community support and active protection, such exceptional lakes could be maintained in a close to pristine state for perpetuity.

Northland Regional Council (NRC) has a programme of lake monitoring for 86 lakes that are surveyed on a rotational basis. This includes surveillance on prioritised lakes for early detection of weed incursions. The most recent update on the status of lakes is Wells and Champion (2012b). NRC engaged NIWA to update this report by providing the following assessments of lakes and water bodies:

1. Ecological assessments of two Central Northland lakes (Lake Kaiwai and Lake Omapere) and eight lakes on the Pouto Peninsula (Lake Humuhumu; Lake Kahuparere; Lake Karaka; Lake Mokeno; Lake Rotokawau; Lake Rotopouua; Lake Rototuna; Lake Whakaneke). Assessments included endangered species identification, wetland extent and species composition, submerged vegetation abundance and composition including LakeSPI (Submerged Plant Indicator) assessment, water bird, fish and aquatic invertebrate presence and abundance, and calculating a "Lake Biodiversity Assessment" ranking
2. Weed surveillance to detect any new incursions of aquatic pests was carried out in six priority lakes (Lake Humuhumu; Lake Kai-iwi; Lake Ngatu; Lake Taharoa; Lake Waikere; Lake Waiporohita).
3. Assess progress grass carp have made towards eradicating the target pest plant species in Lake Heather and Lake Roto-otuauru / Swan.

In addition to this report, lake ecological updates will be added to the compilation of Northland lakes ecological information as last presented in Wells and Champion (2011).

Regarding weed surveillance, assessment of biosecurity risks posed by the freshwater pests is part of the NRC Regional Surveillance Strategy for pest management within Northland Region. Native aquatic flora and fauna are highly susceptible to displacement by invasive species, and freshwater systems are much more vulnerable than forest and other terrestrial ecosystems. Active management of threats involves addressing the pathways and vectors for pests, regular surveillance for early pest detection and timely response, and strategic management of high risk pest incursions.

The two lakes assessed for grass carp impacts (Lake Roto-otuauru and Heather) are part of a programme to remove the threat of invasive weeds to nearby high value lakes and to restore these lakes to a native condition. Monitoring is needed to effectively manage stocking and timing of removal of the grass carp.

2 Methods

2.1 Ecological assessments

2.1.1 Lake description

Lakes were referenced according to assigned lake number and location (NZTM Easting and Northing) in the NRC lakes database. In addition, water bodies were photographed and observations of catchment features and ease of access were noted.

2.1.2 Wetland vegetation

The extent of emergent vegetation (percentage of shoreline, width of beds and depth range), plant species present at profiles and elsewhere around the lake, and wetlands associated with the lake were described.

Presence of endangered species (de Lange et al. 2009; Forester and Townsend 2004 and discussion of known occurrences with Department of Conservation (DOC) and NRC staff) and pest plants were reported along with an estimate of population size.

2.1.3 Submerged vegetation

The submerged vegetation was surveyed by divers using a method similar to Clayton (1983). Divers swam perpendicular to shore recording plant species present, their depth ranges, average and maximum heights and covers. These and other details including those required to complete LakeSPI surveys were recorded on data sheets (Figure 2-1).

Generally lakes were sampled at five localities selected as representative of the underwater vegetation and the range of plant communities present in the lake. Fewer than five sites were surveyed where lakes were small or de-vegetated.

Endangered species were considered as for wetland vegetation.

Prime Length
S = <25m
M = 25-100m
L = >100m

PROFILING % Cover
2=0-25
3=26-50
4=51-75
5=76-85
6=86-100

PROFILE FIELD SHEET

Lake	Station	Date	Collector	GPS
Rohingha/Ponds	E	20/10/12	Rmj	2604024, 6549519

Species	Depth range (m)	Height		Cover		Station Description
		max	avg	max	avg	
Ex	0-0.3	1	1	6	6	2604034 6549519
Ge	0-0.3	-	-	5	4	
Ca	0.2-4.1†	0.8	0.4	6	4	
Stm	0-0.1	1.7	1.7	1	1	
NP	0.5-1.2	0.4	0.4	2	2	
Pa	0.5-3.9	1.7	1.5	6	3	
NC	0.2-4.1†	0.8	0.6	6	3	

Additional LakeSPI Info.

Maximum depths

Depth	Native	Invasive
4.1†		✓
4.1†		

Native Ratio (%) Invasive

Ratio (%)	Native	Invasive
<5		✓
6-25		
26-50		
51-75		
76-85		
>95	✓	

Invasive Cover

Cover	Ratio (%)
Occasional	<10 parts
Common	
Open Canopy	
Partly-Closed	
Closed	>2 x 2m

Max. depth of dive	Total veg. Cover (%)	Visibility	Mussels	Koura
4.1	96	0.15	X	X

PROFILE SKETCH:

Figure 2-1: Survey sheet for submerged vegetation surveys.

2.1.4 LakeSPI

LakeSPI is a macrophyte bio-assessment tool that uses Submerged Plant Indicators (SPI) for assessing the ecological condition of New Zealand lakes and for monitoring trends (Clayton & Edwards 2006a; Clayton & Edwards 2006b, de Winton et al. 2012). LakeSPI data captured on the submerged plant data sheets (Figure 2-1) was used to generate three LakeSPI indices: a Native Condition Index which characterises the diversity and extent of native vegetation within a lake, an Invasive Impact Index which captures the degree of impact from invasive weed species and an overall LakeSPI Index that provides an integrated indication of lake ecological condition.

Key assumptions of the LakeSPI method are that native plant species and high plant diversity are taken to represent healthier lakes or better lake condition, while invasive plants

are ranked for undesirability based on their displacement potential and degree of measured ecological impact (Clayton & Edwards, 2006a).

Because lakes have differing physical characteristics that can influence the extent and type of submerged vegetation, each of the LakeSPI indices are expressed in this report as a percentage of a lake's maximum scoring potential. Scoring potential reflects the maximum depth of the lake to normalise the results from very different types of lakes. A lake scoring full points for all LakeSPI indicator criteria would result in a LakeSPI Index of 100%, a Native Condition Index of 100% and an Invasive Impact Index of 0%.

For ease of interpreting LakeSPI results, five lake condition categories (Excellent, High, Moderate, Poor, Non-vegetated) are used to provide a description of a lake's ecological status at the time of a survey. These categories provide a summary of the LakeSPI data, and allow comparisons to be made between lakes where LakeSPI Index score: >75% = Excellent, >50-75% = High, >20-50% = Moderate, >0-20% = Poor, 0% = Non-vegetated. A complete description of measured characteristics is given in the technical report and user manual at www.niwascience.co.nz/ncwr/tools/lakespi. The LakeSPI method is also supported by a web-reporting service found at www.lakespi.niwa.co.nz, where scores for lakes assessed to date can be searched and displayed.

LakeSPI assesses indicators of lake ecological condition and should not be confused with the 'Lake Biodiversity Assessment'.

2.1.5 Lake Biodiversity Assessment

The lakes were prioritised for 'Lake Biodiversity Assessment' based on three components: Indigenous biota, endangered species and habitat availability.

1. Indigenous biota

For native species or indigenous biota we assessed the value of what species were present at the time and the metrics scored were: species richness, abundance and representativeness:

- 'Species Richness' was the total number of indigenous macroscopic species (fauna and flora) in the lake and wetland margins.
- 'Abundance' for native flora present was assessed on the basis of area and cover, and for fauna it was population size. 'Representativeness' of the species assemblage was obtained by assessing the significance of the communities present (not species rarity) in regional and national context.

2. Endangered species

Endangered species were scored on the basis of the 'New Zealand Threat Classification System lists' (Hitchmough et al. 2007) and also using de Lange et al. (2009). The categories are 'acute', 'chronic' and 'at risk':

Within 'acute' there are four categories:

- 'Extinct in the wild' (e.g., *Isoetes kirkii* var. 'flabellata', Omapere) was not used in this evaluation, as the assessment covered species present at the time, not past species or potential.
- 'Critical' e.g., white heron (a casual visitor to Northland).
- 'Endangered' e.g., brown teal, grey duck, bittern, Northland mudfish, native bladderwort, and
- 'Vulnerable' e.g., *Trithuria inconspicua*.

'Chronic' has two sub-categories:

- 'Serious decline' e.g., dune lakes galaxias (dwarf inanga), *Myriophyllum robustum*, and black-billed gull.
- 'Gradual decline' e.g., longfin eel, giant kokopu, black mudfish, kakahi, koura, marsh fern, and red-billed gull.

The 'At-risk' category are for those naturally uncommon, sparse species such as North Island fernbird, dabchick, crakes, freshwater crab, *Centipeda aotearana*, *Mimulus repens*, and *Sporodanthus ferrugineus*.

3. Habitat availability

The extent or area of indigenous vegetation (wetland, emergents and submerged vegetation) was quantified as it is a measure of habitat availability for native biota.

Each of the parameters was subjectively scored on a 1-6 scale and these metrics used to obtain rankings (from best to worst) for 'Lake Biodiversity Assessment' of: Outstanding; High; Moderate-High; Moderate; Low-Moderate; and Low. Outstanding lakes are nationally important, containing a diverse indigenous biota, with sustainable populations of endangered species. Conversely, low ranked lakes are either de-vegetated with poor water quality, or severely impacted by exotic pest species.

2.1.6 Water birds

Habitat suitability for birds was assessed during the field visit, with bird species presence and abundance observed with binoculars. Results were compared with previous records from OSNZ and DOC SSBI surveys, with any nationally or regionally threatened species noted. The combination of scuba divers and various water craft involved in this survey was not conducive to observing water birds, with many flying away before their identity was ascertained. However, some secretive species such as the nationally endangered bittern (*Botaurus poiciloptilus*) were often disturbed and flew allowing their detection, whereas shore-based observation would probably not detect such species.

2.1.7 Fish

Fish records for the Northland Region extracted from NIWA FBIS comprised 295 records since 1980. These records were assessed to identify lakes containing species of regional or national significance (Hitchmough et al. 2007) and those containing pest fish. While sampling plants, divers also recorded observations of fish but these were not specifically sampled for or quantified.

2.1.8 Aquatic invertebrates

Large aquatic invertebrates such as freshwater mussels (*Ecechyridella menziesii*), koura (*Paranephrops planifrons*) and snails were noted by divers in the course of macrophyte surveys. Mussels and koura are potentially important indicators of lake condition and are likely to be incorporated into LakeSPI methodology in the future.

2.1.9 Changes in indicators

Any significant changes in biota and lake condition compared with previous surveys were reported; for example new species records, and / or change in species dominance, or vegetation depth range.

2.1.10 Threats

Biosecurity threats (current pest plant and fish impacts, potential impacts and risk of introduction), nutrient enrichment (nutrient sources, livestock access) and decreasing water levels were considered for impacts on ecological condition on each lake based on the surveys and discussion with landowners, NRC and DOC staff. Water quality monitoring is carried out by NRC.

2.1.11 Summary

A summary of overall ranking, identified threats and recommendations is presented for each lake in the report Section 3.1 ecological assessments.

2.2 Pest Plant Surveillance

Annual surveillance for aquatic weeds was undertaken for six high-risk lakes (Table 2-1).

Lakes were surveyed using scuba and snorkel, visually inspecting sites where introductions would be most likely, such as known access points and popular anchoring spots. The areas were inspected thoroughly at depths where weed colonisation was likely to occur. Where large areas required surveillance, a diver was towed behind a boat to cover likely sites of colonisation.

The lake margins were also walked and checked for drift of weed fragments on shore and marginal vegetation also checked for emergent and sprawling wetland weeds both from the landward edge (where possible) and by boat.

Table 2-1: Submerged weed surveillance programme for Northland lakes. (Champion et al. 2005).

Lake and No.	Surveillance programme	Frequency
Ngatu (120)	Survey boat ramp area and access points on eastern and southern margins	Annually
Waiporohita (99)	Survey lake and wetland from roadside access point on eastern margin to north end by the road	Annually
Kai-iwi (236)	Survey access point at NE end	Annually
Taharoa (229)	Survey access points at 2 camp grounds, jetty, and Sin Bin.	Annually
Waikere (227)	Survey boat ramp area and roadside access points on western margin	Annually
Humuhumu (350)	Survey access point (NE side)	Annually

2.3 Grass carp assessment

The progress of grass carp in target pest plants in Lakes Swan and Heather was assessed. In Lake Swan the 5 baseline profiles were repeated as for the lake ecological assessment for submerged vegetation. In addition sonar (Lowrance LCX-15MT depth sounder) was used to cover much of the lake to search for any remaining weed growth and to record profiles. A full shoreline inspection of the lake by boat was undertaken to inspect the lake margin for impacts on the emergent communities and presence of weed fragments.

For Lake Heather the two baseline profiles were repeated as for the lake ecological assessment and sonar was used to record weed bed profiles.

2.4 Management recommendations

Monitoring strategies for the highest ranked of the lakes were recommended including:

- Lake biodiversity monitoring and LakeSPI with additional assessment of nationally or regionally significant biota and assessment of any new threats to ecological condition.
- Pest plant surveillance – targeted monitoring of lake access and anchoring sites to detect early incursions of weed species.

And for those lakes where there are some practical measures that could mitigate or avert threats to the lake ecology recommendations include:

- Flagging lakes where pests threaten lake ecology (and suggesting mitigating measures in brief).

- Identifying those lakes where indicators suggest nutrient enrichment has or threatens to have significant impacts on lake ecology.

3 Results and Discussion

3.1 Ecological assessments

3.1.1 Lake Kaiwai (Central Northland), NRC Lake No 193.



Plate: Lake Kaiwai.

Summary

Survey date: 2012

Overall ranking

High; although submerged vegetation is sparse, the wide emergent vegetation zone grading into indigenous forest on surrounding western hills and the presence of rare plants and animals make this a regionally important lake.

Threats

Few, the landowners are keen to maintain the lake in its current condition and were informed of potential threats from pest plant and fish introductions.

Management recommendations

Lake ecological assessment every 5 years. Livestock should be excluded from the wetland margin.

Description

A small (7.5 ha) peat lake (2595306E, 6641419N) with a maximum depth of 8.0 m. The lake is a naturally dammed stream with two arms situated in plantation forest, regenerating native bush and farmland. The outlet, the Terewatoa Stream flows into the Orauta Stream, discharging into the southern part of the Bay of Islands. Access is across private farm land, with no trailer boat access, and no powered craft permitted by the owners.

Wetland vegetation

The lake was ringed with emergent vegetation up to 30 m wide and *Typha orientalis* (growing to 1 m deep) with lesser amounts of *Eleocharis sphacelata*, *Machaerina articulata*, *M. arthrophylla* and *M. teretifolia* with the native swamp millet (*Isachne globosa*). *E. sphacelata* extended to 2.5 m water depth. *Potamogeton cheesemanii* and *Myriophyllum robustum* were present amongst the marginal species and *Utricularia gibba* formed mats to 0.5 m depth throughout the wetland margins. Closer to the shore, the vegetation also contained mats of *Sphagnum cristatum* with emergent flax (*Phormium tenax*), *Gleichenia dicarpa*, *Juncus bulbosus*, *J. fockei* and *J. prismatocarpus* with the regionally rare maru (*Sparganium subglobosum*). Much of the lake margin was forested with manuka fringe vegetation and further from the lake, diverse podocarp dominated vegetation on the western side and plantation pine forest on the eastern side.

Submerged vegetation

Dark stained water significantly reduced light penetration effectively removing visibility beyond 2.5 m. Profiles from the deep emergent fringe descended steeply to 6 m before levelling off. No submerged vegetation was found although some floating fragments of *Potamogeton ochreatus* were noted.

LakeSPI

This lake generates a default LakeSPI Index of 0% (Non-vegetated) on account of submerged plants being recorded at <10% cover.

Water birds

The lake provides significant bird habitat with waterfowl noted in the margins including the regionally significant fernbird (*Bowdleria punctata vealeae*), with the nationally endangered bittern (*Botaurus poiciloptilus*) reported (Paki Thompson, landowner, pers. comm.).

Fish

Williams et al. (2011) recorded longfin and shortfin eels and common bullies in the lake and the Terewatoa Stream.

Aquatic invertebrates

None recorded.

Changes in indicators

Not surveyed before.

Threats

Few, the isolated nature of the lake and access through private land should reduce the risk of pest transfer. Land owners do not permit the use of motorised boats (Paki Thompson pers. comm.) and the risk posed by contaminated eel fishing nets was discussed during the 2012 field visit.

Management recommendations

Conduct a survey of the fish fauna. Local landowners were keen to exclude cattle from the wetland margins and financial assistance available to fence off the wetland was discussed by NRC staff with the owner.

3.1.2 Lake Omapere, (Central Northland) - NRC Lake No. 173



Plate: Lake Omapere in a predominantly pastoral catchment.

Summary based on previous surveys

Survey dates: 2005, 2012

Overall ranking High: This lake is currently de-vegetated with high nutrients an issue, but extensive margins support three critically endangered species.

Threats Low threat of weed invasion due to grass carp and currently degraded state, with hypereutrophic nutrient status.

Management recommendations Consider lake restoration initiatives such as attempting to restore the critically endangered *Isoetes kirkii* var. *flabellata* to its last known locality, monitoring of other critically endangered species and potential establishment of native submerged vegetation.

Description

Lake Omapere (1671879E 6088198N) is the largest lake in Northland being 1,197 ha in area but is only 2.6 m deep (as low as 1.5 m during summer). It was formed by a volcanic flow damming the outlet, with evidence of the lake becoming a forested wetland, then re-flooded following a fire around 1300 (Newnham et al. 2004; Williams et al. 2009). The surrounding catchment is mostly pasture. There are a few inflow streams, mostly in the southern part of the lake, with the outflow, the Utukura River flowing from the south-western margin of Lake Omapere to the Hokianga Harbour. Access is through private property, boats can be launched with a 4-WD.

Wetland vegetation

The western shore of Lake Omapere supported emergent vegetation consisting of dense bands (>75% cover) of *Machaerina articulata*, *Schoenoplectus tabernaemontani* and *Typha orientalis* to a water depth of 1.2 to 1.3 m. The remainder of the shoreline was pasture with the rush *Juncus edgariae* common near the water's edge and a range of turf species such as *Lilaeopsis novae-zelandiae*, *Myriophyllum propinquum*, *Gratiola sexdentata*, *Glossostigma elatinoides* and *G. cleistanthum* in the wettest areas. Two nationally critically threatened plants (de Lange et al. 2009) were discovered during the 2012 field trip. These were the annual composite *Centipeda minima* subsp. *minima* and the fern *Ophioglossum petiolatum*. These discoveries significantly increase the ecological value of this lake. Alligator weed (*Alternanthera philoxeroides*) was well established and formed large floating mats on the eastern shoreline of the lake.

Submerged vegetation

The submerged vegetation of Lake Omapere collapsed in 2001 and the lake has remained in a de-vegetated state dominated by cyanobacterial blooms since that time. On 16th April 2012, a profile from the south side of the lake to the north side, about 3.3 km long from NZMG 2582533E, 6648324N to 2583273E, 6651676N was spot dived. Very small amounts of *Glossostigma cleistanthum* were found at 0.4 m deep at the south end and one tiny plant *Chara australis* at 1.4 m deep was found. High covers of *G. cleistanthum* and *G. elatinoides* were found amongst basalt boulders during a snorkel search around the eastern shore in 2012.

LakeSPI

This lake generates a default LakeSPI Index of 0% (Non-vegetated) on account of submerged plants being recorded at <10% cover. This status is the result of management stocking of grass carp (see below).

Water birds

The restricted emergent vegetation would provide limited water bird habitat, but the lake is fairly isolated. Only common species were recorded by the recent OSNZ survey. Previous surveys reported the presence of the nationally rare bittern (*Botaurus poiciloptilus*) and regionally significant fernbird (*Bowdleria punctata vealeae*) from this lake.

Black swan (*Cygnus atratus*) numbers fluctuate with submerged plant biomass. Prior to the collapse of weed beds in 1985 an estimated 8000 swans utilised Lake Omapere. This dropped to 1000 the following year, which increased to 3000 in 1995 and 9000 in 2002. This number has again dropped since the second weed collapse, with annual counts varying between 50 and 400 over the last decade (Northland Fish and Game unpublished data).

Fish

Eels (*Anguilla dieffenbachii* and *A. australis*), common bully (*Gobiomorphus cotidianus*), smelt (*Retropinna retropinna*), goldfish (*Carassius auratus*) and brown bullhead catfish (*Amieurus nebulosus*) have been caught from Lake Omapere. Two carp species introduced for algal and weed control; silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) are both present in the lake. *Gambusia affinis* have been recorded from this lake. Large populations of nationally significant Northland mudfish (*Neochanna helios*) has been recorded from the wetland margins of Lake Omapere (Barrier 2003).

Aquatic invertebrates

Freshwater mussels, known locally as torewai (*Echyridella menziesi*), koura (*Paranephrops planifrons*), *Potamopyrgus antipodarum*, *Austropeplea tomentosa*, *Hygraula nitens*, dragonfly (Odonata) larvae, planarians, freshwater sponges, bryozoans and chironomids have been recorded. Torewai underwent a major decline during 2001/02 (Champion 2002) and were rare within the lake in 2005. In 2012 torewai had recovered and were abundant right across the lake confirming the lake is not currently experiencing anoxic (minimal oxygen) episodes.

Changes in indicators

The genetically distinct *Isoetes kirkii* var. *flabellata* was last collected from this lake in 1998 and may be extinct apart from cultivated plants held by NIWA.

Utricularia gibba was noted in the eastern basin of the lake during 2000, but has not been seen since.

The exotic invasive *Egeria densa* completely covered the lake during 1984. However, these surface-reaching stands of *E. densa* collapsed in 1985 and the lake became dominated by algal blooms and remained de-vegetated until 1994. From that time *E. densa* re-established weed beds in the lake until 2000 when it again reached maximum biomass, with surface-reaching weed beds covering the lake. From 2001 onwards these beds collapsed and the lake suffered toxic algal blooms again. To prevent this cycle continuing, grass carp (a weed-eating fish) were released to the lake to prevent re-establishment of the *E. densa*.

Threats

The lake is hyper-eutrophic (very high nutrient levels). While catchment loadings are high due to farming, nutrients arising from lake sediments during anoxic (low oxygen) episodes have had a much greater influence on the nutrient budget of Lake Omapere and elevates nutrients in the lake in the order of 380% greater than catchment inputs (Verburg et al. 2012). Currently the water quality of this lake is improving without excessive weed growth causing anoxia and with suspended sediments flushing from the lake during turbid water events.

Egeria densa could re-establish (without grass carp) and the cycle of vegetation collapse and nutrient release from sediments would continue if unmanaged.

Management recommendations

Discussions with Te Roopu Taiao o Utaura and DOC held at the lake during our trip highlighted a number of lake restoration initiatives already underway, such as fencing and planting of indigenous vegetation around lake margins. It is timely to discuss in-lake restoration initiatives such as attempting to restore the critically endangered *Isoetes* (*Isoetes kirkii* var. *flabellata*) to its last known locality and potential to establish native submerged vegetation. Discovery of populations of two nationally critical plants require further monitoring and conservation effort.

Egeria densa could re-establish and the cycle of excessive weed beds, anoxia, nutrient release, vegetation collapse and toxic algal blooms is likely to continue if unmanaged. The introduction of grass carp has prevented this in the medium term, but efforts to ensure the lake catchment is free of this weed and that new introductions do not occur, need attention.

3.1.3 Lake Humuhumu, Pouto, NRC Lake No. 350.



Plate: Lake Humuhumu showing pastoral catchment in foreground, pine forest in background and the large island (centre right) which divides the lake.

Summary

Survey dates: 2005, 2007, 2012

Overall ranking

Outstanding: A large, relatively deep, clear lake with diverse biota including nationally rare plants, fish and birds, with no major pest species.

Threats

High risk of introduction and establishment of invasive pests. High risk of nutrient enrichment from pine plantation activities (fertilisers) and nutrient run-off from farmland.

Management recommendations

Annual invasive weed surveillance at access point. Condition monitoring every 3-5yrs.

Description

A large (139.4 ha) dune lake (1700789E, 5979177N) with a maximum depth of 16 m. The lake has a predominantly pastoral catchment with scattered pockets of manuka and kanuka scrub, except for the western shore, which was comprised of sand dunes with pine forest. A large island with indigenous vegetation divides the lake into two basins. There are no inlet or outlet streams. Easy access from roadway across firm grassed ground. Small boats can be launched with 4-WD.

Wetland vegetation

About 70% of the shoreline had a narrow (< 5 m) band of emergent species extending into about 1 m depth of water. *Schoenoplectus tabernaemontani* and *Eleocharis acuta* were the most common species with *Apodasmia similis*, *Bolboschoenus fluviatilis*, *Cyperus ustulatus*, *E. sphacelata*, *Juncus pallidus*, *Machaerina articulata*, *M. arthropphylla*, *M. juncea* and *Typha orientalis* also present. The invasive exotic weed alligator weed (*Alternanthera philoxeroides*) was present in the marginal vegetation on the north-east shore and the invasive royal fern (*Osmunda regalis*) was recorded (B. Searle pers. comm.). In 2012, the nationally threatened fern *Thelypteris confluens* (At Risk – Declining) was found on the lake margin in two localities, the first records for this lake.

Submerged vegetation

The vegetation pattern has remained similar since regular surveys began in 2005. Turf was common with *Lilaeopsis novae-zelandiae* and *Glossostigma elatinoides* the dominant turf species. The nationally rare *Trithuria inconspicua* was present at very low levels in the lake with occasional plants found in 2005, 2009 and 2010, but not during the 2012 survey. The regionally uncommon *Myriophyllum votschii* was also recorded. Overall the submerged vegetation was dominated by *Chara globularis* and *Chara australis* at high covers and on two profiles to depths approaching 10 m. There were some scattered low-density growths of tall-growing natives commonly *Myriophyllum triphyllum* but also *Potamogeton cheesemanii* and *P. ochreatus* (5.7 m deep). The native *Ruppia polycarpa* was recorded at one transect near the access point. The nationally threatened *Lepilaena bilocularis* was reported in 2001, but the specimen held at the Auckland Herbarium (AK) was subsequently determined (by one of the authors) to be *Ruppia polycarpa*.

The lake had all native vegetation except *Otellia ovalifolia* and *Potamogeton crispus* (found outside profiles), which are of little consequence to native biodiversity, and localised impact from *Utricularia gibba* which was common in shallow water on three profiles in 2012.

LakeSPI

Table 3-1: LakeSPI results for Lake Humuhumu. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		96	92	0
	1984	86	74	0
	1988	80	64	0
Historical data	2001	84	71	0
	2005	81	66	0
	2007	77	66	7
Present day	2012	72	66	16

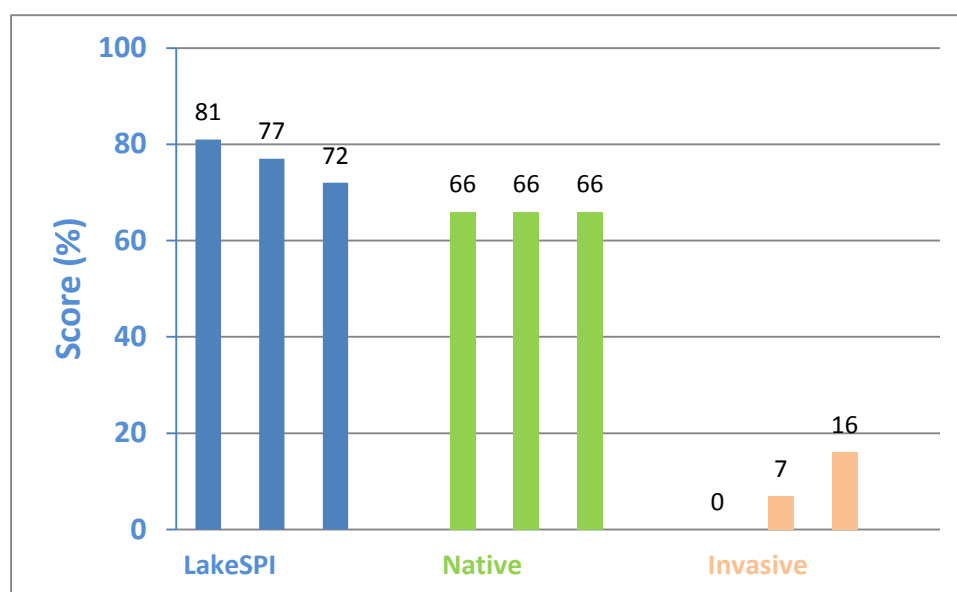


Figure 3-1: LakeSPI Index as % of potential score for Lake Humuhumu with Native Condition Index, and Invasive Impact Index for 2005; 2007 and 2012 from left to right.

The most recent LakeSPI Index (Table 2-1; Figure 3-1) shows a lake in high ecological condition with a LakeSPI index of 72%. This reflects the extent of native submerged vegetation present in the lake with charophyte meadows growing down to a maximum depth of 9.1 m. However the presence of *Utricularia gibba* for the first time at 3 of the 5 LakeSPI sites, has seen the Invasive Impact Index more than double since the 2007 survey and impact negatively on LakeSPI values.

Water birds

The lake provides significant bird habitat with abundant waterfowl noted on the lake including the regionally significant dabchick (*Poliiocephalus rufopectus*) and scaup (*Aythya novaezeelandiae*). The nationally endangered bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) were also seen at this lake. OSNZ also recorded the regionally significant fernbird (*Bowdleria punctata vealeae*) and spotless crake (*Porzana tabuensis plumbea*).

Fish

The common bully (*Gobiomorphus cotidianus*) was most commonly seen. The rare dwarf inanga (*Galaxias gracilis*) was present on most profiles in the shallows. There were no introduced fish species recorded.

Aquatic invertebrates

Nine invertebrates have been recorded including koura (*Paranephrops planifrons*) and freshwater mussels (*Echyridella menziesii*) and the snail (*Glyptophysa variabilis*). Freshwater jellyfish (*Craspedacusta sowerbyi*) medusae were present in the lake.

Changes in indicators

Previous surveys 1984, 1985, 1988, 2001 and 2005, 2007 have shown little change in comparison with the latest 2012 survey. At times the depth limits of the vegetation have been up to 1 m shallower than present, possibly reflecting inter-annual variations with water clarity. The increase in the Invasive Impact Index came about with *Potamogeton crispus* being recorded on one profile at 3 m depth only in 2007, and *Utricularia gibba* has further increased the Invasive Impact Index in 2012.

Threats

This lake has no pest fish; Lake Rototuna with *Gambusia affinis* is the closest threat. No invasive submerged plants of any consequence are present but invasive species would do well in this lake. Nearby Lake Swan would present the most immediate threat with regard to a source of invasive weeds, but near eradication of these species using grass carp has reduced the risk to negligible.

Alternanthera philoxeroides and *Utricularia gibba* were recorded at Lake Humuhumu and both species could threaten other vegetation in sheltered margins of the lake.

Management recommendations

Annual pest plant surveillance at access point.

Lake ecological monitoring every 3-5 yrs.

Surveillance of margins for alligator weed and control for removal if deemed achievable.

4.1.1 Lake Kahuparere (Pouto), NRC Lake No. 384.



Plate: Lake Kahuparere showing pasture foreground, and pine forest on sand dunes to the rear.

Summary

Survey dates: 1985, 1988, 2001, 2005, 2007, 2012.

Overall ranking

High: Medium sized lake with native vegetation, but nutrient enriched with livestock and forestry in the catchment.

Threats

Access restricted, but tall-growing native vegetation would be easily invaded by tall-growing exotic species. Already nutrient enriched and low water clarity. Susceptible to further enrichment and possible plant collapse.

Management recommendations

Lake native biodiversity value monitoring every 5 years. Livestock have been excluded from the lake margins.

Description

A small (9.4 ha) dune lake (1703965E, 5974380N) with a maximum depth of 7.5 m. The lake is situated on sand dunes in a mostly pastoral catchment, with pine forest fringed by kanuka scrub on the steep western dune face. Access across 2 km of private farmland, 4-WD access only and no trailer boat access.

Wetland vegetation

The lake was ringed with emergent vegetation 10 to 15 m wide and dominated by *Schoenoplectus tabernaemontani* (growing to 0.7 m deep), *Typha orientalis* (growing to 1 m deep) and lesser amounts of *Eleocharis sphacelata*, *Baumea articulata* and *Bolboschoenus fluviatilis*. Other marginal species recorded in 2007 were *Carex secta*, *Cyperus ustulatus*, *Eleocharis acuta*, *Juncus pallidus*, *Myriophyllum propinquum*, *Persicaria decipiens* and the introduced *Ludwigia palustris*. Cattle have now been excluded from the lake.

Submerged vegetation

No turf species (due to emergent), dense *Potamogeton ochreatus* beds to 5.9 m deep with high covers of *Chara australis* to nearly 5 m, *Myriophyllum triphyllum* to 3.5 m and *Utricularia gibba* formed a blanketing cover down to 2 – 4.5 m deep. The west profile had no submerged plants.

LakeSPI

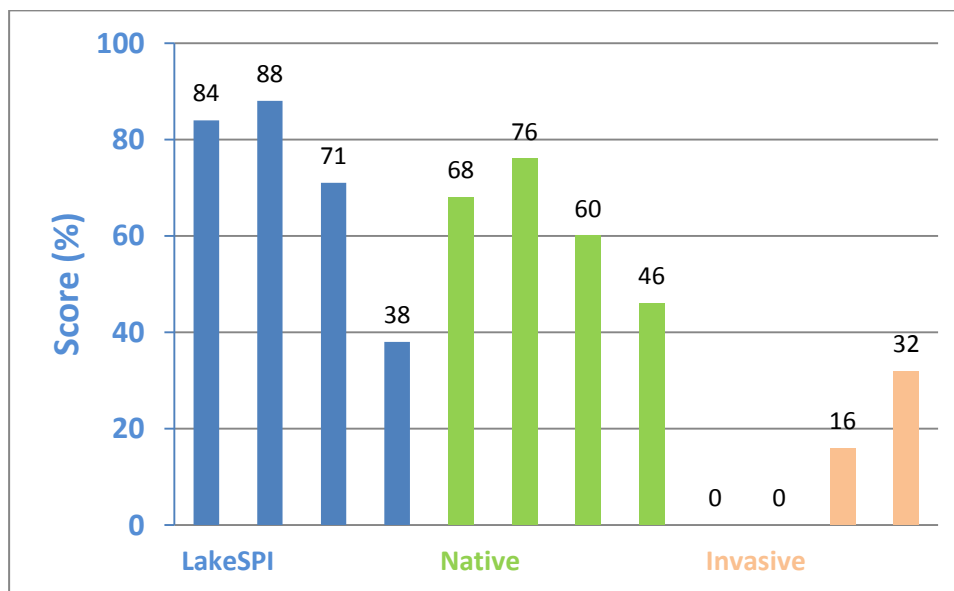


Figure: LakeSPI Index as % of potential score, Native Condition Index, and Invasive Impact Index (from left to right) with 2001, 2005, 2007, 2012, values shown respectively.

The LakeSPI score of 38% was low due to one of the 3 profiles having no submerged vegetation present. Otherwise indicators were good with a slightly deeper bottom limit and an increase in charophyte meadows. *U. gibba* invasive impact has increased further but is not displacing native vegetation. It is now categorised by LakeSPI as being in a moderate ecological condition with a LakeSPI index of 37%.

Water birds

The dense emergent beds on the western side of the lake along with marginal scrub provide good habitat for waterbirds. Pukeko (*Porphyrio melanotus*) and the regionally threatened dabchick (*Poliocephalus rufopectus*) were seen during sampling. DoC SSBI reports these species and also nationally endangered bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) and the regionally threatened scaup (*Aythya novaezeelandiae*) and spotless crane (*Porzana tabuensis plumbea*). The migrant Eastern little tern (*Sterna albifrons sinensis*) was noted in 2007.

Fish

The extensive emergent beds and tall submerged vegetation provide suitable habitat for various fish and NIWA FBIS records include the nationally endangered dwarf inanga (*Galaxias gracilis*), whilst common bully (*Gobiomorphus cotidianus*) were noted during the vegetation sampling.

Aquatic invertebrates

Koura (*Paranephrops planifrons*) were recorded in 2007 and freshwater mussels (*Hyridella menziesi*) were noted in the 2001 survey. The native snail *Glyptophysa variabilis* was seen in 2007.

Changes in indicators

Previous surveys, 1985, 1988, 2001, 2005 and 2007 show no change in species, with the bottom depth limit for *P. ochreatus* changing from 4.5, 5.5, 5.9, 5.6 and 5.6 m respectively. 5.9 m was the bottom limit measured in 2012. *Utricularia gibba* was found for the first time in 2007 and increased the Invasive LakeSPI index since then.

Threats

Currently no pest species are present apart from *Utricularia gibba*. Access is through 2 km of private farmland so the risk of introduction is low for the oxygen weeds but the lake would be very susceptible to invasion if introduced.

The relatively poor visibility and presence of filamentous algae covering the submerged vegetation indicated nutrient enrichment. Cattle access to the east shoreline not only has damaged the marginal vegetation through grazing and trampling, but can also lead to direct addition of nutrients to the lake by defecation and urine. Fencing of the margin was noted in 2009, with a corresponding decline in the abundance of filamentous algae.

Management recommendations

Maintain the awareness of the threats posed by introduced weeds and their mode of introduction on contaminated fishing nets to the owner. Fencing of the lake margin has occurred.

Lake native biodiversity value monitoring every 5 years.

4.1.2 Lake Karaka (Pouto), NRC Lake No. 347.



Plate: Lake Karaka viewed from the access point showing pasture to the lake edge. The remainder of the lake margin is wetland.

Summary

Survey dates: 2005, 2007, 2012

Overall ranking

High: A lake with an indigenous vegetation and fauna, much of the margin surrounded by wetland with nationally endangered plants, fish and birds present.

Threats

Isolation and difficulty of access make likelihood of pest introduction low, but a major impact could result should introduction occur. Water quality likely to be impacted by cattle access.

Management recommendations

Infrequent pest plant surveillance and lake ecological assessment (5 years). Recommend fencing of the eastern margin to exclude cattle. A consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be self-evident.

Description

This dune lake (1693415E, 5980559N) is 11.1 ha in size and about 6 m deep with an undulating bottom. It is one of the lakes situated on the south-western Pouto Peninsula between consolidated dunes to the east and mobile dunes to the west. The catchment is pastoral (25%), and flax/sedge/raupo wetlands (75%) extend to the north and south of the lake, linking it with other water bodies with mobile sand dunes at the western end. There are no inflow or outflow streams. Access is difficult through forestry roads and rough pasture over consolidated dunes. 4-WD access only, not suitable for trailered boats.

Wetland vegetation

Emergent species encircle most of the lake, except the margin bordered by pasture and open to cattle grazing. *Typha orientalis* and *Machaerina articulata* dominated. These extended over a 20 m wide band in most areas growing to depths of 1.5 m. Other emergent species seen included *Apodasmia similis*, *Carex maorica*, *Carex secta*, *Cyperus ustulatus*, *Eleocharis acuta*, *Isachne globosa*, *Isolepis prolifer*, *Juncus pallidus*, *Machaerina arthropphylla*, *M. juncea*, *Schoenoplectus tabernaemontani*, flax and cabbage trees. Common amongst the *M. juncea* vegetation were extensive areas of the nationally threatened fern *Thelypteris confluens*.

Submerged vegetation

All native vegetation. Few turf species recorded (only at access point where marginal species grazed). Charophyte dominated, with exceptionally abundant *Chara australis* that was tall, surface reaching (to 1.8 m) and extended to 2.5 m deep. Tall-growing native species were also present at low average covers with *Potamogeton cheesemanii* dominant and growing to 2.3 m deep. *Chara globularis* was noted in shallow water at the access point. *Chara australis* was fragmenting and rotting, most likely because of the algal bloom.

LakeSPI

Table 4-1: LakeSPI results for Lake Karaka. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	90	0
	2005	83	65	0
	2007	81	62	0
Present day	2012	81	62	0

*LakeSPI surveys are based on only 3 sites.

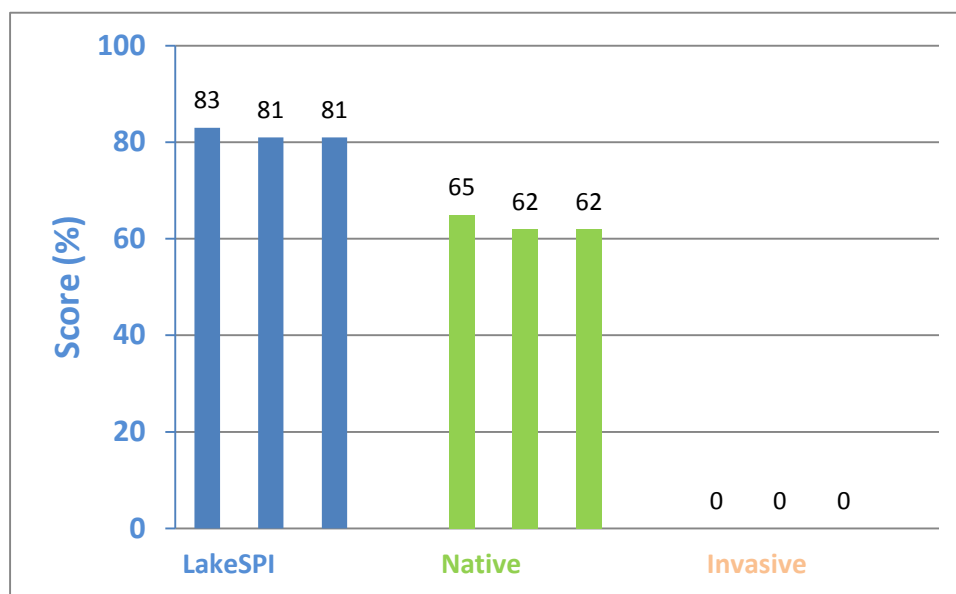


Figure 4-1: LakeSPI Index as % of potential score for Lake Karaka with Native Condition Index, and Invasive Impact Index 2005; 2007; 2012 (from left to right).

Lake Karaka is in 'excellent' ecological condition as categorised by LakeSPI (Table 4-1, Figure 4-1). Its high LakeSPI index of 81% reflects its extensive charophyte meadows and a lack of invasive species.

Water birds

The extensive wetland areas provide outstanding habitat for water birds. Threatened species reported include the nationally rare bittern (*Botaurus poiciloptilus*) and regionally significant banded rail (*Rallus philippensis assimilis*), spotless crane (*Porzana tabuensis plumbea*), dabchick (*Poliocephalus rufopectus*), fernbird (*Bowdleria punctata vealeae*) and scaup (*Aythya novaezeelandiae*). Formerly the Critically Endangered brown teal (*Anas aucklandica chlorotis*) were also recorded in this area and the western Poutu lakes are a stronghold for grey duck (*Anas superciliosa*) and several aggregations of birds fitting their description were seen. These may be hybrids with mallard duck, the main reason for the Nationally Critical ranking of this species.

Fish

Moderate water quality and diverse macrophyte habitat. The common bully (*Gobiomorphus cotidianus*) was very common, with most specimens having swollen abdomens indicative of an infestation of endoparasitic cestode or trematode species. Both longfin and shortfin eels (*Anguilla dieffenbachii* and *A. australis*) are reported from this lake and several eels were seen during the survey. The endangered giant kokopu (*Galaxias argenteus*) has been collected from Lake Karaka (T. Birch, DOC pers. comm.)

Aquatic invertebrates

The native snail *Potamopyrgus antipodarum* was recorded from one profile.

Changes in indicators

No change since 2007.

Threats

Relative isolation and difficulty of access makes risk of introduction of pest species low. However, should these be introduced they would displace or significantly impact indigenous biota. Nutrient enrichment from farming and forestry may be the cause of algal blooms noted and charophytes in poor health.

Management recommendations

Lake ecological assessment and pest plant surveillance every 5 years.

Advocate fencing off the eastern shoreline to prevent cattle access to the lake. A consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be self-evident.

4.1.3 Lake Mokeno (Pouto), NRC Lake No. 356.



Plate: Lake Mokeno surrounded by wetland and indigenous scrub vegetation.

Summary

Survey dates: 2005, 2007, 2012

Overall ranking

Outstanding: A large lake with all native vegetation, functioning as an integral part of a wetland/scrub/dune complex covering the south-western Pouto Peninsula. Contains nationally significant populations of endangered biota.

Threats

Exotic plant invasion, though risk low due to isolation. Possible impacts from forestry fertiliser inputs causing algal blooms.

Management recommendations

Five yearly surveillance for pest plants and lake native biodiversity value monitoring. Algal blooms indicate possible nutrient threat to ecological condition. A nutrient budget is recommended.

Description

Lake Mokeno (1695174E, 5977171N) is a dune lake 148.3 ha in area with a 6.1 m maximum recorded lake depth. The catchment is mostly kanuka scrub adjacent to pine plantation forestry, with large areas of wetland and some unconsolidated dunes on the western margin. There are no inflow or outflow streams but it appears that water flows south from the lake towards Lake Whakaneke eventually discharging to the entrance to Kaipara Harbour via an extensive wetland. Access to the northern end of the lake is through forestry and Māori land (7 km of well-formed tracks) requiring access through a locked gate. Small boats can be launched with difficulty using a 4-WD.

Wetland vegetation

The entire lake was surrounded by extensive beds (up to 20 m across and extending from the lake edge to 2 m deep) of emergent species including *Typha orientalis*, *Eleocharis sphacelata*, *E. acuta*, *Machaerina articulata*, *M. arthropphylla*, *M. rubiginosa*, *M. juncea*, *Schoenoplectus tabernaemontani*, *Carex secta* and *Phormium tenax*. This vegetation merged into a manuka (*Leptospermum scoparium*) / flax (*P. tenax*) wetland zone around much of the lake. At the south east end of the lake a distinctive *C. secta* / *M. arthropphylla* / *Thelypteris confluens* wetland was noted. The fern *Thelypteris confluens*, that was also found on the lakeward edges of flax and *C. secta* tussocks, is a nationally endangered species (classified as 'Gradual Decline') with Pouto being the national stronghold of this species. The invasive royal fern (*Osmunda regalis*) is presently being managed at the northern end of Lake Mokeno by DOC. This species poses a severe threat to the wetlands surrounding this lake and elsewhere in the region.

Submerged vegetation

In 2012 water clarity was only 0.15 m (heavy algal bloom) making scuba assessment impossible. We did confirm *Chara australis* was still present to 5.3 m using a rake. If the bloom were to continue for too long then the submerged vegetation will die due to low light levels. Anoxia would exacerbate the problem by generating more nutrients from the sediments. It would require a period of improved water clarity for charophytes to re-establish from the seed bank.

In previous surveys an entirely native vegetation was present with the whole main lake bottom vegetated to 5.3 m deep and clear water with ~ 4 m of visibility. Turf species including *Lilaeopsis novae-zelandiae* (growing to 0.4 m tall) and *Glossostigma elatinoides* were seen in shallow margins growing amongst emergent vegetation. *Chara australis* filled the lake, with a maximum height of 1.8 m recorded in the past. *C. australis* grew to 5.3 m deep with only a small area of the lake deeper than this (6.0 m max. depth, near 2606019E, 6538508N). Tall-growing native species, *Potamogeton cheesemanii* and *P. ochreatus* were the only other submerged species found in the main body of the lake, however *Chara*

globularis and *Myriophyllum triphyllum* were also found in the narrow channelised northern part of the lake.

LakeSPI

Table 4-2: LakeSPI results for Lake Mokeno. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	90	0
Historical data	2005	83	65	0
Present day	2007	90	80	0

*LakeSPI results are based on 1 representative site.

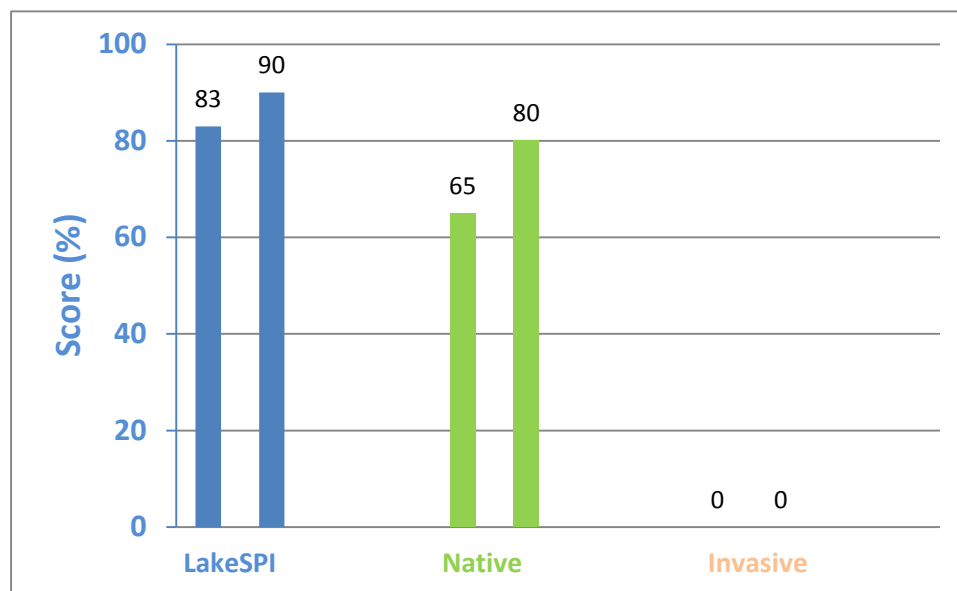


Figure 4-2: LakeSPI Index as % of potential score for Lake Mokeno with Native Condition Index, and Invasive Impact Index shown for 2005; 2007 (from left to right).

Lake Mokeno was in 'excellent' ecological condition as categorised by LakeSPI (Table 4-2, Figure 4-2) during the 2007 survey. Its high LakeSPI index of 90% reflected the quality of native submerged vegetation and lack of invasive species. Due to poor clarity a LakeSPI Index could not be generated in 2012.

Water birds

The indigenous scrub, wetland and emergent margins provide excellent water bird habitat reflected in the large number of species reported from this lake and seen during the field visit. Threatened species reported include the nationally rare bittern (*Botaurus poiciloptilus*) and Caspian tern (*Sterna caspia*) and regionally significant banded rail (*Rallus philippensis assimilis*), spotless crane (*Porzana tabuensis plumbea*), dabchick (*Poliiocephalus*

rufopectus), fernbird (*Bowdleria punctata vealeae*) and scaup (*Aythya novaezeelandiae*). Formerly the critically endangered brown teal (*Anas aucklandica chlorotis*) were also recorded in this area. The indigenous species dabchick, fernbird, scaup, possibly grey duck (*Anas superciliosa*), shoveler (*Anas rhynchosotis*) and two species of shag (*Phalacrocorax* spp.) were seen during the 2012 field visit.

Fish

The lake represents good habitat, with fish access to the sea. Species recorded were common bully (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*), smelt (*Retropinna retropinna*) and shortfin eel (*Anguilla australis*). A possible sighting of grey mullet (*Mugil cephalus*) was made during the 2012 visit, which, if confirmed, would indicate temporary connection of Lake Mokeno to the sea during high water events.

Aquatic invertebrates

Freshwater mussels (*Ecechyridella menziesii*) were common, introduced freshwater jellyfish (*Craspedacusta sowerbyi*) were also noted. In 2012, dead mussels were recorded at 5 to 6 m depth indicating oxygen depletion at times.

Changes in indicators

Previous vegetation surveys in 2000, 2001 and 2005 were similar to the latest survey. There was a dense algal bloom which reduced underwater visibility to 0.1 m in May 2001, but the water was very clear (~4m) in the 2007 m survey and poor again when visited in 2012. Dead mussels at this depth indicated oxygen depletion at times.

Threats

No pest plant or fish impacts evident and the likelihood of introduction of freshwater pests are low. Exotic species would establish in this lake if introduced. Royal fern could invade large areas of the wetland fringe.

The catchment is well buffered by an extensive wetland, but water quality and observations of past algal blooms indicate nutrient enrichment, possibly from fertilisation of pine forests. This would be a worthwhile area for further study.

Management recommendations

Five year monitoring of lake native biodiversity value and pest plant surveillance recommended. Algal blooms threaten in-water values in this lake, so analysis of water quality monitoring and investigation of ground water nutrient fluctuations is required to determine the nutrient sources and potential to manage these.

4.1.4 Lake Rotokawau (Pouto), NRC Lake No. 364.



Plate: Lake Rotokawau showing the exposed north east shoreline with few emergent species.

Summary

Survey dates: 2005, 2007, 2012.

Overall ranking

High: The submerged weed *Egeria densa* is established, however it appears to be declining, possibly due to improving water quality. The lake supports extensive turf communities dominated by the nationally endangered *Trithuria inconspicua*, charophyte meadows with tall-growing native species, and a good population of nationally rare dwarf inanga.

Threats

E. densa (introduced in early 1990's) was present in many submerged profiles and *Utricularia gibba* was present but prolific only in the sheltered lagoon. *Ceratophyllum demersum* could have a much greater impact if introduced, with nearby Lake Swan the most likely source. Presumably eel fishing nets were the mode of introduction and pose a threat for future introductions, although access to the lake is now much more difficult than previously due to changing farm use. Water quality is still good but prone to nutrient enrichment if pastoral practices intensify. The lake is currently fenced preventing cattle access.

Management recommendations

Lake ecological assessment every 5 years.

Description

This dune lake (1702929E 5976997N) is 26.4 ha in size and 12 m deep. The catchment is pastoral, with plantation pine and shrubland. Access is across private farmland, requiring 4-WD but it is possible to launch a boat.

Wetland vegetation

Pockets of emergent species on occasional soft shores occupied 15% of the lake margin. Dominant species included *Schoenoplectus tabernaemontani*, *Machaerina articulata*, *M. juncea*, *Eleocharis acuta*, *Isolepis prolifera*, *Typha orientalis*, *Apodasmia similis* and *E. sphacelata*. The sheltered arm to the north had a dense fringe of emergents. Exposed turf communities were common just above the water line and included regionally significant *Myriophyllum votschii*. The pest plant royal fern (*Osmunda regalis*) was collected from the lake margin in 2010.

Submerged vegetation

Turf communities were well developed with *Lilaeopsis novae-zelandiae* and the nationally threatened *Trithuria inconspicua* co-dominants. There was a very significant *T. inconspicua* habitat within this lake, apparently the largest population of this species in Northland. Tall-growing native species, *Potamogeton cheesemanii* and *P. ochreatus* were common. The exotic species *Egeria densa*, with lesser amounts of *Elodea canadensis*, were widespread but were not having a major impact on native vegetation. In 2012 *E. densa* was much reduced in abundance (lake wide) and did not exceed 0.2 m tall or 25% maximum cover. *Utricularia gibba* was present on some profiles but was of little impact also. Charophytes were the dominant vegetation in much of the lake with *Chara fibrosa* and *Chara australis* the most abundant species and grew across the bottom of the lake.

Table 4-3: LakeSPI results for Lake Rotokawau. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	92	0
	1985	84	71	0
	1988	77	58	0
Historical data	2001	45	58	62
	2005	41	53	64
	2007	56	71	52
Present day	2012	70	78	33

* The 2001 survey is based on 3 sites and some of the 2005 sites differed from later years.

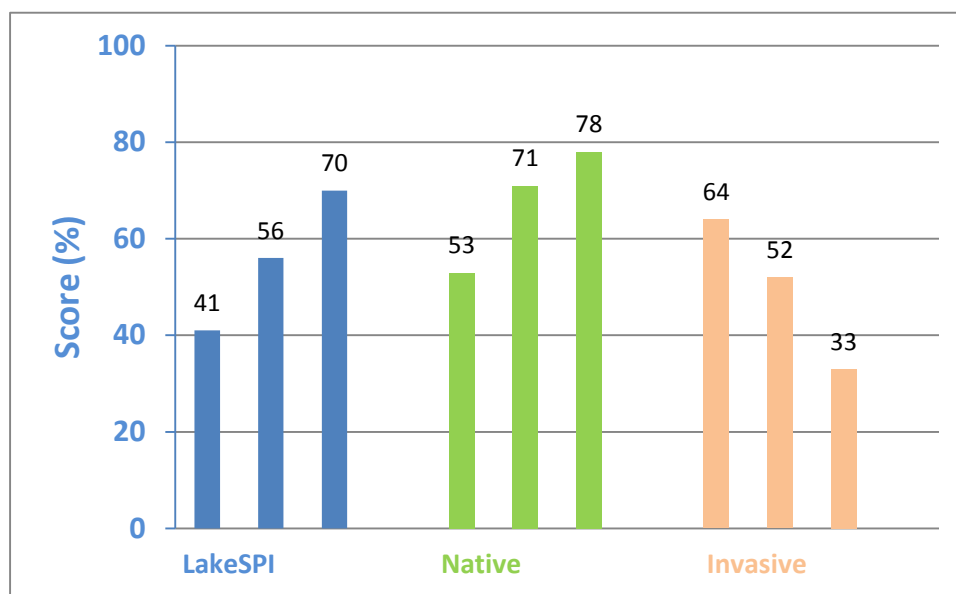


Figure 4-3: LakeSPI Index as % of potential score in Lake Rotokawau with Native Condition Index, and Invasive Impact Index for 2005; 2007; 2012 (from left to right).

Lake Rotokawau is currently categorised by LakeSPI as being in high ecological condition with a LakeSPI index of 70% (Table 4-3, Figure 4-3). The LakeSPI index for this lake has notably improved since the 2007 survey as a result of a reduction in the invasive impact scores. *E. densa* and *U. gibba* while still present during the 2012 survey did not exceed a 10% cover at any of the baseline sites. It is also likely improved water clarity (excess of 5 m during the 2012 survey) has contributed to the growth of native charophyte meadows down to 11.1 m, the maximum depth found at the time.

Water birds

Limited marginal vegetation provides limited cover for resident water birds although good water clarity and submerged vegetation would attract feeding birds. Logan Forrest recorded a total of 19 aquatic birds from Lake Rotokawau including the nationally endangered bittern (*Botaurus poiciloptilus*) and regionally significant dabchick (*Poliiocephalus rufopectus*) and scaup (*Aythya novaeseelandiae*). In 2012, dabchick, scaup, paradise shelduck and a pair of Cape Barren geese (*Cereopsis novaehollandiae*) were seen.

Fish

Good habitat for fish. Common bully (*Gobiomorphus cotidianus*) and the rare dwarf inanga (*Galaxias gracilis*) were observed in this lake, with NIWA FBIS records of these species and also shortfin eel (*Anguilla australis*).

Aquatic invertebrates

Abundant freshwater mussels (*Echyridella menziesii*), leeches (*Richardsonianus mauianus*), and *Potamopyrgus antipodarum* snails were noted.

Changes in indicators

Other surveys were carried out in 1985, 1988, 2001, 2005 and 2007. Depth limits of the vegetation have varied between 10.5 and 6.0 m and are currently at 11.1 m, the maximum depth we found in the lake at the time. Charophytes grew to a maximum depth of 7.6 m in 2001, now 11.1 m. The exotic weed *E. densa* were first reported in 1993 and *E. canadensis* in 2001 and both were common throughout the lake with *E. densa* probably having reached its maximum impact in the 2007 survey. It is now only a minor component of the vegetation and *E. canadensis* was not seen. *U. gibba* was reported for the first time in 2007 but now has little impact on the lake. Why lake condition has improved so markedly is not clear without further study.

Threats

Ceratophyllum demersum introduction would be the greatest threat to the high ecological values. *C. demersum* is invasive in clear water low-nutrient lakes (e.g., Lake Taupo, Tarawera) and poses a much greater threat to this lake than *E. densa*.

Although *C. demersum* risk has been eliminated from the adjacent Lake Swan, the mechanism for its spread, via eel fishing nets, presumably the source of the *E. densa* incursion, still remains although access is now much more difficult.

Management recommendations

Poor access to the lake reduces the risk of weed incursion so weed surveillance monitoring has been suspended. Lake ecological assessment every 5 years.

4.1.5 Lake Roto-otuauru / Swan, (Pouto), NRC Lake No. 355.



Plate: Lake Roto-otuauru (Swan) showing access (centre foreground gap in trees) and the lake catchment.

Summary

Survey dates: 2005, 2009, 2010, 2011, 2012.

Overall ranking

Moderate: Was highly degraded by presence of invasive plant pests *Egeria densa* and *Ceratophyllum demersum*, but is now de-vegetated while grass carp are being deployed. It has the rare fish *Galaxias gracilis*, and several threatened birds utilise the lake margins.

Threats

Grass carp need time to eradicate the pest plants, then removed to allow native regeneration.

Management recommendations

Grass carp were introduced in May 2009 to eradicate *Egeria densa* and *Ceratophyllum demersum*. On-going monitoring is recommended.

Description

The lake (1702249E, 5978792N) is 17.4 ha and is 5.5 m deep. The catchment was mostly pasture, with 30% pine plantation and some areas of scrub. The lake perimeter is fenced. Access is by 4-WD across private land and small boat launching is possible.

Wetland vegetation

Emergent species surround about 75% of the lake forming a dense fringe about 5 to 15 m wide of *Eleocharis sphacelata* (to 2 m tall) with a mix of *Eleocharis acuta*, *Schoenoplectus tabernaemontani*, *Machaerina articulata* and *Typha orientalis*. Grass carp grazing has heavily reduced these species.

Exposed turf areas contained large mats of the 'Regionally Rare' *Gratiola sexdentata*, and also *Triglochin striata* and *Myriophyllum votschii*. The invasive alligator weed (*Alternanthera philoxeroides*) was present at low cover.

Submerged vegetation

At a few locations a wide range of turf species were present with *Glossostigma elatinoides* the dominant species. The rare plant *Hydatella inconspicua* has not been seen since 1988. In 2010 charophytes persisted at one small area in shallow water (to 1.8m) on the northern shore of the main body of the lake but have been eaten by grass carp. These plants dominated the lake vegetation in the past but were displaced from deeper depths by invasives. Prior to 2010 the submerged vegetation was dominated by tall-growing invasive species *Egeria densa* and *C. demersum*. *E. densa* was first reported in the lake in 1992, and *C. demersum* was first recorded in the 2005 survey.

Grass carp were introduced in May 2009 to eradicate the *C. demersum* and *E. densa*. In April 2010 virtually all the *E. densa* had gone and about half the *C. demersum*. In 2011 all the *C. demersum* had gone except for a few shoots amongst the marginal vegetation. *Utricularia gibba* heavily covered much of the *E. densa* in 2010, but none remained in 2011. In 2012 there were no signs of *C. demersum* or *E. densa* or other submerged plants other than the turf species.

LakeSPI

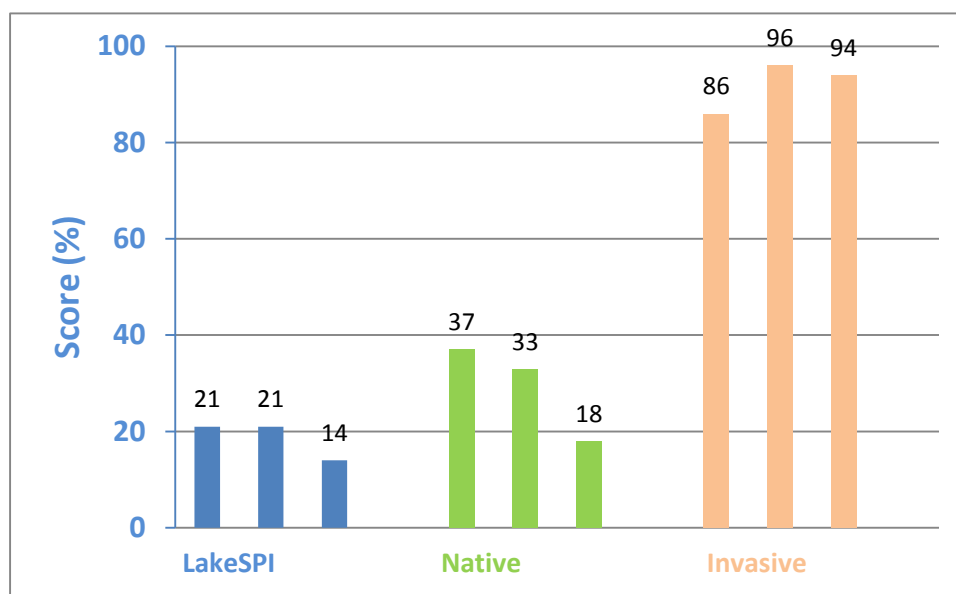


Figure 4-4: LakeSPI Index as % of potential score for Lake Roto-otua with Native Condition Index, and Invasive Impact Index shown from 2005, 2009 and 2010 (from left to right). Note grass carp directly affect LakeSPI metrics and currently the default score is zero with no submerged macrophytes found.

A very low LakeSPI score of 14% was recorded in 2010 as *E. densa* and *C. demersum* have greatly reduced native values in the lake (Figure 4-4). By 2011 grass carp had removed all the submerged vegetation so it scored 0% (Non-vegetated), as in 2012 but as grass carp directly affect the LakeSPI metrics the value of LakeSPI in monitoring ecological condition is markedly reduced. When grass carp grazing pressure is removed LakeSPI is expected to improve markedly with an all-native submerged vegetation restored from the seed bank.

Water birds

Fencing of the lake to exclude cattle and the large emergent beds surrounding much of this lake created a desirable habitat for many water birds. Large numbers of black swan (*Cygnus atratus*) and mallard (*Anas platyrhynchos*) were recorded. Threatened species recorded from the lake include the nationally endangered bittern (*Botaurus poiciloptilus*) and regionally significant dabchick (*Poliocephalus rufopectus*) and fernbird (*Bowdleria punctata vealeae*). More recently bird numbers, particularly black swan have decreased as the aquatic vegetation is eaten by grass carp.

Fish

In shallower water, the large emergent beds provide good habitat for some species. Dwarf inanga (*Galaxias gracilis*), bully (*Gobiomorphus cotidianus*) and shortfin eels (*Anguilla australis*) were noted in 2010.

Grass carp were introduced in May 2009. They will change fish habitat, but other studies have not reported significant fisheries impacts.

Aquatic invertebrates

Large numbers of invertebrates including freshwater mussels (*Echyridella menziesi*) were recorded.

Changes in indicators

Previously this was a native lake of high value, with charophyte meadows and the tall-growing species *Potamogeton ochreatus* dominant. Native species were then displaced by the pest plants *E. densa* and *C. demersum*. Grass carp have since been used to remove all submerged vegetation except for the turf species.

Threats

E. densa and *C. demersum* posed a significant risk to other lakes in the region, particularly nearby 'outstanding' Lakes Humuhumu and Kanono. Boat access to Lake Swan with a 4-WD is easy across private land. This risk has gone with grass carp removal of the pest plants. Re-introduction of pest plants is not a risk until the grass carp have gone.

Alligator weed is apparently present at the access point only and threatens the marginal vegetation of this lake.

Management recommendations

Eradication of submerged weeds by introduction of grass carp has been implemented and this eradication strategy should continue for at least 3 more years and be monitored annually.

A survey of alligator weed abundance and management (if appropriate) is recommended.

4.1.6 Lake Rotopouua (Pouto), NRC Lake No. 348.



Plate: Lake Rotopouua.

Summary

Survey dates: 2008, 2012

Overall ranking Outstanding: Good intact native emergent margin and submerged vegetation with some endangered biota. *Utricularia gibba* present.

Threats

Introduction of invasive species. Further nutrient enrichment and de-oxygenation.

Management recommendations

Lake ecological assessment every 5 years. Algal blooms indicate possible nutrient threat to ecological condition. A nutrient budget is recommended.

Description

Lake Rotopouua (1699531E, 590047N) is a small (<5ha) lake with a maximum depth c. 9 m. The lake is ponded between dunes to the west and weathered hill country, with heavy clay soils, to the east. The catchment is primarily plantation pine forestry manuka/kanuka scrub

and fenced pasture. Access is across farm land from the Pouto Road and the lake has limited boat access as it is fenced off from stock.

Wetland vegetation

The lake is completely fringed with emergent species. The dominant emergent species are *Eleocharis sphacelata*, *Typha orientalis*, *Machaerina juncea*, *M. articulata*, *Schoenoplectus tabernaemontani* and *Carex secta*. The nationally threatened fern *Thelypteris confluens* was common growing amongst emergent sedges, especially *M. juncea*.

Submerged vegetation

Turf communities were not recorded due to extensive and dense emergent beds. Some *Utricularia gibba* was found in shallow water amongst emergent sedges. Tall-growing *Potamogeton ochreatus* was common with charophyte meadows dominated by *Nitella* sp. aff. *cristata* and *Chara australis* to about 5 m.

LakeSPI

Table 4-4: LakeSPI results for Lake Rotopouua. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	91	0
	2008	72	68	21
Present day	2012	71	67	21

*LakeSPI results are based on 3 sites.

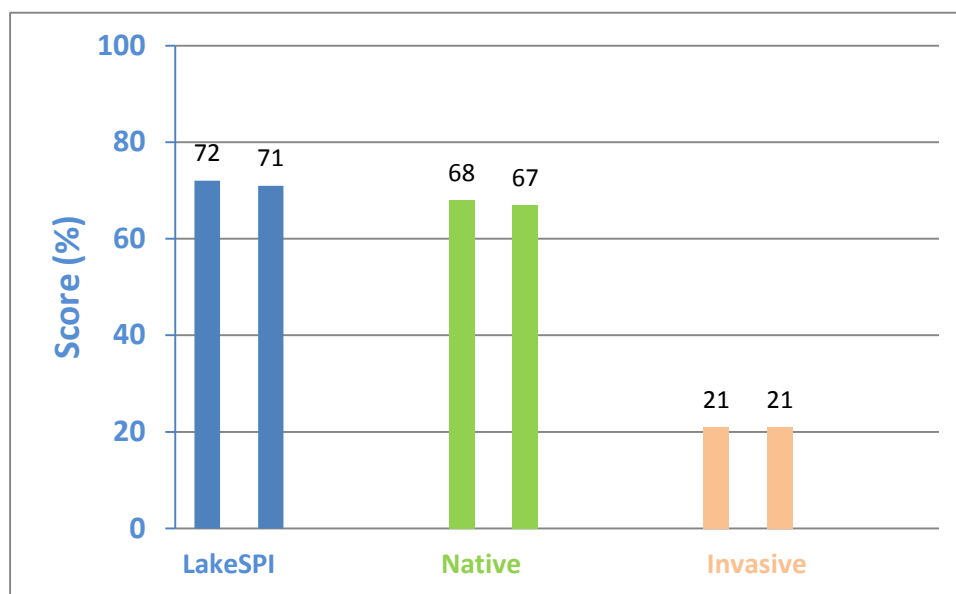


Figure 4-5: LakeSPI Index as % of potential score for lake Rotopouua with Native Condition Index and Invasive Impact Index for 2008 and 2012 shown (from left to right).

Lake Rotopouua is in 'high' ecological condition as categorised by LakeSPI (Table 4-4, Figure 4-5).

Utricularia gibba continues to have a negative impact on lake values but this lake has remained stable since its first LakeSPI assessment in 2008.

Water birds

Extensive emergent vegetation and a relatively isolated lake provide good habitat for water birds. The nationally endangered bittern (*Botaurus poiciloptilus*) and regionally threatened dabchick (*Poliiocephalus rufopectus*) were seen and a spotless crake (*Porzana tabuensis plumbea*) was observed from the lake margin.

Fish

Abundant common bullies (*Gobiomorphus cotidianus*), were observed during vegetation surveys. The endangered dwarf inanga (*Galaxias gracilis*) were reported as common in this lake (Rowe and Chisnall 1997), but a thorough search by DOC Northland Conservancy staff could not relocate this species.

Aquatic invertebrates

Many dead shells of the freshwater mussels (*Echyridella menziesi*) were common throughout the lake in 2008 and no live ones were found. It is likely the lake has been anoxic. Snails, *Potamopyrgus antipodarum*, as well as freshwater sponges and hydra were common.

Changes in indicators

No change.

Threats

The restricted access to this lake reduces the threat of introduction of pest plants. Should invasive species be introduced to the lake it is likely that they would displace much of the current native vegetation. The lake appeared to have deteriorated in 2008 with a mass extinction of mussels and apparently dwarf inanga, probably caused by the lake going anoxic for a period. This indicates increased nutrient input (from farming or forestry?) and resulting algal blooms. The lake is fenced preventing direct access to the lake by livestock. However, an extensive pugged wetland area was noted at the northern end of the lake, a possible source of nutrient enrichment along with fertiliser from pine forests.

Management recommendations

An assessment of lake native biodiversity value at 5 yearly intervals is recommended.

Analysis of annual monitoring of water quality should be undertaken to determine the extent of nutrient enrichment and consideration of sources of nutrients to the lake may find a means of mitigating the nutrient enrichment threat.

4.1.7 Lake Rototuna (Pouto), NRC Lake No. 328.



Plate: Lake Rototuna in a pastoral catchment with some pines on the western margin.

Summary

Survey dates: 2005, 2007, 2012

Overall ranking

High: A lake with retired margins, native vegetated with endangered biota, and pest fish established.

Threats

Invasive submerged weeds would displace the existing vegetation, though access is now more difficult. Possibly issues with road run-off entering lake via a culvert with turbidity/nutrient issues. The invasive reed sweet grass (*Glyceria maxima*) threatens the lake margins.

Management recommendations

Lake ecological assessment every 2 to 3 years. Eradicate *Glyceria maxima*.

Description

A dune lake 6 ha in area and 5.1 m deep, depending on water levels. The catchment is pasture with some pine trees, and the margin fenced since 1999 with a thick mat of kikuyu (*Cenchrus clandestinus*) surrounding the lake. No inflow or outflow streams. Adjacent to main Pouto Road, accessible with a 4-WD.

Wetland vegetation

About 80% of the shoreline had emergent species, with *Typha orientalis*, *Eleocharis spbacelata*, *E. acuta*, and *Schoenoplectus tabernaemontani* forming a narrow band 5 - 10 m wide. *E. spbacelata* beds extended to 1.8 m deep, the other species < 0.5 m. The invasive reed sweet grass (*Glyceria maxima*) was found for the first time in 2007. It was located amongst raupo on the south-eastern shore of the lake.

Submerged vegetation

Low visibility in 2012 (0.4 m) made the survey difficult. Turf species were present around about 20% of the lake, with *Glossostigma elatinoides* and *Lilaeopsis novae-zelandiae* most common but always at low covers (<26%). Tall-growing native species were present on all profiles with *Potamogeton ochreatus* the most abundant (26-95% median cover). No tall-growing exotic species were present except *Potamogeton crispus* and *Juncus bulbosus*, found in 2005 but not seen since. Charophytes were the dominant vegetation in the lake, with *Nitella* sp. aff. *cristata* at high (>75%) average cover at all profiles and composing the deepest growing vegetation to 4.1 m, the deepest part of the lake in 2012. *Chara australis* was also common and *Nitella pseudoflabellata* and *N. hyalina* were also present on some profiles. The nationally 'At-risk' *Stuckenia pectinata* was recorded in 2005 but not found since.

LakeSPI

Table 4-5: LakeSPI results for Lake Rototuna. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Pristine		95	90	0
	2001	86	78	6
	2005	76	66	13
	2007	86	78	0
Present day	2012	83	66	0

* The 2001 survey is based on 3 sites.

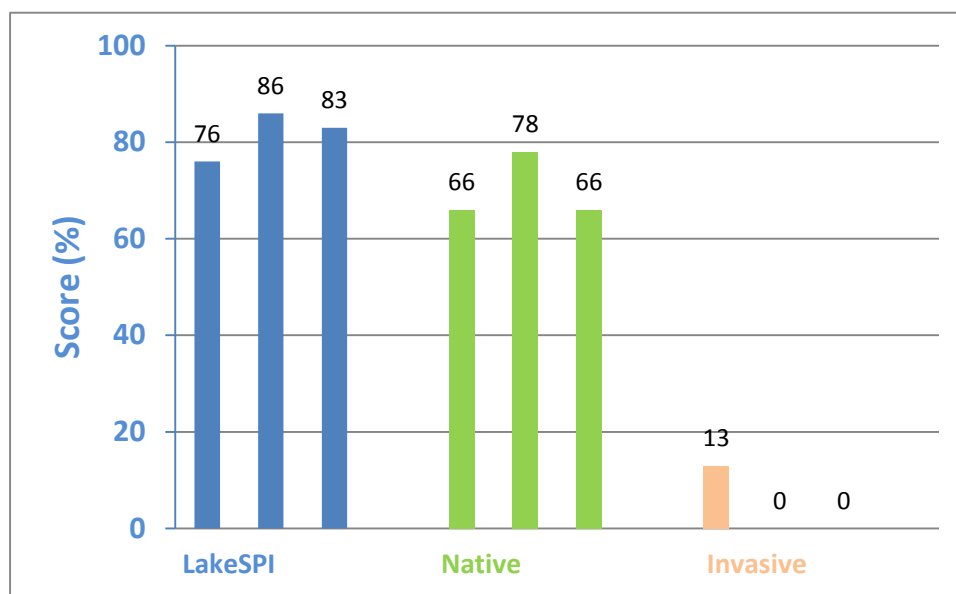


Figure 4-6: LakeSPI Index as % of potential score for Lake Rototuna with Native Condition Index, and Invasive Impact Index shown for 2005; 2007; 2012 (from left to right).

Lake Rototuna is categorised as being in 'excellent' ecological condition with a high LakeSPI index of 83% (Table 4-5, Figure 4-6). LakeSPI values for this lake have remained stable since surveys begun in 2001 with only a small change noted in the invasive impact scores during the 2001 and 2005 surveys on account of *Potamogeton crispus* and *Juncus bulbosus* being present at that time.

Water birds

Dabchick (*Poliiocephalus rufopectus*), regionally significant, and scaup (*Aythya novaezeelandiae*) were noted in previous visits, with 18 other common birds, the most dominant being black swans (*Cygnus atratus*) and paradise shelduck (*Tardorna variegata*). Additional to swans and regionally significant scaup (*Aythya novaezeelandiae*), an endangered Australasian bittern (*Botaurus poiciloptilus*) was seen during the 2012 visit.

Fish

Nationally threatened dwarf inanga (*Galaxias gracilis*) were recorded by the NIWA FBIS database although none were seen during the survey. Common bully (*Gobiomorphus cotidianus*) and exotic *Gambusia affinis* were observed. Rudd (*Scardinius erythrophthalmus*) were also reported.

Aquatic invertebrates

The introduced snail *Physa acuta* was recorded during the vegetation survey.

Changes in indicators

Previous surveys were undertaken in 1988, 2001 and 2005 survey. The 1988 survey had much reduced bottom limits with the maximum depth of vegetation only 2.5 m, but subsequent surveys found the lake mostly vegetated with only a small area deeper than 5 m beyond the bottom limit of the vegetation. The water level in 2012 was low with the maximum depth 4.2 m and the clarity was poor at around 0.4 m with a dense algal bloom that is likely to be recent as the vegetation still grew across the bottom.

Threats

The vegetation is native dominated and introduction of other weed species is a risk. The sprawling emergent weed reed sweet grass, threatens much of the marginal vegetation and has not been controlled yet.

Pest fish (gambusia and rudd) are of concern. The possible loss of dwarf inanga from Lake Kai-iwi, may have resulted from gambusia impacts, and the recent introduction of these pest fish may have similar impacts in Lake Rototuna. Rudd are herbivorous in large part and have been implicated in loss of vegetation in nutrient stressed lakes similar to Lake Rototuna, however they have been present in the lake for around a decade with little apparent impact.

Management recommendations

Lake ecological assessment every 2-3 years.

Eradicate reed sweet grass from the lake margin using a grass-specific herbicide.
Investigate dwarf inanga recovery.

4.1.8 Lake Whakaneke, NRC Lake No. 390



Plate: Lake Whakaneke surrounded by manuka scrub with dense emergent vegetation dominated by *Typha orientalis* and *Schoenoplectus tabernaemontani*.

Summary

Survey dates: 2005, 2012

Overall ranking Moderate: Isolated and set within indigenous vegetation and dense emergent margins, with excellent water bird habitat and good populations of several endangered birds, but with no submerged vegetation and very poor water clarity.

Threats Low risk of introduction of invasive weeds as it is isolated and conditions are unsuitable for submerged plants.

Management recommendations Lake ecological assessment every 5 years. Elevated nutrients have likely severely impacted ecological condition. A nutrient budget is recommended.

Description

A dune lake (1696559E, 5973120N) of 20.5 ha size, about 2.5 m deep, set within a manuka scrub covered area. There were no inflow streams but it appears that water flows south from Lake Mokeno via areas of wetland, with an outflow at the entry point on the western shore, discharging to the entrance to Kaipara Harbour via an extensive wetland. A dune face is situated to the east and rough pasture, wetland and mobile sand dunes to the west. Access is by 4-WD through forestry and Māori land (15 km of tracks, some very boggy) requiring passage through a locked gate. No boat access.

Wetland vegetation

The lake was fringed by dense 10-20 m wide beds of *Typha orientalis* and *Schoenoplectus tabernaemontani* extending from the shore to 0.5 m deep. *Eleocharis sphacelata*, *E. acuta* and *Machaerina articulata* were present in the emergent zone, with the indigenous *Persicaria decipiens* and *Isachne globularis* commonly sprawling amongst these emergent beds.

Submerged vegetation

No submerged vegetation was found in 2007 and 2012 and only occasional stalks of *Myriophyllum triphyllum* and *Chara australis* fragments were found in 2005 during a more detailed search of the lake.

LakeSPI

Lake Whakaneke receives a default LakeSPI index of 0% (Non-vegetated) on account of submerged plants being recorded at <10% cover.

Water birds

The lake and surrounding wetlands provide excellent bird habitat. The nationally rare bittern (*Botaurus poiciloptilus*) and 20 of the regionally threatened dabchick (*Poliiocephalus rufopectus*), 10 scaup (*Aythya novaezeelandiae*) and a spotless crake (*Porzana tabuensis plumbea*) were observed from the lake margin in 2007. Other threatened species reported include the regionally significant banded rail (*Rallus philippensis assimilis*) and fernbird (*Bowdleria punctata vealeae*). Brown teal (*Anas aucklandica chlorotis*) 'Critically Endangered', were recorded in this area. Birds observations were hampered by lack of light in 2012.

Fish

Common bullies (*Gobiomorphus cotidianus*) were seen.

Aquatic invertebrates

Backswimmers (*Sigara arguta*), snails *Potamopyrgus antipodarum* and *Physella acuta* (exotic species) were present with a large number of benthic chironomids.

Changes in indicators

No submerged plant indicators to monitor. The lake is likely to support good populations of a number of endangered birds and although not seen in 2012, this visit was carried out near dusk so visibility was poor.

Threats

Isolation provides a lower risk of introduction of invasive weeds and establishment is unlikely should this occur as water clarity is currently very low.

Management recommendations

Lake ecological assessment every 5 years.

5 Surveillance

5.1 Lake Ngatu

The shallow bay out from the main access point for Lake Ngatu, at the north end of the lake off West Coast Road (2529000E 6683000N), was intensively checked for new weed incursions deploying 3 SCUBA divers and 3 snorkelers.

In the Southwest of the lake an area was searched from where waka ama are launched south to the sandy beach.

The lake currently still has no *E. canadensis*, *E. densa* or *C. demersum* present, and all are potential weeds (particularly *C. demersum*) that could markedly impact on the ecological and recreational lake values. *L. major* remains present but has decreased in abundance since surveyed in 2006.

Currently the *L. major* present in the lake is not causing a nuisance to recreation but it is a well-used lake and could provide a source of weed fragments for dispersal to other weed-free lakes.

Information displayed on signage for boaters would be a useful way to inform users that any weed fragments could pose a significant risk to the next water body they visit. Advice on cleaning boats, boating equipment and trailers should be included on the signage.

5.2 Lake Waiporohita

The eastern shore of the lake was checked for submerged weed, shoreline drift fragments and marginal weeds. Water clarity was good (~1.5 m) and submerged vegetation was checked by snorkel. No new weeds were found, but alligator weed has spread around the lake.

5.3 Lake Kai-iwi

The boat access point useable by 4-wheel drive in 2005 (25701100E 6598580N) has had public access restricted by a locked gate since 2006. Snorkelers made two passes of the shoreline up to 150 m either side of this site to cover the depth range to 3.5 m. No new invasive species were found.

5.4 Lake Taharoa

At the beach launching site for boats (2568960E 6598645N) near the beginning of Domain Rd, about 400 m of the shoreline was searched for invasive weed with towed scuba divers covering the 0 - 10 m depth range. No invasive weed was found.

The camping ground beach at the eastern end of the lake (2570410E 6599045N), which is used for boat launching and mooring, was checked. About 500 m of the shore was checked and was mostly bare sand on the shallow shelving beach with suitable habitat at about 7 to 9 m deep. Scuba divers were towed along the upper vegetated depth limit. Visibility was good and sparse native vegetation was low growing, enabling large areas to be effectively searched. No new invasive species were found.

At the Peninsula boat launching area (2568375E 6599495N), a section of shoreline about 250 m long, was checked by towing scuba divers. Also the other side of the Peninsula, in the Sin Bin area (the most southern part of the northwest bay), was searched. No invasive species were found, nor are there any other submerged plants in this area.

5.5 Lake Waikere

The shoreline 200 m either side of the concrete boat ramp (2567290E 6600270N) was searched by a scuba divers and two towed snorkelers. The water is very clear so snorkelers could see well into 5 m of water. No invasive weed species were found.

In the southeast bay of the lake (2567725E 6599910N), about 400 m of shoreline was checked by towing two scuba divers. Conditions were very still and water clarity very good so rapid inspection was possible. No invasive weed species were found except for *U. gibba* which has been found in small quantities since 2009.

5.6 Lake Humuhumu

The access at the eastern side of the lake was checked by 3 scuba divers and 3 snorkelers covering about 300 m of shoreline and out to the 6 m depth contour. Alligator weed was abundant amongst the marginal vegetation, and it has spread. No invasive submerged weedy species were found apart from some *U. gibba*, which was present in small patches growing over other submerged species.

6 Grass carp assessments

6.1 Lake Roto-otuauru (Lake Swan)

E. densa was first reported in the lake in 1992, and *C. demersum* was first recorded in the 2005 survey. The threat of spread by hornwort and egeria from Lake Roto-otuauru to adjacent high-value lakes (Figure 6-1) was a high risk. Grass carp were introduced in May 2009 to eradicate the *C. demersum* and *E. densa*, to eliminate the risk of weed spread to high value neighbouring lakes, and to enable eventual native vegetation restoration in Lake Swan.

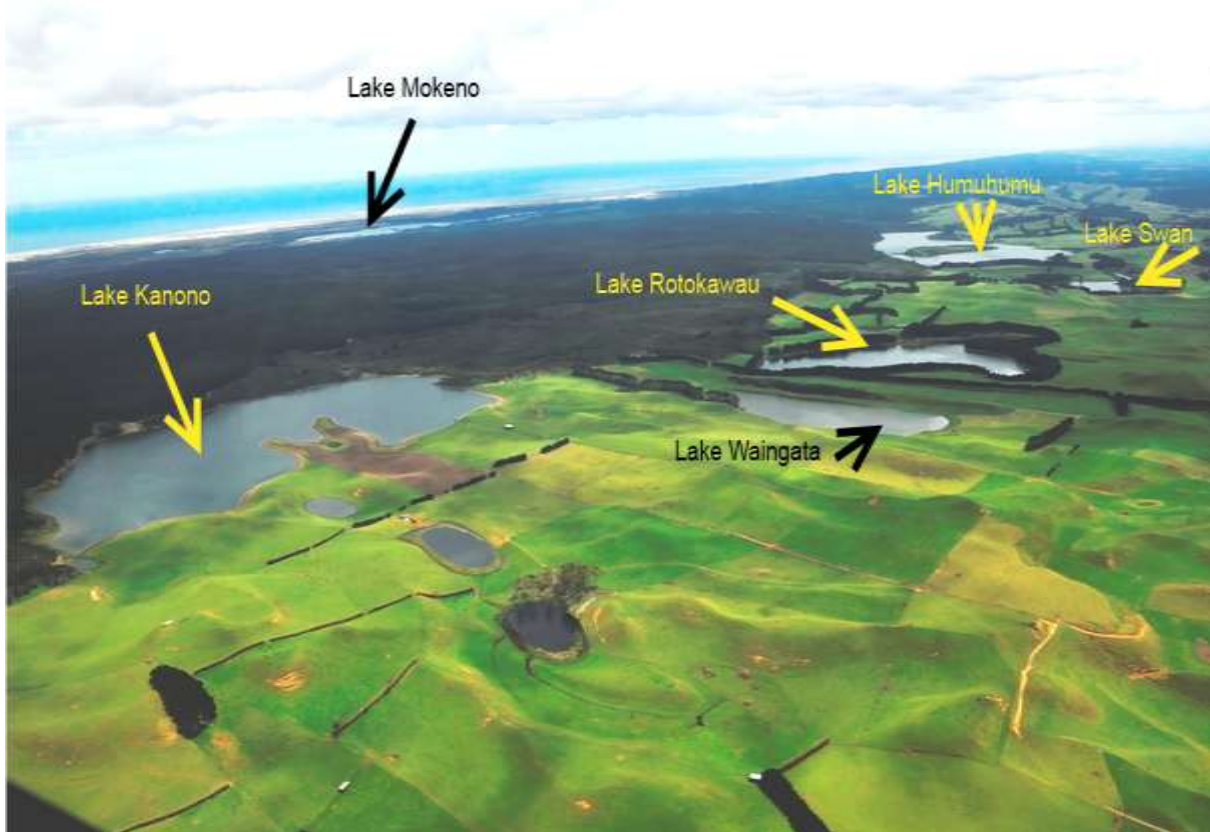


Figure 6-1: The location of Lake Swan is shown in relation to other lakes on the Pouto Peninsula. [Photo Rod Budd, NIWA, Hamilton].

In April 2010 virtually all the *E. densa* had gone and about half the *C. demersum* had been removed. At a few locations with sandy margins, a wide range of turf species were present with *Glossostigma elatinoides* the dominant species. Also charophytes persisted at one small site in water to 1.8 m deep on the eastern shore of the main body of the lake.

In March 2011 only a few pieces of *C. demersum* were found floating amongst the emergent species on the lake margin and the lake basin was de-vegetated. The marginal emergent species were also reduced considerably in extent with only remnants of *Typha orientalis* stands left (**Figure 6-2**). The area least grazed was in the arm at the north end of the lake

where the lake extends into a wetland. Low growing turf species were not affected by grass carp grazing.

In 2012 five sites were surveyed (A = 2613090E 6540457N; B = 2612861E 6540388N; C = 2612641E 6540444N; D = 2612652E 6540548N; E = 2612879E 6540643N) and no *C. demersum* or *E. densa* was found.

The threat of spread by hornwort and egeria from Lake Roto-otuauru to adjacent high-value lakes is no longer a risk.



Figure 6-2: Lake Swan margins. Grass carp were introduced in May 2009 and by 2011 had removed much of the *T. orientalis* (raupo) from the margins.

6.2 Lake Heather

Grass carp were introduced to Lake Heather as part of a lake restoration programme aimed at eradicating both *E. densa* and *C. demersum* and safeguarding nearby high-value lakes from the spread of these weeds.

The two baseline profiles recorded prior to grass carp release in 2010 were repeated in 2011 and 2012 (Figure 6-3).



Figure 6-3: Lake Heather showing the location of the 2 profiles monitored, with one in each basin.

In 2011 the *E. densa* had been heavily grazed but little damage was noted on the *C. demersum*. In 2012 the *E. densa* had been heavily grazed and reduced to basal stalks (Figure 6-4) but only about 50% of the *C. demersum* has been removed. Most of the *C. demersum* was still recorded up to 2.2 m tall. The rate of progress for grass carp in removing the weed beds is slower than in Lake Swan, but they are making steady progress.



Figure 6-4: *E. densa* remnants in Lake Heather at 2.6 m deep heavily grazed by grass carp.

7 Acknowledgements

We would like to thank the following people for their assistance with the field work:

NIWA: Aleki Taumoepeau for diving, boating, general field assistance and working long hours.

NRC: Gail Townsend for organising the contract and field schedule, Lisa Forester for underwater and wetland botanical expertise, Sara Brill for wetland botany and Kane McElrea for snorkelling skills.

DOC: Andrew Townsend for snorkelling and botanical expertise.

Maureen Young for her enthusiasm and marvellous botanical knowledge.

Thanks to other NIWA staff for their assistance: Tracey Edwards and Mary de Winton provided LakeSPI calculations. Erica Williams provided contact details for iwi groups at Lakes Omapere and Kaiwai.

Thanks also to Hine Tohu and Myrtle Sanson (Te Roopu Taiao o Utakura) and Adrian Walker and Steve McManus from DOC for discussions at Lake Omapere and to Wendy Henwood (Te Roopu Taiao o Utakura) for helping to organise the meeting. Pita Tipene (Te Runanga o Ngati Hine) assisted with access to Lake Kaiwai and Paki Thompson (Tereawatea Marae) discussed management of this lake.

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