9 LAKE QUALITY

Summary

RPS objectives

- Maintenance and enhancement of lake water quality in Northland to be suitable, in the long term, for aquatic ecosystems, contact recreation, water supplies, aesthetic and cultural purposes.
- Reduction in the quantity of contaminants that impact on water quality entering lakes.
- Maintenance of the biodiversity of the Northland region.
- Protection of the life-supporting capacity of ecosystems through avoiding, remedying or mitigating the adverse effects of activities, substances and introduced species on the functioning of natural ecosystems.
- Protection of areas of significant indigenous vegetation and fauna.

Pressures

- Aquatic weeds are a major threat to Northland's lakes. Some aquatic weeds have already significantly degraded some Northland lakes, such as Lake Omapere and Swan Lake, by growing over the entire area of the lake and preventing the growth of native species.
- There is a strong link between land use type and lake status. Lakes are much more at risk of eutrophication if situated in a pastoral-dominated catchment than in a native catchment.

State

- The water quality of the Kai Iwi lakes shows little change over time, with Lake Taharoa and Waikere having excellent water clarity and low nutrient concentrations to remain as two of the most pristine lakes in Northland.
- Water quality varies widely over the rest of Northland with signs of eutrophication becoming apparent in some lakes on Aupouri and Pouto Peninsulas.
- Half of Northland lakes that are monitored regularly are eutrophic or worse. The majority of these lakes are situated in highly modified catchments such as pastoral land.
- The ecological condition of 21% of Northland lakes surveyed is outstanding.

Doing well

- The Council has successfully established a Lake Water Quality Monitoring Network, weed surveillance programme and Lake submerged plant indicators (LakeSPI) monitoring programme.
- The Council and Lake Omapere Trustees have developed a Restoration and Management Strategy for Lake Omapere and with huge support from many key stakeholders and the community carried out large amounts of restoration work in the lake catchment.

Areas for improvement

- Protection of lakes from stock having direct access to the lake shores, including fencing and planting of lake margins.
- Protection of lakes from the spread of invasive aquatic weeds.

9.1 Introduction

The Northland region has a large number of small and generally shallow lakes. They were formed either by dune activity, volcanic activity or are artificially made.

The dune lakes are in four main groups situated on the Aupouri, Karikari and Pouto peninsulas and the Kai Iwi lakes. They generally range in size between five and 35 hectares and are usually less than 15 metres deep. Lake Taharoa of the Kai Iwi group is one of the largest and deepest dune lakes in the country, covering an area of 237 hectares and being 37 metres deep.

Lakes Omapere and Owhareiti near Kaikohe were formed by lava flows damming valleys. Further to the north are two large artificially made lakes associated with the Kerikeri irrigation scheme, which are a major water resource for the area.

Lake policy

Regional Policy Statement

The Regional Policy Statement for Northland (NRC 2002) contains objectives relating to the quality of Northland's surface fresh water resources. These objectives seek to maintain and, where possible, improve water quality in the Northland region. There are also objectives relating to the protection and maintenance of ecosystems and biodiversity.

The Regional Policy Statement (RPS) objectives pertaining to lakes are:

- The maintenance and enhancement of the water quality of natural water bodies in Northland to be suitable, in the long term, and after reasonable mixing of any contaminant with the receiving environment and disregarding the effect of any natural events for the following purposes: Aquatic ecosystems, contact recreation, water supplies, aesthetic and cultural purposes.
- The reduction and minimisation of the quantities of contaminants which adversely affect water bodies, in particular those that are potentially toxic, persistent or bio-accumulative.
- Avoid, remedy or mitigate the adverse effects of discharges of contaminants on the traditional, cultural and spiritual values of water held by tangata whenua.
- Maintenance of the biodiversity of the Northland region.
- Protection of the life supporting capacity of ecosystems through avoiding, remedying or mitigating (in that order of priority) the adverse effects of activities, substances and introduced species on the functioning of natural ecosystems.
- Protection of areas of significant indigenous vegetation and the significant habitats of indigenous fauna.

The following are the anticipated environmental results after the implementation of the water quality policies in the RPS:

- Water quality suitable for desired purposes.
- Contaminants in water bodies reduced.

- The adverse effects of contaminants in water bodies and coastal waters be avoided, remedied or mitigated.

The following are the anticipated environmental results after the implementation of the policies for ecosystems and biodiversity in the RPS:

- An increase in the areas of significant indigenous vegetation and the significant habitats of indigenous fauna which are formally protected.
- No significant increase in the number of threatened species in the region.

Regional Water and Soil Plan

The Regional Water and Soil Plan (RWSP) for Northland (NRC 2007a) contains rules that prohibit the discharge of any sewage and animal effluent into the dune lakes listed in Schedule E of the RWSP. Closed systems such as dune lakes are more sensitive to the adverse effects of effluent discharges. Dune lakes have been recognised as having high recreational and aesthetic qualities and are an important tourism feature of Northland. Discharges into any of the dune lakes would threaten those qualities.

9.2 What are the pressures on our lakes?

Weeds and pest fish

Aquatic weeds are a major threat to Northland's lakes. Native aquatic plant species are generally low growing, and present no management problems. However, species such as *Egeria densa* (oxygen weed) have spread throughout Northland and are a major threat to both the aquatic biodiversity and water quality of Northland lakes. These types of plants spread rapidly and can create large problems in lakes shallow enough to allow growth over their entire area.

Aquatic weeds present in Northland that adversely impact or threaten lakes include hornwort (*Ceratophyllum demersum*), oxygen weeds (*Egeria densa* and *Lagarosiphon major*), and bladderwort (*Utricularia gibba*). Other weeds that pose less of a threat include the oxygen weed *Elodea canadensis*, *Azolla pinnata*, the pond weed *Potamogeton crispus* and the swamp lily *Ottelia ovalifolia*.

Bladderwort sprawling over submerged vegetation, Morehurehu.

Pest fish can have adverse effects on water quality and native flora and fauna communities. The impacts of introduced pest fish on lake ecosystems in Northland are still largely unknown.

The mosquito fish (*Gambusia affinis*) is the most widespread pest fish in Northland. They are prolific breeders, so they can quickly populate new habitats. They are an aggressive fish that out-compete native fish species such as dwarf inanga (*Galaxias gracilis*), Inanga (*G. maculatus*) and common bully (*Gobiomorphus cotidianus*) for habitat and food sources. Other pest fish species found in Northland lakes include rudd (*Scardinius erythrophthalmus*) and goldfish (*Crassius auratus*).

Grass carp (*Ctenopharyngodon idella*) are commonly used as a control agent for removing aquatic weeds such as oxygen weed in water bodies.

Eutrophication

Eutrophication is the enrichment or pollution of water bodies by nutrients – particularly nitrogen and phosphorus. These nutrients cause excessive growth of aquatic plants and algae. Excessive growths become a problem when:

- Aquatic plants impede lake users.
- One plant grows excessively and excludes other plants.
- Aquatic organisms are damaged by dissolved oxygen depletion when large weed beds collapse and rot.
- Toxic algal species proliferate in large numbers.
- Waters become highly turbid.

Eutrophication of lakes is a major problem in New Zealand and throughout the world. Approximately half of the 134 lakes monitored routinely in New Zealand are eutrophic or worse (Hamill 2006). Fifty-four percent of lakes in the Asia Pacific region are eutrophic.

Europe, Africa, North America and South America have 53%; 28%; 48%; 41% of their lake degraded by nutrient pollution respectively (Chorus and Bartam, 1999).

Land use

Pastoral farming

Northland's lakes are particularly vulnerable to eutrophication, as they tend to be small, shallow and often have intensive pastoral farming activities within their catchments that can contribute significant phosphorus and nitrogen pollution.

Stock access to the lake margins destroys the native riparian and emergent vegetation, which is important habitat for fish and birds, as well as increasing sediment and nutrient levels in the lake water.

Impacts of stock: Emergent vegetation removed, sediment stirred up through pugging.

Plantation forestry

Pinus radiata forestry is a major land use around the Aupouri and Pouto peninsulas, where the majority of Northland lakes are. Small lakes are becoming infilled with reeds, which is a natural process but has been accelerated by the sheltering effect of the pines.

This sheltering effect can also prevent the mixing of lakes resulting in greater stratification of the lake water. The deoxygenation, as a result of this stratification, can lead to the release of nutrients from the lakes' bottom sediments.

Lake catchment dominated by Pinus Radiata forestry.

9.3 What is the state of our lakes?

Water quality

The state of a lake can be determined by using the Trophic Level Index (TLI). The TLI uses four key variables, chlorophyll α (indicator of algal biomass), water clarity (secchi disc depth), total nitrogen and total phosphorus, which together are an indication of a lake's overall health. Table 1 (below) shows the values that define the different trophic levels (Burns et al. 2000).

Table 1: Values of variables that define the boundaries of different trophic levels.

Lake type	Trophic level	Chlα (mg/m^3)	Clarity (m)	TP (mg/m^3)	TN (mg/m^3)
Ultra-microtrophic	0.0 - 1.0	0.13 - 0.33	33 - 25	0.84 - 1.8	16 - 34
Microtrophic	1.0 - 2.0	0.33 - 0.82	25 - 15	1.8 – 4.1	34 - 73
Oligotrophic	2.0 - 3.0	0.82 - 2.0	15 - 7.0	4.1 – 9.0	73 - 157
Mesotrophic	3.0 - 4.0	2.0 - 5.0	7.0 - 2.8	9.0 - 20	157 - 337
Eutrophic	4.0 - 5.0	5.0 - 12	2.8 - 1.1	20 - 43	337 - 725
Supertrophic	5.0 - 6.0	12 - 31	1.1 - 0.4	43 - 96	725 - 1558
Hypertrophic	6.0 - 7.0	> 31	< 0.4	> 96	> 1558

Established in 2005 the Northland Lake Water Quality Monitoring Network (LWQMN) includes 31 lakes throughout Northland, which are sampled every three months. The results are presented in table 2 in Appendix A.

Aupouri lakes

Between November 2005 and March 2007, 16 dune lakes on Aupouri Peninsula were monitored as part of the LWQMN. From these results nine lakes were classed as mesotrophic, one oligotrophic and the remaining eutrophic or worse, as shown in figure 1 (below).

Mesotrophic lakes have high to moderate water clarity and have low to no algae present. Approximately half of the lakes classed as mesotrophic are situated in catchments dominated by exotic forestry with the rest situated in farm land. Lakes in catchments dominated by farm land are more at risk of becoming eutrophic unless measures are put in place to prevent nutrients from entering the lake.

Blue-green algal bloom in Lake Waiporohita.

Lake Te Kahika is the only one classed as oligotrophic, of the 16 regularly monitored Aupouri lakes. Oligotrophic lakes have excellent water clarity and low concentrations of nutrients and algal biomass.

Karikari lakes

Only one lake on the Karikari Peninsula is part of the LWQMN, Lake Waiporohita. It is hypertrophic, as shown in figure 1 (below), with high levels of nutrients and low clarity, due to the peat stained water. Algal blooms often occur in this lake during summer.

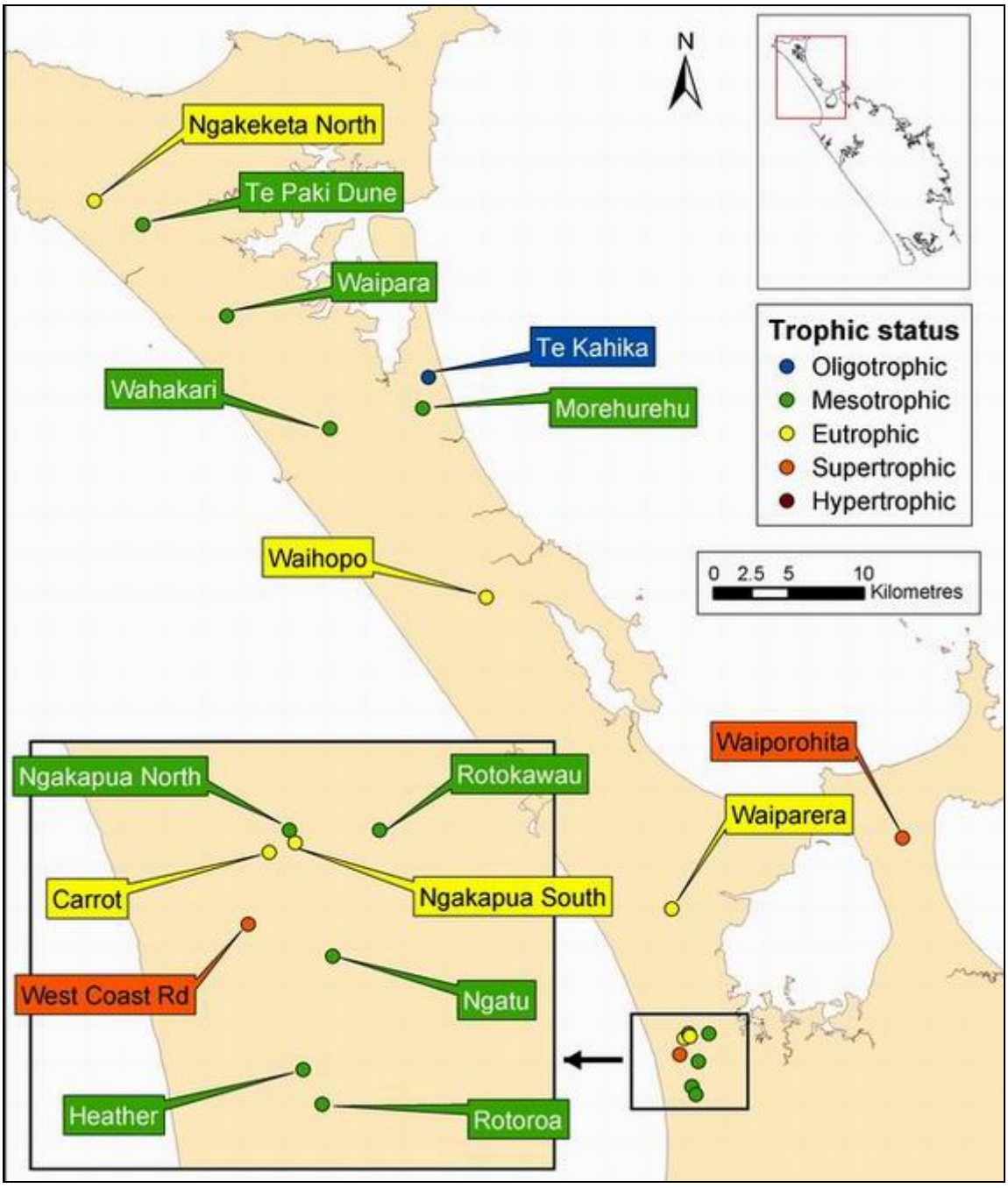

Figure 1: Map of the Aupouri and Karikari Peninsulas showing the trophic status of 17 monitored lakes.

Lake Omapere

Lake Omapere is Northland's largest lake at approximately 1200 hectares. It is a volcanic lake situated north of Kaikohe, which was formed when a lava flow blocked water flowing eastwards. Lake Omapere is an important taonga to the hapu and iwi of Ngapuhi and has important amenity value to the wider Kaikohe community.

Lake Omapere has a more intensive monitoring programme than the 31 lakes in the LWQMN. It has been sampled at least every second month for more than 10 years. It has shifted from a weed-dominated lake to its current state as a turbid algal-dominated lake.

Water clarity is poor and nutrient levels are high, which means this lake is classed as hypertrophic, as shown in figure 2 (below). Lake Omapere often has blue-green algal blooms in the summer making it unsafe for human and stock use.

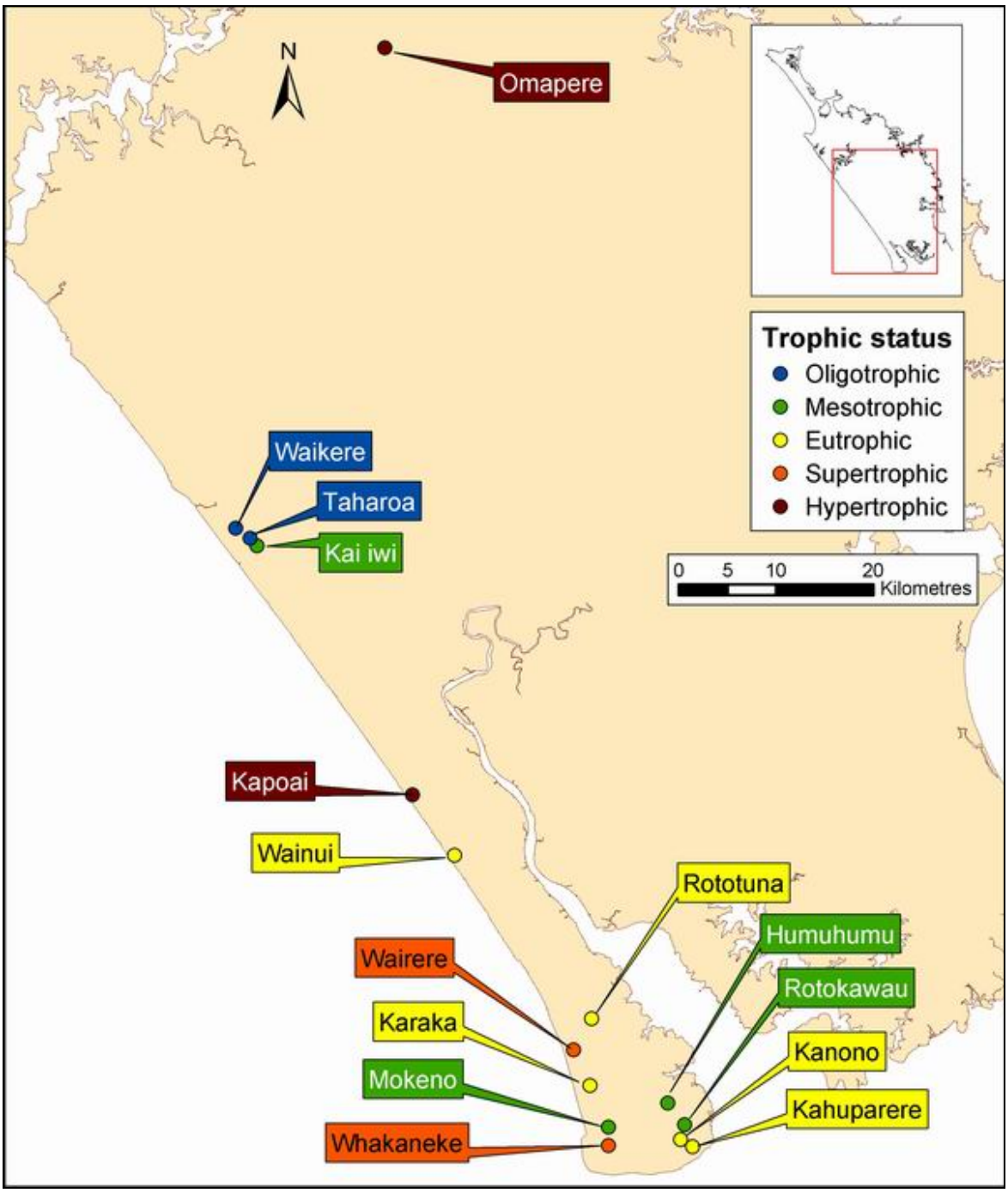

Figure 2: Map of the central and west coast area showing the trophic status of 15 monitored lakes.

Kai Iwi lakes

Lakes Taharoa and Waikere have low nutrient concentrations, excellent water clarity and no algal problems, which imply that both have an oligotrophic status, as shown in figure 2 (above). Lake Kai Iwi is classed as mesotrophic and also has excellent water clarity.

All the Kai Iwi lakes stratify over the spring/summer period with bottom waters always becoming deoxygenated in Lake Waikere and sometimes in Lake Taharoa. This can trigger the release of nutrients from the bottom sediment causing an increase in nutrients in the water column. All of the Kai Iwi lakes are surrounded by exotic forestry with a fringe of native scrub.

Pouto lakes

Water quality sampling was undertaken at 11 lakes on the Pouto Peninsula between 2005 and 2007. Results show that there are only three mesotrophic lakes in Pouto: Humuhumu, Mokeno and Rotokawau, as shown in figure 2 (above). The rest of the lakes are eutrophic or worse and often have high algal abundance over summer when the water is warmer. Most of the eutrophic lakes are located in catchments dominated by pastoral farming, often where stock have direct access to the lake.

Overall

Between November 2005 and March 2007, 32 lakes have been regularly monitored for water quality. Trophic Level Index scores were generated for all the lakes sampled, as shown in table 2 (Appendix A).

Based on these results half of these lakes are eutrophic or worse as shown in figure 3 (right). This means that these lakes have an oversupply of nutrients, poor clarity, low oxygen and toxic algae blooms can often occur. Two lakes are classed as oligotrophic and 41% of lakes are mesotrophic.

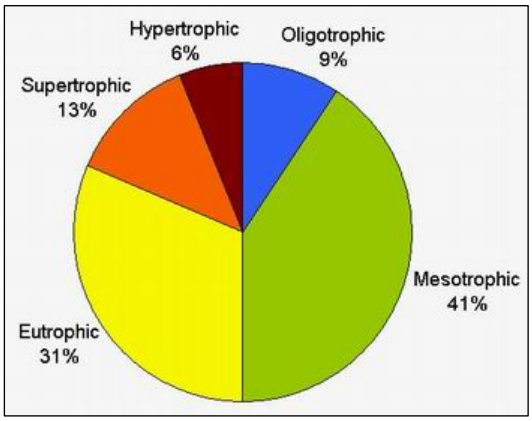

Figure 3: Trophic level of 32 Northland lakes for results from Nov 05 to Mar 07.

Other lakes

A further 23 lakes throughout Northland have been sampled intermittently over the last five years. Although most of these lakes have only been sampled one or two times, an estimation of their trophic status can still be calculated, as shown in table 3 (Appendix A).

Most of these 23 lakes are dune lakes. The exceptions are two man-made water supply reservoirs near Kerikeri: Lakes Manuwai and Waingaro, Lake Owhareiti, a volcanic lake and Jacks Lake, which has been artificially dammed (both in central Northland) and Lake Waro, near Whangarei, which is man-made.

Of these 23 lakes, four have an estimated tropic status of oligotrophic and three of mesotrophic and the remaining 16 are eutrophic or worse, as shown in figure 4 (below).

Geothermal lakes

The two small Ngawha geothermal lakes, Ngamokaikai and Waiparaheka were first monitored in October 1998. They were monitored for a second time in April 2006, which

shows that the lakes are still acidic with a pH range of 3.5 – 3.7. Both lakes are unique environments and are home to equally unique flora and fauna.

In March 2000, the Council assisted a student from the University of Auckland to carry out a bathymetric survey of the Ngawha geothermal lakes. The main lake (Waiparaheka) was found to have a maximum depth of 40 metres, making it one of the deepest (if not the deepest) lakes in Northland.

For more information on Northland's geothermal resources refer to the 'geothermal resources' chapter of this report.

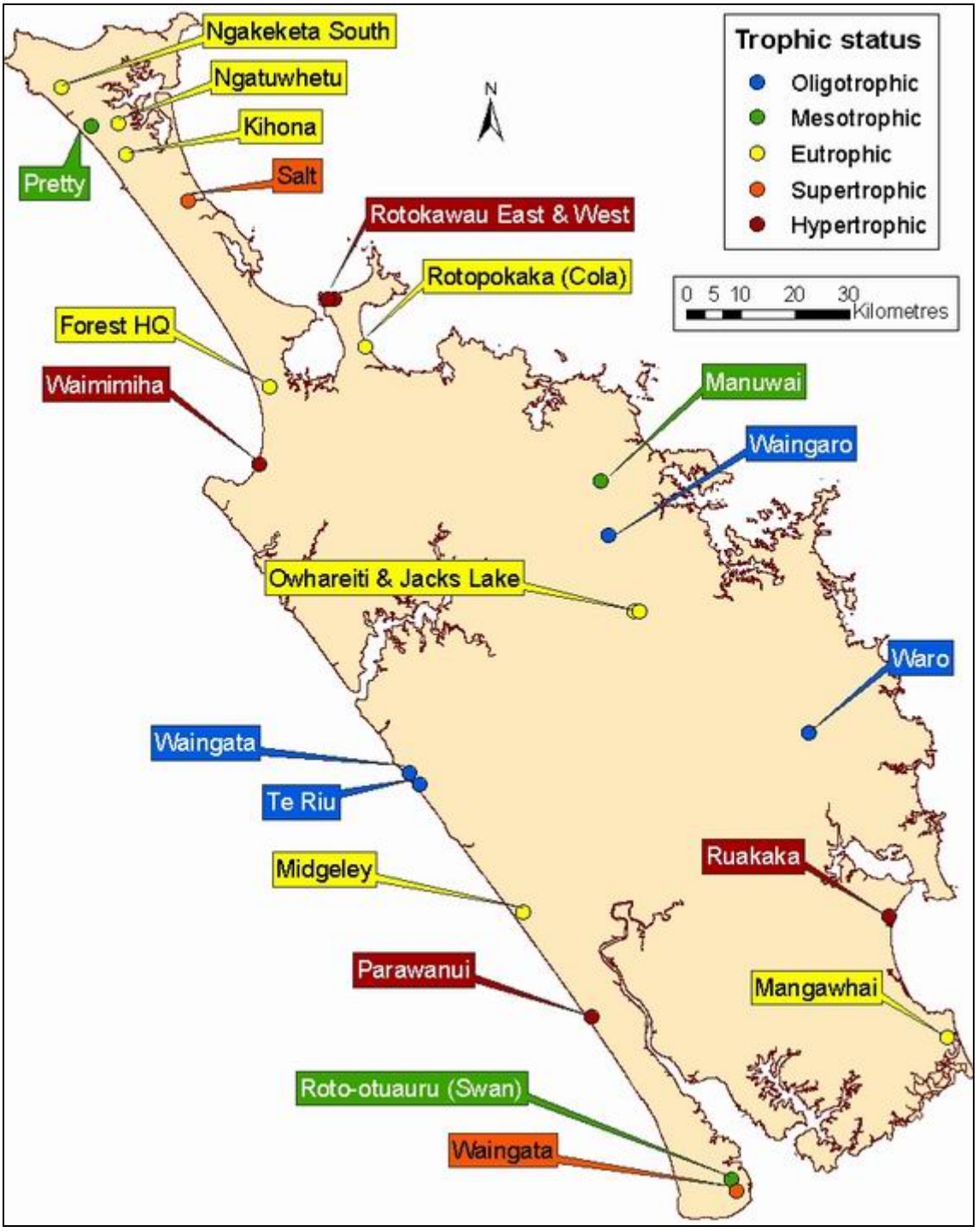

Figure 4: Map showing the estimated trophic status of 23 irregularly monitored lakes.

Observed trends in the Kai Iwi lakes

The Northland Regional Council first monitored the Kai Iwi lakes in 1990; and intermittently between 1990 and 2001. In 2002, an intensive monitoring programme was established for a year by Dargaville High School. Sampling was undertaken almost monthly creating a good data set which can be used to identify trends. Since 2002, sampling has been carried out on average four times a year.

The TLI for the Kai Iwi lakes over the last five years shows there has been little change in all lakes as shown in figure 5 (below). The TLI for Lake Taharoa in 2004 appears lower than the other four years, although only two samples were taken in 2004. Lake Waikere had a higher TLI score in 2005 compared to other years. This higher trophic level was due to high nutrient readings from prolonged stratification and/or fertiliser use on neighbouring land.

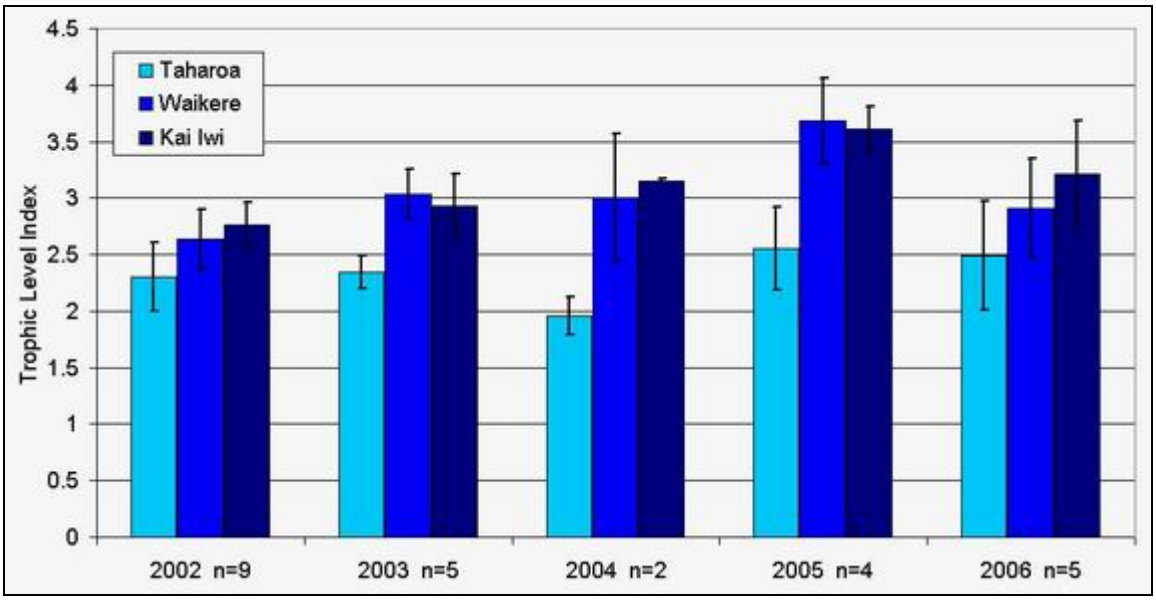

Figure 5: Trophic level index in the three Kai Iwi lakes from 2002 to 2006.

Freshwater biodiversity

Ecological value

Assessments of the ecological value of a lake can be made based on representativeness of biota, intactness of vegetation, presence of significant species, absence of pest species, and absence of detrimental impacts such as nutrient enrichment. Between 2004 and 2007, National Institute of Water and Atmospheric Research (NIWA) staff have surveyed 72 lakes and ranked them based on these assessments. The rankings from best to worst are; outstanding, high, moderate to high, moderate, low to moderate and low. The results for the 72 lakes are presented in tables 2 and 3 in Appendix A.

Ranking lakes based on their ecological value helps with prioritising lakes for protection, enhancement and monitoring frequency. For example most of the lakes ranked outstanding are surveyed annually as part of the Pest Plant Surveillance Programme. LakeSPI which is used to assess the ecological condition of a lake is also carried out regularly to assess any changes. No monitoring is carried out on lakes that have a low ranking (except Lake Omapere which has its own monitoring programme).

Outstanding lakes are nationally important, containing a diverse indigenous biota with sustainable populations of endangered species. Fifteen of the 72 lakes surveyed were

ranked as outstanding as shown in figure 6 (below). They were found in all four areas but predominantly on the Aupouri Peninsula. Examples of Northland lakes that are ranked as outstanding include Ngatu, Wahakari (both Aupouri), Taharoa (Kai Iwi), Mokeno (Pouto) and Te Riu (Waipoua).

Of the 72 lakes surveyed 13 were ranked as high, eight as high to moderate, and 26 lakes were ranked as low. Lakes ranked with low ecological value are either de-vegetated with poor water quality or severely impacted by exotic pests (including fish and plants).

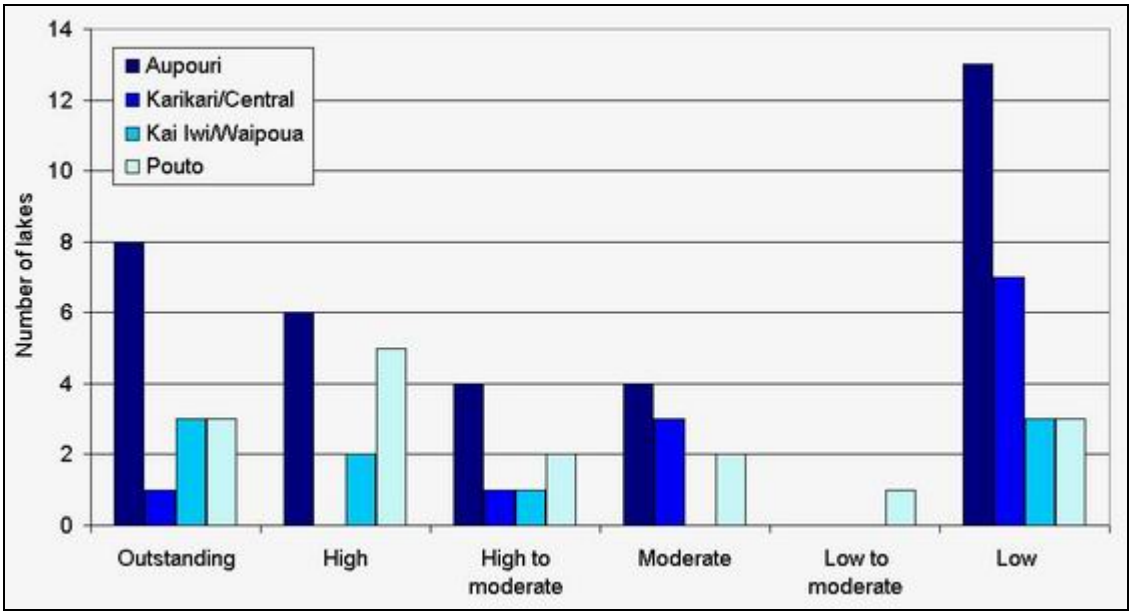

Figure 6: Ecological value of 72 Northland Lakes based on NIWA surveys from 2004 to 2007.

LakeSPI (ecological condition)

The LakeSPI index score is a measure of how close a water body is to its potential un-impacted state i.e. the closer the LakeSPI score is to 100% the less impacted or more pristine a lake is. This index allows us to detect changes in the lake condition over time and to make comparisons between lakes.

LakeSPI assesses the composition of native and introduced plants growing in a lake and the depth to which they grow. The LakeSPI method is carried out by qualified divers at five sites around the lake. The LakeSPI percentage scores for the 40 lakes surveyed are presented in tables 2 and 3 in Appendix A.

These scores can be used to assign lakes to one of four categories: Excellent (LakeSPI score >85%), high (50-85%), moderate (20-50%) or poor (<20%). Of the 40 lakes, six have excellent and 22 have high ecological condition as shown in figure 7 (below).

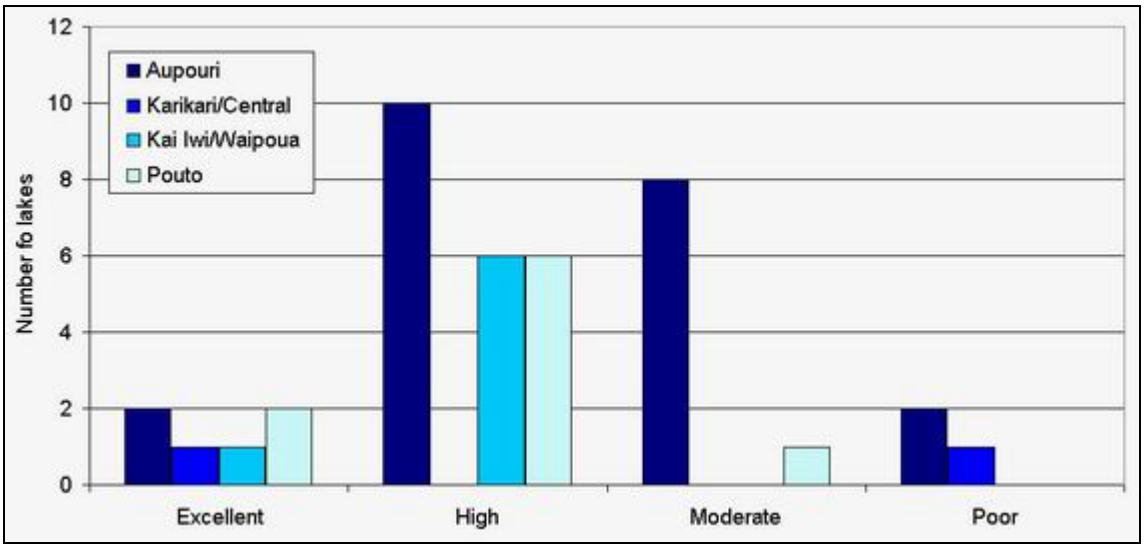

Figure 7: Ecological condition (LakeSPI ranking) of 40 lakes based on the 2007 LakeSPI scores.

Very few lakes in Northland are near pristine as most lakes contain at least one submerged weed species. Examples of lakes that are classed as excellent include Lake Te Paki (Aupouri), Te Riu (Waipoua) and Mokeno (Pouto). These lakes are not impacted by pest plants as they are very isolated with difficult access.

Te Paki Dune Lake on Aupouri peninsula.

A high proportion of lakes are classed as high, having a good native plant community with the odd patch of aquatic weeds. These lakes have reasonably easy access which increases the likelihood of pest plants being introduced. Examples include Lakes Ngatu (Aupouri), Taharoa (Kai Iwi), Humuhumu and Kanono (Pouto).

Aquatic weeds

Bladderwort (*Utricularia gibba*) is the most widespread aquatic weed species in Northland recorded in 23 lakes in 2007 as shown in figure 8 (below). Prior to 2004, bladderwort was only found in Lake Omapere where it has probably been eradicated through the introduction of grass carp.

It has been found in isolated lakes such as Te Paki Dune Lake and Lake Morehurehu, indicating that dispersal could be through natural agents such as water birds. The majority of lakes with bladderwort are on the Aupouri peninsula.

Hornwort (*Ceratophyllum demersum*) is currently the worst submerged weed in New Zealand as it can grow from the water's edge to depths greater than 15 metres and can displace all submerged vegetation including other weed species. Hornwort is found in seven Northland lakes, most of which are on the Aupouri Peninsula.

Oxygen weed (*Egeria densa*) is a major threat to shallow eutrophic water bodies where it can grow over the entire water body, eventually collapsing and switching the lake from a macrophyte-dominated to an algal-dominated lake. Oxygen weed is found in 11 Northland lakes.

Lagarosiphon major is only found in two lakes on the Aupouri Peninsula and one lake on the Pouto Peninsula. *L. major* is of concern as it can successfully grow in oligotrophic waters and can tolerate wave action.

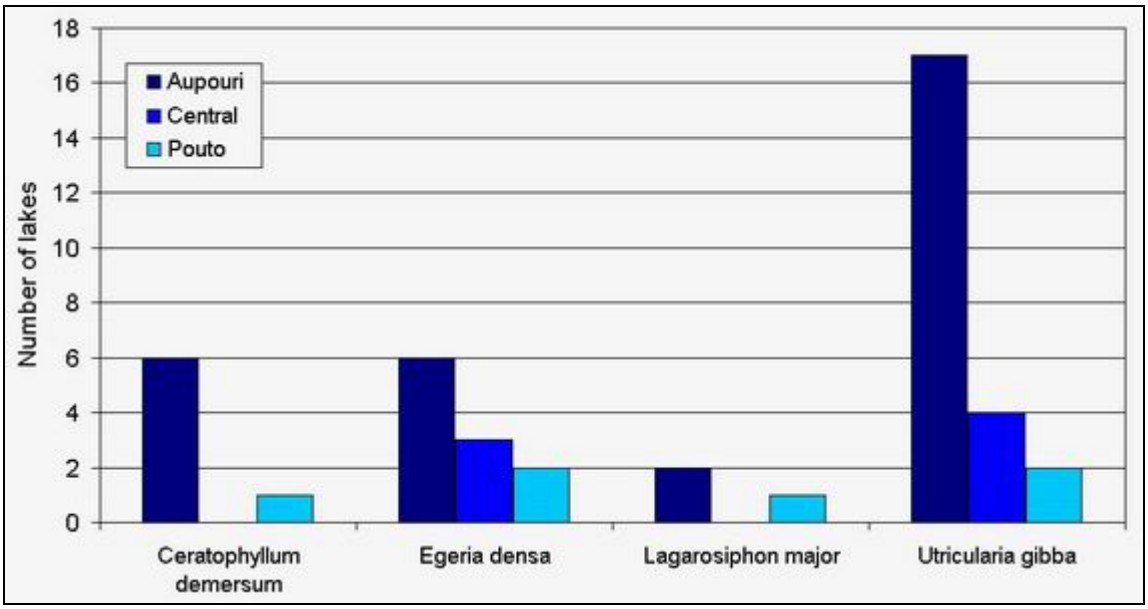

Figure 8: Number of lakes with four invasive weed species recorded in them in 2007.

Fish

There are 10 introduced fish species found in Northland lakes. Mosquito fish (*Gambusia affinis*) are by far the most widely distributed pest fish in Northland, being recorded in 17 of the 72 lakes surveyed. All other pest fish species have been recorded in one to five lakes.

There are 10 native fish species recorded in Northland lakes. Common bullies (*Gobiomorphus cotidianus*) are the most widely distributed native fish species, which have been observed in 39 Northland lakes. Short finned eels (*Anguilla australis*) are the second most widely distributed native fish, being recorded in 20 lakes.

The rare dwarf inanga (*Galaxias gracilis*) has been recorded in 11 lakes, including eight lakes on the Pouto Peninsula and the three Kai Iwi lakes. One dwarf inanga population from Lake Kai Iwi has become extinct, probably due to the introduction of pest fish, and numbers are declining in other lakes.

9.4 What is being done?

Policy documents

The Regional Policy Statement for Northland (NRC 2002) provides an overview of resource management issues in Northland, including those with regard to lake water quality and quantity, ecosystems and biodiversity. It contains objectives, policies and methods to achieve integrated management of Northland's environment.

The objectives of the Regional Policy Statement seek to maintain or enhance water quality of Northland lakes for the purposes of aquatic ecosystems, contact recreation, water supplies and cultural and aesthetic purposes and to protect and enhance indigenous ecosystems and biodiversity.

The Regional Water and Soil Plan (RWSP) for Northland (NRC 2007a) contains rules that prohibit the discharge of any sewage and animal effluent into the dune lakes as specified in the plan. Plan change 1 to the RWSP was made operative on 30 August 2007 and included changes to the rules for water takes, damming and diversions.

Lake Omapere Restoration and Management Project

The Lake Omapere Restoration and Management Project was a joint initiative between the Lake Omapere Trustees and the Northland Regional Council, funded by the Ministry for the Environment's Sustainable Management Fund. Other key stakeholders, including landowners, local iwi and hapu, Far North District Council, Department of Conservation, local schools and the local community, have also been involved in the project.

The project ran for three years with an overall aim to develop and implement a voluntary lake management strategy that will work towards improving the health of the lake and help establish the Lake Omapere Trustees in their role as Kaitiakitanga. It included developing the strategy as well as water quality and biodiversity monitoring, aquatic weed management and integrated catchment management.

As of 30 June 2007, 85% of the margins of Lake Omapere are fenced (NRC 2007b), with more fencing planned for the 2007/2008 year. There has been several successful planting days in the lake catchment over the last thee years, with over 15,000 plants being planted.

Planting day in 2006 at the edge of Lake Omapere.

Restoration and Management Strategy for Lake Omapere

The Lake Omapere Trustees and the Northland Regional Council have prepared a joint management strategy for Lake Omapere and its wider catchment. The Lake Omapere Trust and Northland Regional Council's Chairman formally signed the 'Restoration and Management Strategy for Lake Omapere' on 29 September 2006, at a ceremony held at the Parawhenua Marae near the lake.

The Council and Trustees will continue to work together with landowners, the community and other stakeholders to restore Lake Omapere and work towards the targets in the strategy.

For more information on the Lake Omapere Restoration and Management Project and Strategy refer to the following link on the council website:

http://www.nrc.govt.nz/Your-Council/Council-Projects/Lake-Omapere-Restoration-Project/

Monitoring

Resource consent monitoring

Major point source discharges to water and land require resource consent from the Northland Regional Council. Attached to the resource consent are conditions. These conditions may include provisions for effective waste treatment systems, management plans for the use of treatment systems, limits for the concentration of contaminants that are allowed to be discharged and monitoring programmes that assess the effect of the discharges on the environment.

State of the environment monitoring

In November 2005 the Northland Regional Council began monitoring 31 lakes as part of the Lake Water Quality Monitoring Network (LWQMN). Lakes in the network are monitored four times a year for a range of parameters including total and dissolved nutrients, chlorophyll α, suspended solids, water clarity, pH, temperature and dissolved oxygen. In addition to these 31 lakes, Lake Omapere is sampled at least every two months.

Lake conditional monitoring (LakeSPI) is carried out on all lakes in the LWQMN every one to five years. Weed surveillance is carried out on 11 lakes, the majority surveyed on an annual basis.

Reconnaissance surveys and water quality sampling is carried out on lakes not currently in the network to establish their ranking based on the presence of indigenous and exotic flora and fauna and water quality status. If a high ecological ranking is given to a lake and/or issues concerning the lake have been raised then the lake may be added to the LWQMN or a separate monitoring programme set up for the lake.

Other responses

Lake care groups carry out projects aimed at protecting lakes and wetlands in their area. The Bushlands Trust has started a number of restoration projects around lakes in the Kaitaia area such as planting around Lake Ngatu and Lake Heather.

The Northland Regional Council has an Environment Fund available to help people improve and protect Northland's natural environment. The fund provides up to 50% of the costs of projects protecting indigenous habitats by fencing out stock and replanting streamsides and lake margins with appropriate native plants.

9.5 Where to from here?

Monitoring

The Northland Regional Council will continue to monitor the water quality and vegetation of lakes in the network. Once there is three to four years of data for each lake we will be able to identify trends in water quality. This will allow us to recognise which lakes are improving, degrading or not changing at all. With this information we will be to able to focus on preventing lakes from degrading any further or look at options for improving water quality in lakes.

Weed management

The Northland Regional Council is currently looking at controlling and, where possible, eradicating aquatic weeds and pests in high value and/or high risk lakes. The council has started establishing aquatic weed control programmes in three Northland lakes using different control methods. These include two Aupouri lakes (Lakes Heather and Ngatu) and one on the Pouto Peninsula (Lake Swan). For more information refer to Case study 1.

Policy documents

Regional Water and Soil Plan changes

The council is currently reviewing rules in the RWSP pertaining to discharges and land disturbance. This review will lead to 'proposed plan change 2'. This will incorporate rules for stock exclusion from water bodies of significance, including selected lakes. The council intends to notify 'proposed plan change 2' in early 2008 for submissions.

Lake management

The council has started a review of the RWSP implementation. As part of this review it has been identified that the council is lacking a document which prioritises and identifies actions for the management of Northland's lakes. It is likely that this review will recommend the development of a Lake Management Strategy or similar document for Northland, which sets out action plans for all significant lakes in Northland.

9.6 What can you do to help?

You can help protect Northland's lakes by:

- Preventing the spread of aquatic weeds. Make sure your boat, trailer and anchor, drainage machinery, eel nets, diving or fishing gear are free of vegetation and are cleaned after use.

- Preventing the eutrophication of waterways. Fence off and plant out the riparian margins of waterways. Keep stock away from lake margins and do not use fertilisers near waterways.

- Report any incidents of pollution to the environmental hotline on **0800 504 639** and any biosecurity threats to the Regional Council on **0800 002 004**.

- Join in at a community planting day near you or start up an environmental care group in your area. For more information contact the Northland Regional Council.

9.7 Case study 1: Weeds in Lake Swan

Introduction

Lake Swan is 17.4 hectares with a maximum depth of 5.5m, situated near the bottom of the Pouto Peninsula. There is no public access to the lake. The lake has been fenced off to exclude stock and the majority of the lake margin is surrounded by a dense fringe of *Eleocharis sphacelate* and raupo (*Typha orientalis*). Water quality data collected from Lake Swan indicates a mesotrophic status (good water clarity, low nutrient and chlorophyll α concentrations).

The problem with this lake is that it is severely impacted by exotic weeds. Prior to the introduction of oxygen weed (*Egeria densa*) and hornwort (*Ceratophyllum demersum*), the lake was dominated by charophyte meadows and the tall-growing native pond weed *Potamogeton ochreatus*. In March 2005, NIWA resurveyed the lake and concluded that 70% of the lake is now covered by hornwort with the remainder covered by surface-reaching beds of oxygen weed.

Vegetation changes

E. densa (oxygen weed) was first recorded in the lake in 1992. In 2001 the oxygen weed had formed dense beds up to 2.5m tall and occupied most of the lake from a depth of 0.6m to 4.2m.

Hornwort was first discovered in 2005 and had already taken over most of the lake including areas previously occupied by *E. densa*. Hornwort can grow in water depths up to 10m, so could easily grow throughout the entire lake. Hornwort grows to an average height of 2.3m in Lake Swan. Both plants reach the surface in parts of the lake and form dense beds.

Water quality

Water quality monitoring has been carried out on five occasions, the first being in 1990. No change has been observed in water clarity, pH and chlorophyll α since 1990. However there has been a slight decrease in nutrient levels which is expected with increased macrophyte growth.

Stratification occurs during summer causing anoxia (deoxygenation) of the bottom water with an associated release of nutrients from the sediment. Water clarity, nutrient and chlorophyll α (algal biomass) data indicate a mesotrophic status.

The problem

Vegetation collapse is the greatest threat to Lake Swan at present. Overnight oxygen depletion is already likely to occur in the dense vegetation beds, which will eventually cause the plants to die. Water quality is expected to deteriorate if the lake flips from a macrophyte-dominated into an algal-dominated lake. This would probably deem the lake unusable for humans and stock as toxic algal blooms would be likely. This would also be visually unappealing.

Lake Swan is the only source of hornwort on the Pouto Peninsula and is only a few hundred metres away from Lake Humuhumu, which is one of the most pristine lakes in the area. Hornwort could easily be spread into Humuhumu and other lakes unless care is taken to prevent the spread.

The eradication of the hornwort and *E. densa* is needed to prevent the spread of New Zealand's worst submerged weed and to prevent water quality degradation in Lake Swan.

Solution

A Community Pest Control Area (CPCA) has been established for Lake Swan to eliminate both hornwort and *E. densa*. The CPCA programme has been developed to assist groups of land occupiers committed to protecting economic, biodiversity and/or cultural values of a defined area.

As part of this programme, monitoring will be undertaken to assess the effectiveness of the method chosen to control these two weed species. It will be the landowner's responsibility to monitor who is entering the lake and making sure they remove any weed from boats, nets and other equipment used in the lake.

After discussions with landowners, local Iwi and other interested parties, it was decided that grass carp would be used to eradicate hornwort and *E. densa*. Spraying the weeds with herbicide was an option that was rejected by landowners and iwi who did not want to use chemicals in the lake.

9.8 References

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9.9 Appendix A: Lake data

Table 2: Water quality and ecological data for the 31 lakes in the Lake Water Quality Monitoring Network and Lake Omapere including upper NRC sampling site, site location (New Zealand Transverse Mercator) trophic level index (TLI) score, trophic status, LakeSPI percentage score and ecological condition ranking.

Aupouri	Site	Easting	Northing	TLI	Status	LakeSPI%	Cond ranking
Carrot	107776	1617103	6124469	4.87	Eutrophic	60	High
Heather	101031	1617689	6121305	3.66	Mesotrophic	22	High
Morehurehu	101908	1599734	6166636	3.7	Mesotrophic	51	Outstanding
Ngakapua (North)	108242	1617483	6124853	3.93	Mesotrophic	49	Moderate-High
Ngakapua (South)	101913	1617570	6124668	4.13	Eutrophic	46	Moderate-High
Ngakeketa North	108620	1577785	6180516	4.39	Eutrophic	66	High
Ngatu	101032	1618124	6122985	3.82	Mesotrophic	65	Outstanding
Rotokawau	106734	1618821	6124849	4.14	Eutrophic	56	Moderate-High
Rotoroa	100425	1617883	6120400	3.87	Mesotrophic	25	High
Te Kahika	101909	1600106	6168707	2.77	Oligotrophic	NA	Outstanding
Te Paki	108230	1581037	6178905	3.73	Mesotrophic	97	Outstanding
Wahakari	100410	1593521	6165291	3.97	Mesotrophic	80	Outstanding
Waihopo	108232	1603957	6154018	4.04	Eutrophic	54	Outstanding
Waipara	108240	1586635	6172824	3.28	Mesotrophic	NA	Moderate
Waiparera	101033	1616351	6133188	4.47	Eutrophic	48	Moderate-High
West Coast Road	108707	1616741	6123403	5.95	Supertrophic	NA	High
Central & Karikari	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Omapere	106461	1673276	6088407	6.37	Hypertrophic	NA	Low
Waiporohita	101930	1631763	6137937	5.62	Supertrophic	93	Outstanding
Kai iwi	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Kai-iwi	100438	1659037	6036328	3.19	Mesotrophic	83	Outstanding
Taharoa	100442	1658316	6037090	2.36	Oligotrophic	82	Outstanding
Waikere	100448	1656853	6038145	2.97	Oligotrophic	79	Outstanding
Pouto	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Humuhumu	101379	1701253	5978969	3.66	Mesotrophic	81	Outstanding
Kahuparere	101367	1703965	5974380	4.23	Eutrophic	88	High
Kapoai	108634	1675020	6010692	6.09	Hypertrophic	NA	Low-Moderate
Kanono	101369	1702592	5975202	4.02	Eutrophic	76	Outstanding
Karaka	108347	1693273	5980792	4.73	Eutrophic	83	High
Mokeno	100593	1695144	5976511	3.96	Mesotrophic	83	Outstanding
Rotokawau	101373	1702973	5976737	3.31	Mesotrophic	41	High
Rototuna	101375	1693437	5987648	4.41	Eutrophic	76	High
Wainui	108346	1679349	6004457	4.9	Eutrophic	80	Moderate-High
Wairere	108641	1691585	5984453	5.4	Supertrophic	NA	Moderate-High
Whakaneke	108643	1695160	5974605	5.78	Supertrophic	NA	High

Table 3: Water quality and ecological data for all other lakes in Northland monitored in the last five years including upper NRC sampling site, site location (NZTM), estimated trophic level index (TLI) score, trophic status, LakeSPI percentage score and ecological condition ranking.

Aupouri	Site	Easting	Northing	TLI	Status	LakeSPI%	Cond ranking
Austria	NA	1584726	6174708	NA	NA	46	Moderate
Bulrush	101910	1599692	6159296	NA	NA	NA	Low
Forest HQ	101912	1617426	6125182	4.8	Eutrophic	NA	Low
Little gem by Ngatu	NA	1617747	6122596	NA	NA	57	Outstanding
Half Mile Lagoon	NA	1617390	6118790	NA	NA	NA	Low
Katavich	NA	1614995	6133225	NA	NA	NA	Low
Kihona	101907	1590973	6168112	4.55	Eutrophic	16	Low
Mini	105083	1617346	6118386	NA	NA	NA	Low
Morehurehu South	NA	1600485	6165737	NA	NA	57	Moderate-High
Ngakeketa South	100996	1579030	6180278	4.44	Eutrophic	17	Low
Ngatuwhetu	108231	1589438	6173746	4.1	Eutrophic	41	Low
Pretty	108241	1584432	6173153	3.46	Mesotrophic	95	Moderate
Salt	101911	1602278	6159460	5.4	Supertrophic	NA	Low
Te Arai wetland/pond	NA	1598022	6159812	NA	NA	NA	Moderate
Te Arai Lake	NA	1597154	6159761	NA	NA	NA	Low
Te Werahi Lagoon	NA	1573420	6184962	NA	NA	37	Low
Waimimiha North	101914	1615468	6110685	6.8	Hypertrophic	NA	Low
Waimimiha South	NA	1615561	6110795	NA	NA	NA	Low
Waitahora Lagoon	NA	1582837	6187464	NA	NA	NA	Outstanding
Waitahora lakes	NA	1583187	6187509	NA	NA	NA	Outstanding
Karikari	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Rotokawau East	100435	1629275	6141208	6.9	Hypertrophic	NA	Moderate
Rotokawau West	100432	1627975	6141304	6.52	Hypertrophic	NA	Moderate
Rotopokaka (Cola)	105413	1635006	6132588	4.82	Eutrophic	NA	Moderate
Central & Southern	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Jacks	108243	1684545	6083544	4.73	Eutrophic	50	Low
Mangawhai	NA	1742178	6004872	4.06	Eutrophic	NA	NA
Manuwai	101985	1678437	6107774	3.31	Mesotrophic	NA	Low
Ora	NA	1716200	6049022	NA	NA	NA	Low
Owhareiti	101989	1685502	6083555	4.97	Eutrophic	16	Low
Ruakaka	108786	1731493	6027263	6.49	Hypertrophic	NA	NA
Waingaro	101981	1679774	6097659	2.13	Oligotrophic	NA	Low
Waro	108784	1716828	6061273	2.69	Oligotrophic	50	Moderate-High
Kai iwi	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Freidrichs	NA	1668632	6022433	NA	NA	57	Low
McEnvoy	NA	1666781	6023612	NA	NA	NA	Low
Midgeley	108348	1664170	6028099	4.47	Eutrophic	66	Moderate-High
Shag	100442	1658316	6037090	NA	NA	NA	Low
Te Riu	100448	1656853	6038145	2.03	Oligotrophic	96	High
Waingata - Waipoua	108967	1642989	6053766	2.13	Oligotrophic	80	High
Pouto	**Site**	**Easting**	**Northing**	**TLI**	**Status**	**LakeSPI%**	**Cond ranking**
Grevilles Lagoon	NA	1674139	6011706	NA	NA	NA	Moderate
Parawanui	101416	1676596	6008803	6	Hypertrophic	NA	Low
Phoebes	NA	1696918	5981917	NA	NA	NA	Low
Roto-otuauru (Swan)	101377	1702363	5978672	3.9	Mesotrophic	21	Moderate
Waingata - Pouto	101371	1703387	5976524	5.02	Supertrophic	NA	Low