

Lake Brunton

Broad Scale Habitat/Macrophyte Mapping 2013



Prepared
for

Environment
Southland

August
2013

Cover Photo: Lake Brunton near mouth at eastern end.



Lake Brunton showing oioi (jointed wire rush) and flax margin in central lagoon area.

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by

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All photos by Wriggle except where noted otherwise.



LAKE BRUNTON - EXECUTIVE SUMMARY

This report summarises the 2013 broad scale habitat mapping for Lake Brunton, a small (75ha) coastal shallow intermittently closed/open lake/lagoon (ICOLL) in eastern Southland. It is one of several shallow lakes, lagoons and estuaries in Environment Southland's long-term coastal monitoring programme, and has been assessed previously in 2008 and 2009 (Robertson and Stevens 2008, 2009). The following sections summarise monitoring results, macrophyte condition, overall lagoon condition, and monitoring and management recommendations.

2013 MONITORING RESULTS

- Sediments were predominantly sands overlain by a 2-5cm layer of mud, and were relatively well oxygenated (3->10cm).
- Water clarity (secchi depth 1.1m) was low, indicating the lagoon was not in a clear water state (not in good condition).
- Nutrient data (limited to one occasion in 2012 when the lagoon was open to sea), and modelled CLUES catchment load estimates, indicated elevated nutrient concentrations entering the lagoon.
- Macrophyte cover was estimated at 8.3ha or 33% of the lagoon bed, but at a relatively low density (34% cover).
- Maximum depth of macrophyte cover (MCD) was 0.8m.
- Native macrophyte cover was 100% (no introduced macrophytes were observed) in both 2013 and in 2009. The dominant species in 2013 was *Ruppia polycarpa*, but *R. megacarpa* was dominant in 2009. Small areas of the native milfoil *Myriophyllum triphyllum* were present in both 2009 and 2013.
- An unidentified brown filamentous macroalgal layer (2mm thick over 30% of lagoon) was present at a low density on the sediment surface in 2013, and as epiphytic growth in many places. Present in 2009 at much greater densities (~1cm thick over 80% of the lagoon) and accompanied by black, anoxic, sulphide-rich surface sediments at many locations.
- Emergent saltmarsh cover was relatively extensive (9ha, 23% of the lagoon), with little change since 2008.
- The 200m terrestrial margin was extensively modified (38% pasture (including dairying) and 36% exotic duneland).

LAKE CONDITION AND ISSUES

The results of the 2008, 2009 and 2013 surveys of Lake Brunton identify several features that indicate that the lagoon is currently in an **early eutrophic or moderate-highly enriched state**. These include low *Ruppia* cover, variable slime algal cover, the variable presence of anoxic, sulphide-rich sediments, and low water clarity. Multiple shallow lake studies from overseas indicate that submerged macrophyte cover needs to be greater than approximately 50% to ensure a clear water state i.e. be in good condition. Given that Lake Brunton has only 33% cover (i.e. well below its full potential of >80% cover), and catchment nutrient input loads (based on preliminary model estimates) are elevated, the most likely cause of the observed eutrophic conditions is nutrient enrichment. If so, it is unlikely that Lake Brunton will shift back to a clear water state unless nutrient loads to the lake decrease. However, additional information is required to verify this situation. This includes nutrient and suspended sediment status of input waters and the lagoon, updated catchment model estimates (accounting for specific Southland factors), and a development/review of appropriate trophic state guidelines for Lake Brunton.

RECOMMENDED MONITORING AND MANAGEMENT

Maintenance of Lake Brunton in a *Ruppia*-dominated state is considered important if the lagoon is to maintain a relatively high ecological status. For effective ongoing management the current survey identified a need for regular targeted macrophyte monitoring, as well as intensive studies of lagoon and input water quality, as follows:

- Water Quality: TN, TP, water clarity, salinity, chlorophyll a, temperature, and dissolved oxygen near the middle of the lagoon (0.5m deep measurements when the lagoon water level is high) once annually for 3 years to establish a baseline, and subsequently every 5 years. In addition, monitor water quality of the main input stream (TN, TP, turbidity, conductivity) when flows are elevated following a rainfall event, and during baseflows (3 occasions) to provide an indication of current nutrient loads to the lagoon.
- Macrophyte Mapping: To assess the condition of macrophyte beds and sediment quality, undertake monitoring (every 5 years) of the following: aquatic macrophytes and nuisance macroalgae presence, location, % cover and life stage (include salinity, depth, and clarity at each site on fixed transects). Sediment quality - broad scale (depth to RPD layer, sediment type) and fine scale (grain size, TN, TP, and total organic carbon) at 3 representative sites.
- Monitor key indicators of catchment landuse, freshwater abstraction, mouth opening/closing, lagoon water level.

To maintain the lake's macrophyte cover at a level that ensures a clear water state with good water clarity, the following management actions, undertaken in a step-wise fashion, are also recommended.

- Develop appropriate nutrient and sediment load guidelines for the lagoon.
- Assess current nutrient and sediment loads, and reduce loads to meet lagoon guidelines (if they are exceeded).
- Maintain a natural lagoon opening regime, or fully assess the consequences of artificial openings.
- Ensure the lagoon is adequately flushed by maintaining or improving freshwater inflow volumes.
- Develop a plan to encourage the long-term survival of saltmarsh and terrestrial margin vegetation.
- Manage any invasive aquatic plants (should they occur).
- Plan to minimise the ecological impacts of predicted sea level rise.

1. INTRODUCTION

OBJECTIVES

The Southland region has two intermittently closed/open coastal lakes/lagoons (ICOLLS) that are relatively large, shallow, poorly flushed, and have developed catchments. Determining the condition of these shallow lagoons is important to Environment Southland (ES) in fulfilling its resource management role for the region. A recent broad scale study (Robertson and Stevens 2008) and synoptic survey (Robertson and Stevens 2009) identified Lake Brunton as having two key high value habitats that were vulnerable to degradation; i. the submerged aquatic plant community and ii. the surrounding saltmarsh and terrestrial margin vegetation. In early 2013, ES contracted Wriggle Coastal Management to undertake macrophyte monitoring of the lagoon to fulfil three main aims.

1. To remap the major habitat features, in particular the spatial distribution of the dominant sediment types, plant species, and water column characteristics.
2. To determine the general condition of the lagoon, particularly in relation to sedimentation and eutrophication, in order to determine the extent that the lagoon is currently impacted by catchment landuse activities.
3. To recommend appropriate long term, fine-scale monitoring programmes for the lagoon.

This approach follows a similar procedure to that used for the ES estuary and coastal lakes monitoring programmes, and is specifically designed to provide defensible, cost effective, monitoring of shallow water bodies. This report summarises the results of the Lake Brunton survey undertaken on 22 February 2013.

SETTING

Lake Brunton (25ha) and its associated wetland (50ha), is centred at Waipapa Beach in eastern Southland (Figure 1). The 15km² catchment is dominated by farmland (sheep, beef and dairying) and consequently drainage is expected to have elevated nutrient concentrations compared to its natural state. Freshwater inputs come predominately from three small streams, and the lagoon water has a characteristic brown humic stain and low pH. The lagoon is separated from the sea by a barrier beach which, when not closed, drains through an unmanaged opening to the sea. The lagoon is bordered by extensive areas of saltmarsh (jointed wire rush and flax), and its bed has a high value *Ruppia*-dominated submerged aquatic plant community. The 2009 survey characterised the lagoon as particularly sensitive to nutrient and sediment enrichment.



Figure 1. Location of the coastal lagoon, Lake Brunton, and its catchment (shown as red line).

1. Introduction (Continued)

BACKGROUND

Shallow coastal lagoons that are intermittently open/closed to the sea are defined as generally:

- having an average depth of less than three metres and therefore with closely coupled interactions between the sediment, water phase, and biological components;
- being able to support large aquatic plant life; and
- being unstratified - their shallow depth means the lake's water is stirred up regularly from wind and wave action.

The key threats to shallow ICOLLs are eutrophication, sedimentation, disease risk, habitat loss and, to a lesser extent, toxicity. Because excessive nutrient and fine sediment inputs are the major risk to Lake Brunton, a more comprehensive discussion on eutrophication and sediment processes in shallow coastal lagoons, and the methodologies used for their assessment, particularly in relation to macrophytes, are presented below.

1. Eutrophication

In shallow coastal lagoons (<3m deep), which are amongst the most productive ecosystems in the world (Barnes 1980), primary production is performed by two major groups; aquatic plant species and saltmarsh (McGlathery et al. 2001).

Aquatic Plant Species

Aquatic plants include submerged and emergent macrophytes, macroalgae, epiphytes and phytoplankton. The dominance of one of these groups of primary producers over others is often related to nutrient levels or sediment resuspension, but many factors appear to be involved (Duarte 1995, Taylor et al. 1995, Valiela et al. 1997). In general, aquatic and emergent macrophytes dominate under low-moderate nutrient loads, but as nutrients become excessive they stimulate the production and abundance of fast-growing algae (short-lived macroalgae, and phytoplankton), at the expense of rooted aquatic macrophytes. During this change there is a switch from a clear water to a turbid state. Whether this switch happens abruptly, when a threshold level of N and P is reached (Scheffer et al. 1993), or gradually over many years (James et al. 2005), is somewhat controversial, yet there is no debate that when a lagoon switches to a turbid state, the dense algae in the water shade out the submerged plants. If the rooted submerged plants die, the benefits that reduce the impacts of nutrients are no longer provided (e.g. they no longer stabilise sediments with their roots, support attached algae which take up nutrients from the water, or provide daytime cover for zooplankton which emerge at night to feed on suspended algae). This means that shallow lagoons without macrophytes are more prone to algal blooms, increased turbidity, and water quality deterioration (i.e. eutrophication) than those with macrophytes. They also require a greater nutrient load reduction to switch back to a clear macrophyte dominated state. Multiple shallow lake studies from overseas indicate that submerged macrophyte cover needs to be >50% to ensure a clear water state indicative of good conditions (Jeppesen et al. 1994, Kosten et al. 2009, Tatrai et al. 2009, Blindow et al. 2002). Consequently, there is now a strong emphasis on macrophyte abundance and diversity monitoring as a key tool for assessing the ecology and trophic status of shallow coastal lagoons.

Saltmarsh

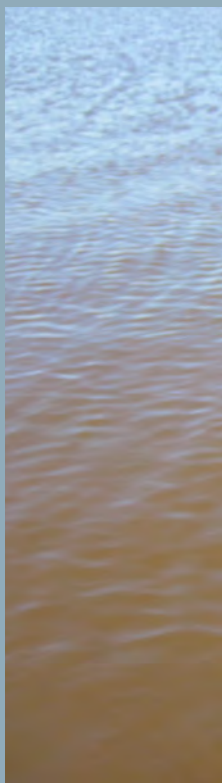
Recent studies indicate that nutrient enrichment can also be a driver of saltmarsh loss, implying that regular monitoring of saltmarsh cover is important for at-risk shallow coastal lagoons. The primary impacts of excessive nutrients (i.e. overfertilisation) on saltmarsh are as follows:

- Saltmarsh loss through weakened plants and plant collapse. Studies indicate that this can occur when moderately to highly eutrophic conditions are reached (Deegan et al. 2012).
- Reduced ability to remove nitrogen to the atmosphere (denitrification).

The reduced ability to remove nitrogen in eutrophic saltmarsh areas means more nitrogen is exported into the main body of the lagoon, fuelling increased growths of nuisance slime algae and phytoplankton.

2. Increased Muddiness (Sedimentation)

Because shallow lagoons/lakes are a sediment sink, their natural cycle is to slowly infill with fine muds and clays. In the last 150 years, with catchment clearance, wetland drainage, and land development for agriculture and settlements, many NZ shallow lakes have begun to infill rapidly. Today, average sedimentation rates in our shallow lakes are typically 10 times or more higher than before humans arrived. Excessive inputs of muds results in low water clarity and reduced oxygenation of bottom sediments, which negatively impact upon aquatic plant growth and benthic invertebrates.



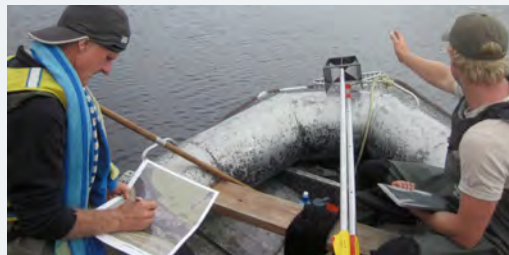
2. METHODS



The 2013 broad scale habitat survey of Lake Brunton was undertaken by three experienced scientists, when the lagoon was closed to the sea and submerged aquatic vegetation (SAV) exhibited maximum biomass. The methodology involved sampling georeferenced sites along transects which, through future repeat sampling (and replication), can be used as a rapid and robust technique to indicate change. The methodology used in 2013 followed that previously applied in 2009 (Robertson and Stevens 2009) and involved replicated sampling of 37 specific lake bed sites in conjunction with broad scale assessment over the wider lake area. The specific lake bed sites were located along 7 transects positioned in representative areas throughout the lake (Appendix 1).



- **Methods of Transport** - In order to rapidly survey a large portion of the lake, including shallow water (0-0.5m), near shore areas (0.5-1.5m), and deeper water (up to 5m depth), we used a combination of a dinghy and outboard motor, wading, canoes, and snorkelling.



- **Instrumentation** - The following combination of techniques and equipment was used to record depth, identify SAV species and heights, and sample bed substrate:

- **Depth Sounder.** A Garmin Fishfinder 90 dual-beam transducer, which provides excellent shallow-water performance, was used to record depths along and between the georeferenced transects. This unit also provided a visual indication of the presence of SAV in deeper water where the beds did not extend to, or were not visible from, the surface.
- **Underwater Videography.** A lightweight compact 420TVL CCD underwater camera with attached surface viewing monitor, 30m cable, built-in white LED lighting for illumination in darker waters (5m in pitch black), and an adjustable ballast enabling it to be tilted slightly up or down, was used to provide clear underwater video images, even during high turbidity and/or low light conditions (Secchi depths <0.5m), which were occasionally encountered. The equipment and configuration used is self contained and portable on a small vessel/canoe, while acquisition of high quality video images ensures sources of variation in acquiring and classifying SAV habitat are minimised.

For field deployment, the camera was lowered overboard on a cable or pole, angled slightly downwards, until the bed sediments and/or SAV came into focus on the viewer. Features present were recorded directly onto laminated aerial photos or as georeferenced notes on an iPad.



2. Methods (Continued)



- SAV/Substrate Sampler.** A custom built sediment sampler mounted on the end of a telescopic 4-5m pole was used to sample the benthic substrate (usually mud/sand and gravel). The sampler has a 20cm square flat bottom, two 20cm high enclosed sides and a supported open back. The front section, which digs into the sediments, is pointed. In addition, in shallow areas where sediment overflow from the sampler was not an issue, a garden hoe was used.
- Bathyscope.** A bathyscope is a cone-shaped device (in our case 48cm high) with an 11.5cm open-ended viewing hole at the top and a 31.0cm diameter perspex transparent cover at the bottom. This device allows non-destructive viewing of the lake bed and the associated macrophyte community. The bathyscope was lowered over the side of a boat to allow assessment of the macrophyte community composition at each site where it was used.



Percent Cover
0-5%



Percent Cover
5-10%



Percent Cover
10-20%



Percent Cover
20-50%



Percent Cover
50-80%



Percent Cover
80-100%

At sites along the transects, the boat, canoe or wading person was positioned, and the substrate sampler used to carefully dig and bring up a 5-6cm deep layer of surface sediment to the surface. Representative photographs were taken and the submerged aquatic vegetation (taxa, height, percentage cover, life stage), the sediment type, and the depth to any blackened sulphide rich layer (Redox Potential Discontinuity layer - RPD) recorded as summary information on field sheets or laminated aerial photos. These data were subsequently used to create validated ArcMap GIS shapefiles of key broad scale habitat features throughout the lake. Examples of percentage cover classes used are shown in the margin figure. Three replicate samples were collected at each site. Between transect sites, additional sampling using underwater video or direct observation was undertaken to delineate changes in plant densities, and boundaries between dominant plant species and substrate types. The water column at representative sites was also sampled for secchi disc clarity, dissolved oxygen, conductivity, temperature, and salinity (at surface and bottom), with summary measurements presented in Appendix 1. The approach was based on the broad scale habitat methods described in the National Estuary Monitoring Protocol (Robertson et al. 2002), and previously applied to coastal lakes (e.g. Robertson and Stevens 2013). Broad scale mapping summary data are presented in Section 3 and Appendix 1.



Low density macrophyte beds in muddy sediments of Lake Brunton at southern end, 2013.

3. RESULTS

Lake Brunton was sampled on 22 February 2013. Weather during sampling was sunny with a light westerly wind, and the lake was calm with no wave mixing. Detailed results and discussion are presented below, along with other relevant information.

WATER DEPTH AND MORPHOMETRY

The survey of lagoon water depth (see Appendix 1 for details on the path followed to collect depth and other information) and morphometry showed a 1.2km long, guitar-shaped (maximum width ~500m) lagoon with a maximum depth of 2.5m and the majority less than 1m deep (Figure 2). On 22 February 2013, the lagoon was closed to the sea and, according to the local landowner, the water level was approximately 1m below the maximum above which the lagoon mouth opens by bursting through the sand barrier between the lagoon and the sea.

The most extensive shallow areas were located at the western end of the lagoon. The deepest sections were located in the eastern arm of the lagoon near the outlet. In general, the lagoon was exposed to the prevailing southwesterly winds and had relatively high wind fetch, particularly towards the north in the main basin.

On earlier visits, the lagoon was at different levels. On 23 March 2008, the lagoon water level was 0.4m shallower, and large areas of the lagoon bed were exposed. On 23 February 2009, the lagoon water depth was ~0.75m deeper, with the majority in the 1-2m range.

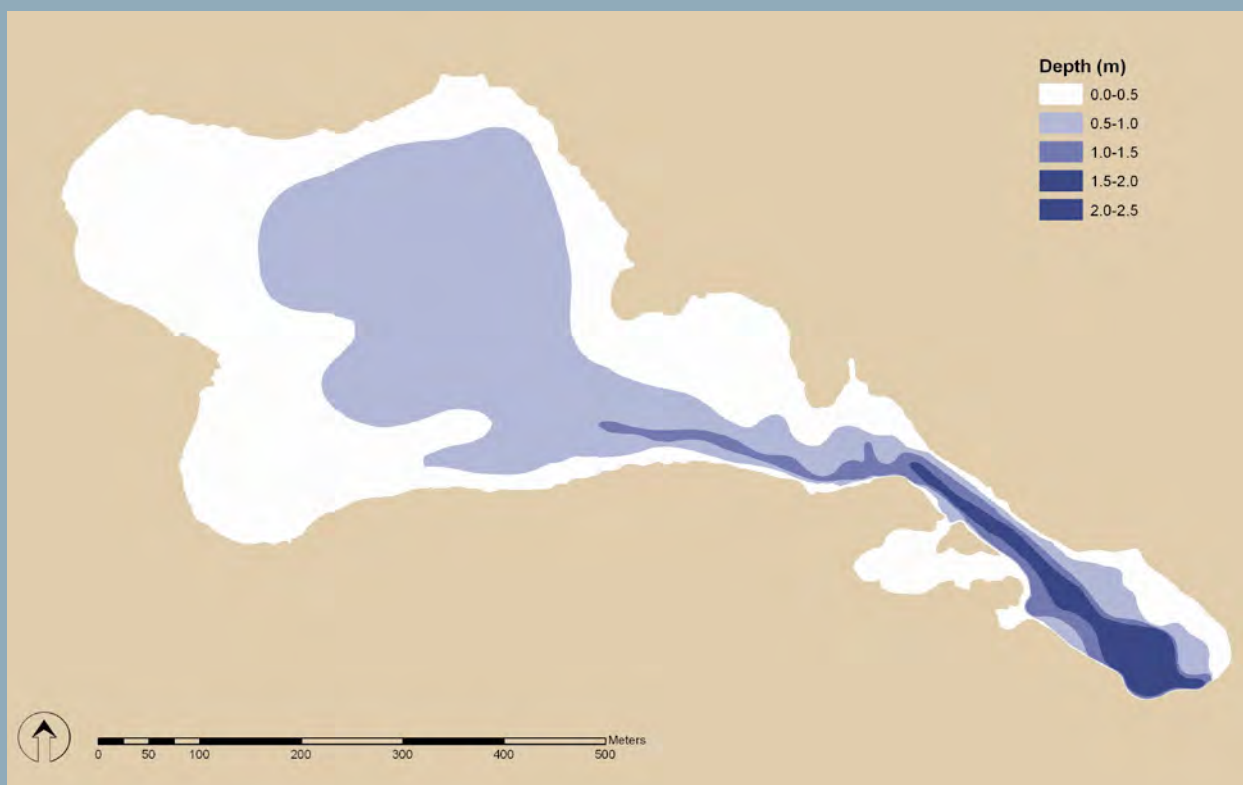


Figure 2. Lake Brunton, water depth, 22 February 2013.

WATER CLARITY

Secchi disc clarity was similar throughout the lagoon and was relatively low (~1.1m) when conditions were calm with no wave mixing. Under these conditions benthic (lake bottom) macrophyte growth is unlikely to be light limited in the shallower parts of the lagoon. However, clarity reduces when wind-waves disturb bottom sediments (e.g. 0.78-1.0m during windy conditions on 23 February 2009), and the amount of light reaching the lakebed also reduces as the lagoon water level increases. Consequently, the combined influence of low clarity and lagoon depth is expected to limit macrophyte growth throughout deeper parts of the lagoon much of the time.

3. Results (Continued)

Visibility of the RPD Layer

In estuaries and the ocean, the use of the depth of the Redox Potential Discontinuity (RPD) layer as an indicator of the extent of eutrophication is well understood as a recognisable division between oxidised (sub-oxic) and reduced chemical conditions in the sediment (Fenchel 1970, Lyle 1983, Santschi et al. 1990). The oxidised part appears as rust-brown, and the reduced layer below is generally grey or black. Monitoring results indicate that the RPD should be deeper than 2cm to allow the existence of a normal macrobenthic community (Grizzle and Penniman 1991, Tett et al. 2007).

SALINITY, TEMPERATURE AND DISSOLVED OXYGEN

Salinity measurements (4.6-6.1ppt) indicated that the lagoon was unstratified (little difference evident between the surface and bottom), with salinity similar throughout the lagoon. The salinities were similar to those measured in 2009 (3.8-4.5ppt). During low water levels, when the lagoon was open to the sea on 23 March 2008, salinity in the lagoon was 24ppt.

Water temperature varied from 17.4 to 18.6°C, which was considerably warmer than that measured at the same time of the year in 2009 (11.7 to 12.8°C).

Dissolved oxygen concentrations in the water column in 2013 were relatively high (92-110% saturation), and similar to those recorded in 2009 (92-102% saturation).

SUBSTRATE TYPE, REDOX STATUS

The substrate type on the bed of the lagoon was predominantly sands and gravels (Figure 3), with a significant mud and organic ooze component near the surface. The mud component was most evident in the sediments at the more sheltered southwestern end of the lagoon. At the eastern end, near the sea, the sediments were mainly clean sands. A thin layer of black, sulphide rich sediment was sometimes present near the surface under rotting organic detritus, particularly at the southwestern end.

An anoxic layer (RPD layer - see margin) was also present at most sites but was relatively deep at 3->10cm. In 2009, this layer was closer to the surface and more extensive across the lagoon (Robertson and Stevens 2009). Such RPD results indicate changing levels of sediment oxygenation, therefore variable conditions for submerged macrophyte and benthic invertebrates.

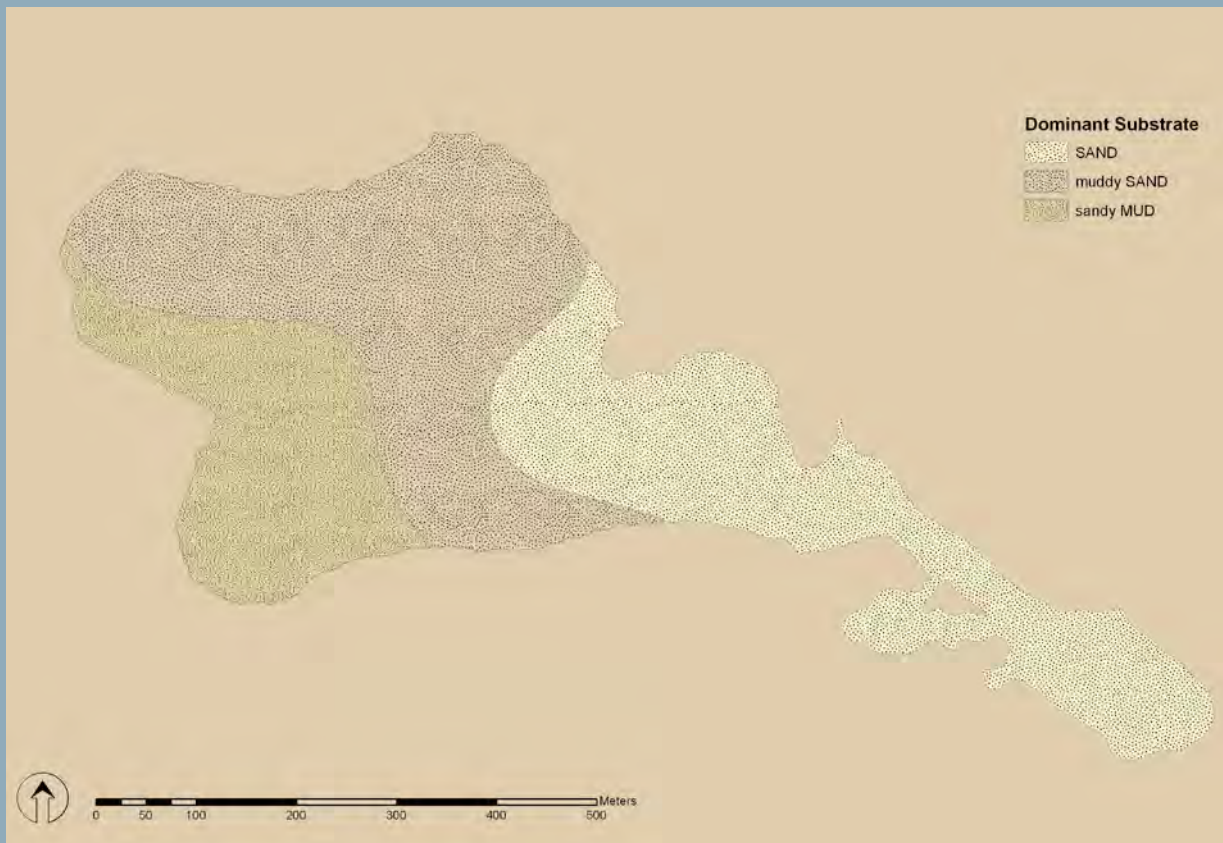


Figure 3. Lake Brunton, dominant substrate type, 22 February 2013.

3. Results (Continued)



Sandy sediments from the eastern end of Lake Brunton, February 2013.



Muddy sand sediments from middle section of Lake Brunton, February 2013.



Anoxic, sandy mud sediments from the western end of Lake Brunton, February 2013.



Anoxic, sandy mud sediments and *Ruppia polycarpa* from the western end of Lake Brunton, February 2013.

Table 1. Area of major aquatic vegetation classes in Lake Brunton, 22 February 2013.

Vegetation Class	Area (ha)	% of lake
Macrophyte	8.3	33
Unvegetated	17.0	67
Total	25.3	100

MACROPHYTE AND MACROALGAL COVER

The results of the broad scale survey of dominant macrophyte and macroalgal cover (Figure 4, Table 1) indicated the following (Appendix 1):

- **Macrophyte cover** was relatively low and estimated at 8.3ha or 33% of the lagoon bed in 2013, but at a relatively low density (34% cover). The height of the beds ranged from 5-20cm and most plants showed fruiting structures. In February 2009, the cover was 9.1ha spread over 36% of the bed and the density was 28%.
- Maximum depth of macrophyte cover (MCD) was 0.8m. In 2009, when the water level was much higher, the MCD was 1.6m.
- Native macrophyte cover was 100% in 2013 (no introduced macrophytes were observed) with the dominant species being the seagrass *Ruppia polycarpa*. In 2009, native cover was also 100% (again, no introduced macrophytes were observed), with *R. megacarpa* the dominant species. The macrophyte cover also included small areas of the native milfoil *Myriophyllum triphyllum* in both years.
- Also present at a low density on the sediment surface in 2013, and as epiphytic growth in many places, was an unidentified brown filamentous slime algal layer (2mm thick covering 30% of lagoon bed). In 2009 the same macroalga was present but at much greater densities (approx. 1cm thick over 80% of the lagoon) when it was also accompanied by black, anoxic, sulphide-rich surface sediments at many locations.

3. Results (Continued)



Rushland and dunes at the southwestern end of Lake Brunton, February 2013.



Exposed *Ruppia* beds in the southwestern section of Lake Brunton, April 2008 (Note: lagoon was open and tidal at the time).



Sample of submerged *Ruppia* beds in the western end of Lake Brunton, February 2013.



Slime algae and *Ruppia* beds in the southwestern end of Lake Brunton, Feb. 2009 (lagoon was at max. water level at that time).

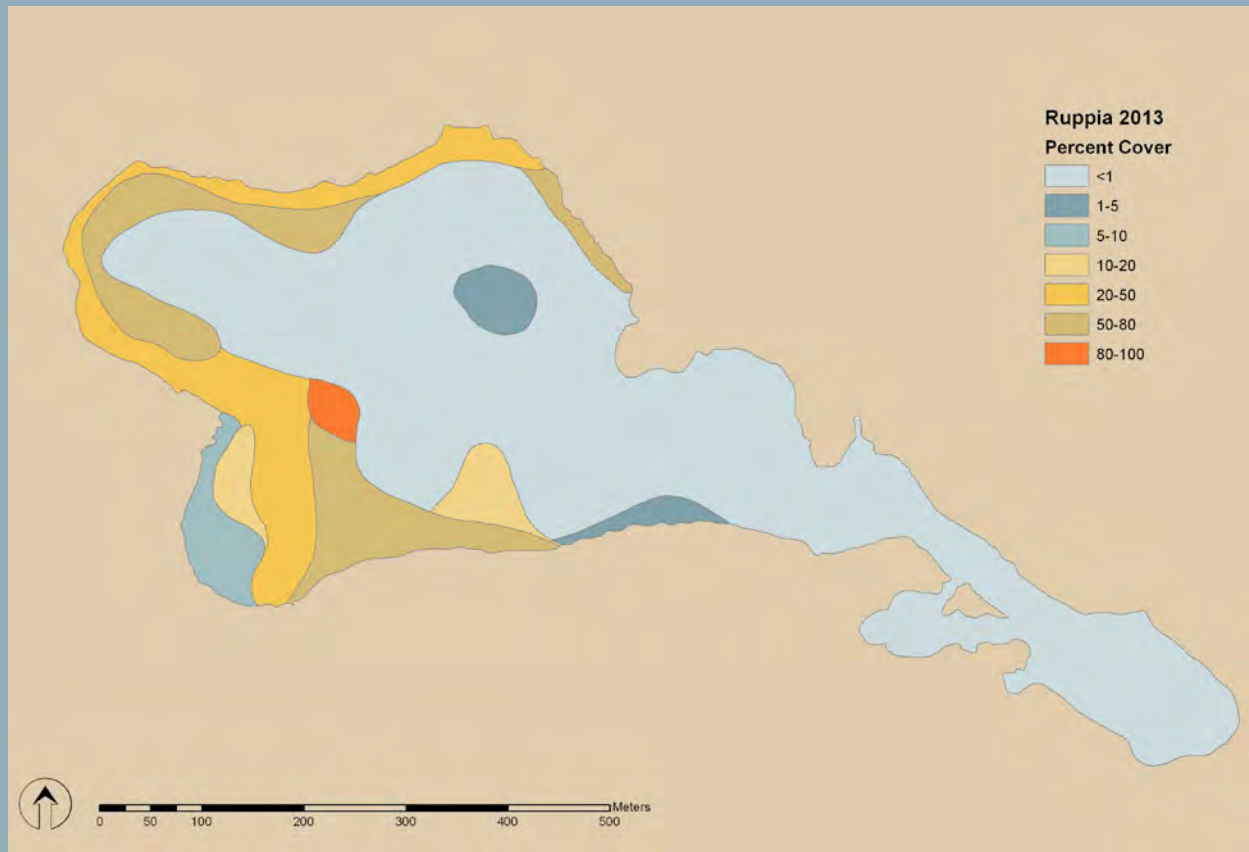


Figure 4. Lake Brunton, aquatic macrophyte percentage cover, 22 February 2013.

3. Results (Continued)

Table 2. Dominant plants recorded in Lake Brunton, 22 February 2013.

Taller Growing Native Macrophytes

These are the dominant visible species of macrophytes and they include two main genera *Ruppia polycarpa/megacarpa* and *Myriophyllum triphyllum*. These taxa often form a canopy above smaller turf species and charophytes, and are often dotted amongst them without seriously impacting on their density.



***Ruppia polycarpa* and *Ruppia megacarpa* (Horse's mane weed).**

Ruppia polycarpa is a native surface-flowering submerged aquatic annual or perennial; stems to 50cm long, with the longer stems formed in deeper water; vegetative buds (turions) can be formed in some ephemeral habitats. Grows in fresh to hypersaline coastal lakes, lagoons and estuaries and is relatively common in the 0-1.5m depth range (depending on water clarity), often in sandy sediments. Seed germination can occur at high salinities, (e.g. germination of *R. polycarpa* from Westenport Bay (Australia) begins in April when field salinities are 40ppt), but optimal germination under laboratory conditions is at 20°C in freshwater (Vollebergh and Congdon 1986, Ungar 1991).

Ruppia megacarpa is a native surface-flowering, large, robust perennial with long, much branched stems, thread-like long narrow leaves, and distinctive small flowers that are terminal on white stalks. Common in relatively shallow (~2m) permanent water (salinity range 5-46ppt), although seeds require salinities in the lower end of range to germinate. Grows slowly and matures later, producing fewer, larger seeds than *R. polycarpa*. Seeds germinate and form seedlings in spring, with flowering and fruiting occur in summer and autumn.

Many other poorly flushed, shallow lakes/lagoons in NZ previously supported *Ruppia* populations prior to excessive sedimentation and eutrophication, and the introduction of exotic macrophytes (e.g. Lake Waahi, Lake Ellesmere).

Lake Waahi (522ha and max. depth 5m) had a predominantly native macrophyte population including *Ruppia polycarpa*, which became dominated by exotic macrophytes prior to 1978, before the macrophyte populations crashed in 1978-79. This was attributed to low lake levels (due to low rainfall), high nutrient concentrations, and sediment input from mining (Dell 1988). Currently Lake Waahi is super-eutrophic, remains unvegetated, and is extremely turbid, which renders it undesirable for recreational activities.

Lake Ellesmere (20,000ha and average depth 1.5m) once had extensive macrophyte beds dominated by *Ruppia megacarpa* and *Potamogeton pectinatus* (Ward 2008). Loss of these beds has been attributed to a major storm in 1967, as well as excessive nitrogen loads and swan damage (Gerbeaux and Ward 1991). The lake is now super-eutrophic (mean TN 1.5-2mg/l, TP 0.2mg/l, chlorophyll a 80mg.m⁻³), highly turbid (Kelly and Jellyman 2007), and remains unvegetated. Studies indicate that the lake is light-limited for 51% of the year, phosphorus-limited for 12% of the year and nitrogen-limited for the remaining 37% of year (Hamilton 2005).

Waituna Lagoon in Southland (1,350ha and average depth 1m) has extensive beds of both *Ruppia* species. It also has extensive nuisance macroalgal cover, is close to being eutrophic (mean TN 0.6mg/l and TP 0.04mg/l, chlorophyll a 1-15mg.m⁻³), with low water clarity (secchi 0.5 to 0.8m) (Robertson and Stevens 2009).



***Myriophyllum triphyllum*.**

Myriophyllum triphyllum is a wide-spread native water milfoil species. Plants grow to 3m tall, have emergent and submerged leaves. Emergent stem apices (mid summer) often reddish, flowers male and female together. Emergent leaves 4-11mm long and 4mm wide. Submerged leaves pinately divided 1.5-3.0cm long. Patches in Lakes George, and Vincent.



3. Results (Continued)

Table 2 (continued). Dominant plants recorded in Lake Brunton, 22 February 2013.

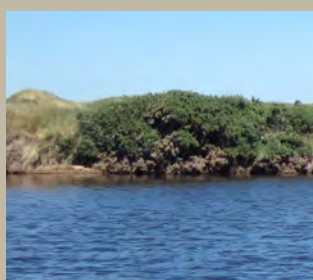
Emergent Shoreline Plants

These are the dominant visible species of emergent shoreline macrophytes and they include a variety of wetland species that tend to be tall-growing, erect and occupy the lagoon margin from just above the water line and can extend out into the water to a depth of around 1m.



***Apodasmia similis* - oi oi or jointed wire rush.**

Formerly *Leptocarpus similis*. A rush with dark-banded wire-like slightly zigzagging stems. An endemic coastal rush but is also found around peat bogs and hot springs. It flowers from October to December and bears fruit from December to March. It spreads from a creeping rhizome but is slow spreading, and is dioecious, having male and female flowers on separate plants. Sometimes used traditionally for outer thatching of houses, 'being by far the best of all the rushes and sedges for thatching, on account of its durability'.



***Ulex europaeus* - gorse.**

Growing to 2–3m tall, it is an evergreen shrub. The young stems are green, with the shoots and leaves modified into green spines. Flowers are yellow, and the fruit is a legume (pod). Seeds remain viable for 30 years. An extremely tough and hardy plant, it can live for about thirty years. It was introduced to New Zealand from Scotland as a type of hedge, but became a major blight to farmers as the NZ climate suited its growth better than its native habitat and many of its natural predators were absent. It fixes nitrogen into the soil. Interestingly, lectin extracted from seeds of this species binds to H-substance on human red blood cells. The vast majority of humans express H-substance, which is the basis for the ABO blood group system, but a few rare individuals ("Bombay phenotype") do not. A chemical isolated from *Ulex europaeus* is the standard method used to identify these individuals, for which it is remarkably specific.



***Ammophila* sp. - marram grass.**

These exotic grasses are found almost exclusively on the first line of coastal sand dunes; their extensive systems of creeping underground stems or rhizomes allow them to thrive under conditions of shifting sands and high winds. Marram grass and lupin were introduced to NZ for erosion control and to stop the spread of wind blown sand, with exotic forests or pasture often established on stabilised dunes. The dominance of marram (which is prolific and has tended to out-compete the native sand-binders spinifex and/or pingao) has caused dune instability problems. This has tended to result from over-stabilisation of the dune system, resulting in marram dunes that are generally taller, have a steeper front, and occupy more area than native dunes. Such dunes tend to lock up sand, limiting replenishment of sand to the beach and being susceptible to erosion of the dune front during storms. They also tend to contribute to the loss of biodiversity and natural character with blow-outs being common (Hilton 2006).



***Phormium tenax* - flax.**

An evergreen perennial plant native to New Zealand and Norfolk Island that is an important fibre plant and a popular ornamental plant. The plant grows as a clump of long, straplike leaves, up to two metres long, from which arises a much taller flowering shoot, with dramatic yellow or red flowers. The fibre has been widely used since the arrival of Māori to New Zealand, originally in Māori traditional textiles and also in rope and sail making after the arrival of Europeans up until at least WWII. It is an invasive species in some of the Pacific islands and in Australia.

3. Results (Continued)

Saltmarsh and Terrestrial Vegetation

The extent of 200m terrestrial margin vegetation, saltmarsh and water in Lake Brunton was mapped in 2008 (Robertson and Stevens 2008) and again in February 2013 (Figure 5). The results showed a high incidence of saltmarsh (9ha), a relatively modified terrestrial margin and a small intertidal area (Table 3). The distribution of terrestrial margin vegetation and saltmarsh was similar to that measured in 2008. On close inspection, the saltmarsh showed little sign of decay or loss around the lagoon margins.

Table 3. Dominant habitat (water and emergent plants) and 200m terrestrial margin vegetation, Lake Brunton, 22 February 2013.

Lake Brunton Habitat	Area (ha)	% of Estuary
Emergent Tussockland - dominated by flax mixed with gorse, wire rush, knobby clubrush and occasional natives.	5.1	13%
Emergent Saltmarsh - dominated by wire rush with flax.	9.1	23%
Water	25.3	64%
200m Terrestrial Margin	Area (ha)	% of margin
Duneland - marram grass with knobby clubrush and flax.	25.4	36%
Grassland - grazed pasture.	27.5	38%
Scrub/Forest - dominated by gorse.	12.7	18%
Tussockland - dominated by flax mixed with gorse, wire rush, knobby clubrush and occasional natives.	6.0	8%



Figure 5. Lake Brunton, 200m terrestrial margin cover, 22 February 2013.

3. Results (Continued)



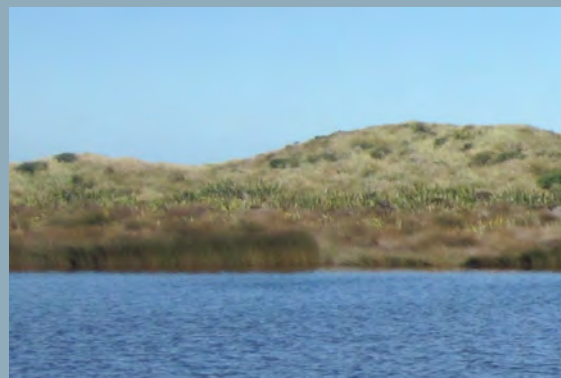
Jointed wire rush and flax, Lake Brunton February 2013.



Jointed wire rush and gorse, Lake Brunton February 2013.



Marram sand dunes, Lake Brunton February 2013.



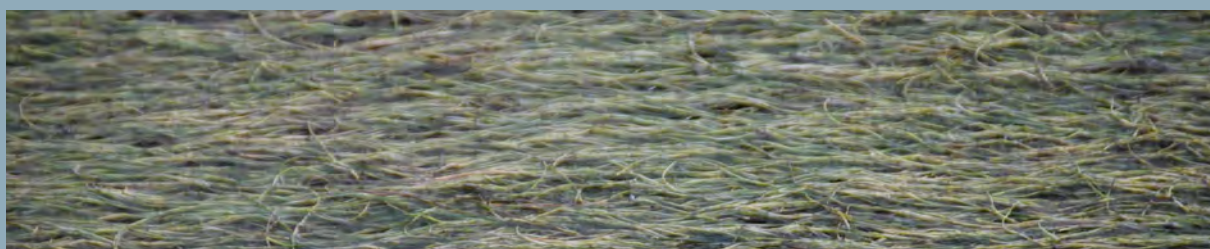
Saltmarsh and sandhills, Lake Brunton February 2013.



Low clarity waters, Lake Brunton February 2013.



Low clarity waters, Lake Brunton February 2009.



Exposed Ruppia beds, Lake Brunton February 2008.

4. DISCUSSION AND CONCLUSIONS

The 2008, 2009 and 2013 broad scale monitoring results provide a relatively comprehensive framework to assess both:

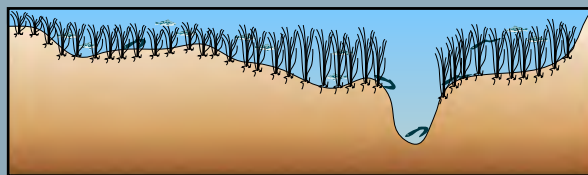
- the condition of the lagoon's high value habitats (i.e. aquatic macrophyte beds and saltmarsh), and
- the key threat to these habitats, i.e. its trophic status or degree of enrichment.

TROPHIC STATUS

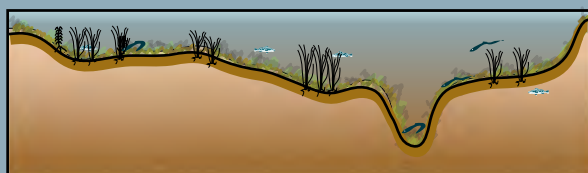
In terms of trophic status, shallow coastal lagoons (<3m mean depth) are in best condition when macrophytes cover the entire lake bed, unless physical factors limit their distribution in certain areas, for example wind uprooting, exposure to the atmosphere when the lagoon is open and water level drops, or unusual mouth opening regimes (e.g. long closed phases followed by long open phases). However, as they become more nutrient enriched and eutrophic, the macrophyte beds can become less dense, support increased nuisance macroalgal (slime algae) cover, or gaps may occur in the macrophyte cover either temporally (seasonally or between-years) or spatially (macrophyte-free areas). In addition, a shift towards more invasive introduced species can accompany this increase in bare areas, but only in freshwater dominated coastal lagoons (e.g. Waiau Lagoon). Under eutrophic conditions, macrophyte cover is low or absent (e.g. Lake Ellesmere), and nuisance macroalgae and phytoplankton often dominate. The susceptibility of coastal lagoons to eutrophication increases with residence time.

The results of the 2008, 2009 and 2013 surveys of Lake Brunton identify several features that indicate that the lagoon is currently in a **high enrichment** state or **early eutrophic state** (2nd profile in Figure 6), i.e. a low-moderate cover of *Ruppia* with a variable slime algal presence, and anoxic, sulphide rich sediments as follows:

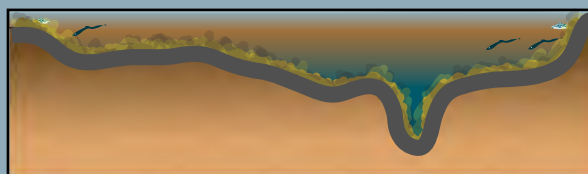
Oligotrophic/Mesotrophic - dense native macrophytes



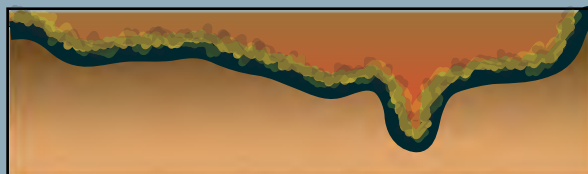
Early Eutrophic Macrophytes Declining, Macroalgae Increasing



Eutrophic Macroalgae/Algae Dominant



Hypertrophic Cyanobacteria/Algae Dominant



Increasing nutrients

Macrophyte Cover and Maximum Depth of Plant Colonisation (MCD).

In both 2009 and 2013 aquatic macrophyte cover occupied only 30-35% of the lagoon bed at a relatively low density, and the MCD was relatively shallow (0.8m in 2013 and 1.6m in 2009), despite the lagoon depth extending to 2.5-3m in the channel near the eastern end. The likely explanation for such limited plant growth can be attributed to the poor water clarity (range 0.78-1.1m), which restricts aquatic macrophyte growth to areas less than 1.5m deep (measured when the lagoon water level is at its highest). Because only 30-40% of the lagoon sits in this shallow depth range when the lagoon is full, macrophyte growth is therefore restricted to this limited area. Such low macrophyte cover and absence of clear water conditions, indicates that light limits growth over much of the lagoon bed.

Macroalgae and Sediment Oxygenation.

The presence of nuisance macroalgal cover was assessed in 2008, 2009 and 2013.

- In February 2013, nuisance macroalgal cover was relatively low.
- In February 2009, it was present at moderate levels, with the majority of the lagoon having a 1cm deep mat of slime algae over its surface and underlying black sulphide-rich sediments near the sediment surface.
- In February 2008, it was present at low levels.

Figure 6. Conceptual diagram of eutrophication stages in a coastal lake.

4. Discussion and Conclusions (Continued)

The reason for the differences between the years is most likely explained by gradual nutrient build-up in the water column after the lagoon closes, with maximum slime algal cover coinciding with high lagoon water levels. The source of the nutrients is expected to be runoff from the primarily grazed (dairy and sheep) catchment (see conclusions below for preliminary estimates of their magnitude). Maximum nutrient concentrations within the lagoon are likely to coincide with the period just prior to the lagoon opening, which theoretically occurs at approximately 6-12 day intervals (based on $0.49\text{m}^3\cdot\text{s}^{-1}$ mean inflow, and $250,000\text{m}^3$ lagoon volume between low and full levels). However, because the lagoon outlet overtops and leaks through the sand into the sea before the mouth fully opens, and often for months, the actual residence time is considerably longer. In general, the pattern at present is for the mouth to open around May each year and stay open all winter, then to close and open at intervals from 1 week to several months, depending on water inflows (pers. comm. Jules Blair, local farmer, Aug 2013). Once the lagoon opens, the high nutrient lagoon water is replaced and diluted by low nutrient seawater.

Compared to Waituna Lagoon, Lake Brunton is currently exhibiting fewer symptoms of eutrophication primarily because it regularly overtops, has a likely higher relative rate of leakage, and naturally opens more frequently - all facilitating the transfer of high nutrient waters from the lake to the sea.

Based on this, the low slime algal cover in 2013 and 2008 is likely due to the water level in the lagoon being either low (2008) or half-full (2013), and consequently nutrient levels not having increased to levels that stimulate mass nuisance macroalgal blooms. The extensive slime algal cover in 2009 occurred when the lagoon was full and therefore nutrient concentrations were likely to have been high. The low macrophyte cover, combined with elevated slime algal conditions, place the lagoon in an **early eutrophic or moderate-highly enriched state**. The combination of the ongoing low macrophyte cover and the periodic elevated slime algal cover when the lagoon is full, support the premise that the main stressor to the macrophyte community is likely to be excessive nutrients rather than suspended sediment. However, the low plant cover may also be partly attributable to the latter through strong wind driven turbulence in the northern section of the lagoon making plant growth difficult, particularly when the lagoon is open and water levels low.

Saltmarsh Condition

The other important component of the ecosystem to assess in relation to trophic status is saltmarsh. The 2013 survey results indicated a relatively healthy saltmarsh (apart from weed growth) with little sign of loss (particularly in the sensitive submerged areas) since the last survey in 2008. Because any loss of this ecosystem will likely compound problems for the lake, ES should, along with nutrient load reduction measures, encourage saltmarsh protection and enhancement to help maintain a healthy lake.

CONCLUSIONS

Overall, these findings of persistent low aquatic macrophyte cover, and the presence of nuisance slime algal blooms during high water levels, indicated that the capacity of the lagoon to assimilate and process incoming nutrients from the surrounding agricultural catchment without detrimental eutrophication effects is likely being exceeded. This is supported by the following information:

- Preliminary estimated catchment N and P inputs to Lake Brunton ($>120\text{mgN}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ and $>9\text{mgP}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ areal loading based on NIWA's CLUES model outputs and FENZ model outputs - Schallenberg and Kelly 2012) greatly exceed the recommended guidelines of $\sim 20\text{mgN}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ and $2\text{mgP}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ for ensuring a *Ruppia* dominated/low slime algae community in long residence times shallow coastal lagoons (Scanes 2011).
- The preliminary estimates of the N and P loads to Lake Brunton exceed the current areal nitrogen loading estimates of two already eutrophic South Island coastal lagoons, Waituna Lagoon and Lake Ellesmere (50 and $44\text{mgN}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ respectively - Schallenberg et al. 2010), indicating that if the preliminary estimates are correct for Brunton, then load reductions would be required to return the lagoon to a more stable, *Ruppia*-dominated state.
- Total nitrogen (TN) and total phosphorus (TP) concentrations in the water column were measured just after the lagoon had opened in March 2012 (Schallenberg and Kelly 2012). At such times, the concentrations of TN and TP would be expected to be relatively low, given that the lagoon is being flushed with clean low-nutrient seawater, unless lagoon concentrations were elevated prior to opening. The elevated post-opening 2012 results (595ugN/l and 27ugP/l) confirm the latter situation as the most likely (i.e. the lagoon has high concentrations of TN and TP when the lagoon is full).

4. Discussion and Conclusions (Continued)

Clearly, the next step is to verify the actual nutrient loads and to develop appropriate input load guidelines for Lake Brunton (noting that this lagoon is likely to be less sensitive to nutrient loads than either Waituna or Ellesmere, given its shorter residence time). The additional information required to achieve this is summarised as follows.

- Collect monitoring data to identify the current nutrient and suspended sediment concentrations of both the input waters (during floods and baseflows) and within the lagoon (when the lagoon is full).
- Update the CLUES model nutrient and sediment load estimates (accounting for specific Southland factors) for the Brunton catchment, and verify these loads with monitoring data.
- Develop appropriate nutrient and sediment load guidelines for Lake Brunton. This should be supported by a review of relevant trophic state guidelines for coastal lagoons with similar hydrology to Lake Brunton, particularly opening regimes and depth, given the fact that the response to nitrogen loading of plant growth in coastal lagoons varies with residence time, such that short residence time ICOLLs are less sensitive to eutrophication than longer residence time lagoons.

Once this data is collected and the load guidelines identified, then the necessary information will be available to decide on appropriate management of the lagoon towards a less eutrophic condition.

5. MONITORING

Maintenance of Lake Brunton in a *Ruppia*-dominated state is considered important if the lagoon is to retain a relatively high ecological status. The current survey identified a need for regular targeted macrophyte monitoring, as well as intensive studies of lagoon and input water quality, for effective ongoing management of this lagoon as follows:

Water Quality. To assess trophic status, and the likelihood of further degradation from macrophyte to macroalgal dominance, undertake monitoring for nutrients, water clarity, salinity, chlorophyll a, temperature, and dissolved oxygen near the middle of the lagoon (0.5m deep measurements when the lagoon water level is high) once annually for 3 years to establish a baseline, and subsequently every 5 years. In addition, monitor water quality of the main input stream (TN, TP, turbidity, conductivity) when flows are elevated following a rainfall event, and during baseflows (3 occasions) to provide an indication of current nutrient loads to the lagoon.

Macrophyte Mapping. To assess the condition of macrophyte beds and sediment quality, undertake monitoring (every 5 years) of the following:

- Map aquatic macrophytes and nuisance macroalgae presence, location, % cover and life stage on fixed transects (include salinity, depth, and clarity at each site).
- Sediment quality - broad scale (depth to RPD layer, sediment type) and fine scale (grain size, total nitrogen, total phosphorus and total organic carbon) at 3 representative sites.

Catchment Landuse, Freshwater Abstractions, Mouth Openings/Constrictions.

To assess the potential for increasing nutrients and sediment entering the lagoon, and the potential for reduced flushing, monitor the following:

- intensive catchment landuse,
- freshwater abstractions,
- mouth opening/closing times over 1 year period (possibly using a salinity logger),
- water level.

Because of the high susceptibility of the lagoon to eutrophication and sedimentation, any changes in the key stressors should trigger an evaluation of likely impact.

6. MANAGEMENT

To maintain the lakes macrophyte cover at a level that ensures a clear water state with good water clarity, the following management actions, undertaken in a step-wise fashion, are recommended:

- **Develop Nutrient and Sediment Input Guidelines.** Undertake studies to develop appropriate nutrient and sediment input guidelines for the lagoon, taking residence time into account.
- **Nutrient and Sediment Management Plan for Catchment.** Assess current nutrient and sediment loads and develop plans to reduce input loads to meet guidelines (if they are exceeded).
- **Maintain Natural Lagoon Opening Regime.** Many coastal lagoons in NZ and Australia are artificially opened from time to time, usually to avoid flooding of adjacent lands. However, a recent assessment of such lagoons (Haines et al. 2006), recommended against artificially opening a lagoon at a level lower than the natural breakout range without a thorough environmental risk assessment as this may lead to more frequent openings, increased shoaling at the entrance, drying out, terrestrialisation of fringing wetlands, and adverse changes to macrophyte and benthic communities.
- **Ensure Adequate Freshwater Input Flushing Flows.** Ensure the lagoon is well-flushed by maintaining or improving existing freshwater inflow volumes.
- **Saltmarsh and Terrestrial Margin Management Plan.** Because of the importance of the current saltmarsh and natural vegetated terrestrial margin to ecological values of the lagoon, it is recommended that a plan be developed to encourage its long-term survival.
- **Manage any invasive aquatic plants** - should they occur.
- **Plan to Minimise Ecological Impacts of Sea Level Rise.** Develop a plan to minimise the loss of ecosystem services of Lake Brunton that are vulnerable to climate change effects, particularly sea level rise. A preliminary requirement is a detailed vulnerability assessment.

7. ACKNOWLEDGEMENTS

This survey and report has been undertaken with help from Nick Ward (Coastal Scientist, Environment Southland). Many thanks to Jules Blair who allowed access to the lake, and provided background information on lake levels.

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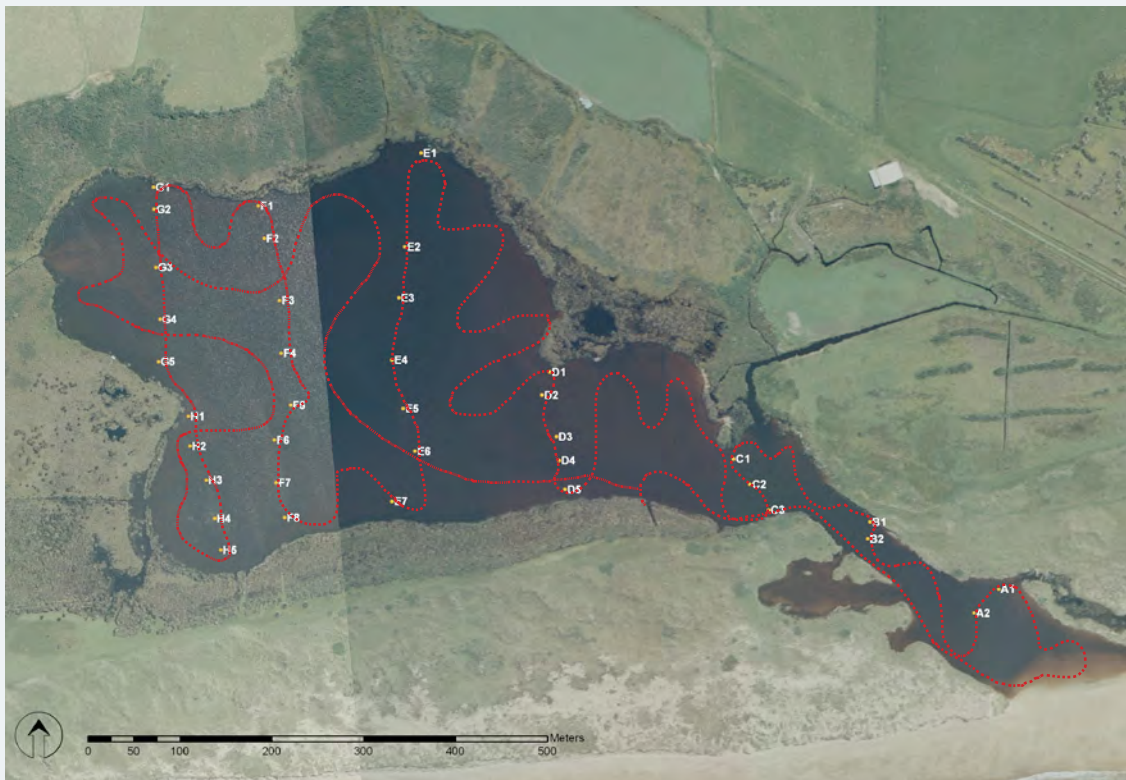
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APPENDIX 1

Aquatic Vegetation, and Site Details Lake Brunton, 22 February 2013

Map of Lake Brunton, with transects and site locations sampled on 22 February 2013.



Appendix 1 (Continued)

LAKE BRUNTON, 22 February 2013

Site	Depth (m)	Secchi (m)	Temp (deg C)	Salinity (ppt)	DO (%sat)	NZTM East	NZTM North	Sed Type	RPD (cm)
A1	0.4	bed	18.3	5.2	89.5	1285894.1	4825044.9	clean SAND	1
A2	1.8	1.1	17.1	5.6	99.5	1285867.1	4825018.9	clean SAND	>5
B1	0.5	bed	18.7	5.1	92.1	1285753.9	4825118.3	clean SAND	>5
B2	1.5	1.1	17.6	5.7	98.4	1285751.1	4825099.7	2cm mud over clean SAND	Surface anoxia
C1	0.4	bed	17.6	5.8	102.1	1285605.3	4825187.0	clean SAND	3
C2	0.6	bed	17.3	5.8	97.8	1285623.0	4825159.1	clean SAND	1
C3	1.5	1.1	17.5	5.8	96.5	1285643.4	4825131.3	clean SAND	>5
D1	0.5	bed	17.1	5.9	97.6	1285404.8	4825281.7	clean SAND	3
D2	0.5	bed	17.5	4.6	102.2	1285396.4	4825256.6	clean SAND	3
D3	0.6	bed	16.6	6	98.8	1285412.2	4825211.1	clean SAND	3
D4	1	bed	16.9	5.9	96.9	1285415.0	4825185.1	muddy SAND	1
D5	0.4	bed	16.9	5.9	97.5	1285421.5	4825153.6	muddy SAND	1
E1	0.5	bed	17.6	5.9	113	1285264.6	4825520.3	muddy SAND	1
E2	0.8	bed	17.4	6.1	110.1	1285247.0	4825418.1	muddy SAND	3
E3	0.8	bed	17.2	6.1	101.6	1285240.5	4825362.4	muddy SAND	1
E4	0.5	bed	17.5	5.5	106.7	1285233.0	4825294.7	muddy SAND	2
E5	0.5	bed	17.8	6	110.4	1285245.1	4825241.8	muddy SAND	3
E6	0.5	bed	18	5.8	108.9	1285258.1	4825195.3	muddy SAND	3
E7	0.5	bed	18.3	5.7	110.5	1285233.0	4825140.6	muddy SAND	1
F1	0.4	bed	17.8	5.9	107	1285087.3	4825462.7	muddy SAND	3
F2	0.5	bed	17.9	6	109.9	1285093.8	4825427.4	muddy SAND	3
F3	0.9	bed	17.5	6.1	103.1	1285110.5	4825359.7	muddy SAND	3
F4	0.8	bed	17.4	6.2	101.1	1285112.3	4825302.1	sandy MUD	3
F5	0.6	bed	17.6	6.1	110.5	1285122.6	4825245.5	sandy MUD	3
F6	0.6	bed	17.6	5.8	113	1285104.9	4825207.4	sandy MUD	1
F7	0.6	bed	17.9	5.9	114	1285106.8	4825161.0	sandy MUD	3
F8	0.6	bed	17.8	5.8	118.6	1285116.1	4825122.9	sandy MUD	3
G1	0.4	bed	18.7	5.7	105	1284973.1	4825483.1	muddy SAND	3
G2	0.5	bed	18.8	5.6	107.6	1284974.0	4825459.0	muddy SAND	2
G3	0.4	bed	18.1	6.1	103.1	1284975.9	4825395.9	muddy SAND	2
G4	0.5	bed	18.2	6	103.3	1284980.5	4825339.2	sandy MUD	1
G5	0.6	bed	18.4	5.9	110	1284978.6	4825292.8	sandy MUD	1
H1	0.5	bed	18.7	5.8	108.3	1285011.1	4825233.4	sandy MUD	1
H2	0.5	bed	18.7	5.8	108.3	1285013.0	4825200.9	sandy MUD	1
H3	0.5	bed	18.7	5.8	108.3	1285030.6	4825163.8	sandy MUD	1
H4	0.5	bed	18.7	5.8	108.3	1285039.9	4825122.0	sandy MUD	1
H5	0.5	bed	18.7	5.8	108.3	1285046.4	4825087.6	sandy MUD	1

Appendix 1 (Continued)

LAKE BRUNTON, 22 February 2013

Site	Macrophyte	Height (cm)	% cover	Vegetative State	Site	Macroalgae	Height	% cover
A1					A1			
A2					A2			
B1					B1			
B2					B2			
C1					C1			
C2					C2			
C3					C3			
D1					D1			
D2					D2			
D3					D3			
D4					D4			
D5					D5			
E1	<i>Ruppia polycarpa</i>	10	20-50	v (vegetative)	E1	Unknown	2cm	100
E2					E2			
E3	<i>Ruppia polycarpa</i>	5	1-5	v	E3	Unknown	2cm	100
E4					E4			
E5					E5			
E6	<i>Ruppia polycarpa</i>	10	10-20	v	E6	Unknown	2cm	100
E7	<i>Ruppia polycarpa</i>	15	50-80	v	E7	Unknown	2cm	100
F1	<i>Ruppia polycarpa</i> / <i>Myriophyllum triphyllum</i>	15 25	20-50 1-5%	v	F1	Unknown	2cm	100
F2	<i>Ruppia polycarpa</i>	15	50-80	f (fruiting)	F2	Unknown	2cm	100
F3					F3			
F4					F4			
F5	<i>Ruppia polycarpa</i>	15	80-100	f	F5	Unknown	2cm	100
F6	<i>Ruppia polycarpa</i>	20	50-80	f	F6	Unknown	2cm	100
F7	<i>Ruppia polycarpa</i>	20	50-80	f	F7	Unknown	2cm	100
F8	<i>Ruppia polycarpa</i>	20	50-80	f	F8	Unknown	2cm	100
G1	<i>Ruppia polycarpa</i>	20	20-50	f	G1	Unknown	2cm	100
G2	<i>Ruppia polycarpa</i>	15	50-80	f	G2	Unknown	2cm	100
G3					G3			
G4	<i>Ruppia polycarpa</i>	10	50-80	f	G4	Unknown	2cm	100
G5	<i>Ruppia polycarpa</i>	10	20-50	f	G5	Unknown	2cm	100
H1	<i>Ruppia polycarpa</i>	10	5-10	f	H1	Unknown	2cm	100
H2	<i>Ruppia polycarpa</i>	10	10-20	f	H2	Unknown	2cm	100
H3	<i>Ruppia polycarpa</i>	10	10-20	f	H3	Unknown	2cm	100
H4	<i>Ruppia polycarpa</i>	10	5-10	f	H4	Unknown	2cm	100
H5	<i>Ruppia polycarpa</i>	10	20-50	f	H5	Unknown	2cm	100