



Te Waihora/Lake Ellesmere State of the Lake 2013

Edited by: Kenneth F. D. Hughey, Kirsty A. Johnston, Adrienne J. Lomax, Kenneth J. W. Taylor



Acknowledgements

Te Waihora/Lake Ellesmere State of the Lake and Future Monitoring 2013 represents the collective effort of many people and organisations – partners, sponsors and contributors alike.

Partners

Partners have contributed data, knowledge and expertise, and have helped with planning and preparing this report and the fourth Living Lake symposium. We would like to thank: Waihora Ellesmere Trust, Environment Canterbury, Te Rūnanga o Ngāi Tahu, Department of Conservation, Christchurch City Council, Selwyn District Council, Fish & Game NZ (North Canterbury), and Lincoln University.



Gold Sponsors

The following organisations have sponsored this report and the symposium. We would like to thank: Fonterra, Synlait Ltd



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The following organisation was a Silver Sponsor for the symposium. We would like to thank: DairyNZ

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The following organisations were Bronze Sponsors for the symposium. We would like to thank: Central Plains Water Ltd, Ngāi Tahu Property, Te Whāriki

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We suggest this publication be referenced as: Hughey, K.F.D., Johnston, K.A., Lomax, A.J., and Taylor K.J.W. (eds). 2013.

Te Waihora/Lake Ellesmere: State of the Lake 2013. Technical Report No.1, Waihora Ellesmere Trust, Christchurch.

ISBN 978-0-473-26750-6 (hard) ISBN 978-0-473-26751-3 (web)

This report has been prepared as a downloadable resource and is available from the WET website: www.wet.org.nz. Many sections in this report are based on a more detailed report which can also be found on the WET website, along with additional links to supporting information.

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In addition to providing content and assistance with developing the ideas behind this report, we must acknowledge Environment Canterbury for the design, layout and printing, in particular, Amanda Sinclair and Glenda Duffell.

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7. Peter Langlands (lake flies),
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8. Environment Canterbury (eel fishing),
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9. Fish & Game NZ (boys with fish, duck shooters),
Peter Langlands (photographer, kayakers),
Little River Rail Trail Trust (rail trail)
10. Andy Spanton (Te Waihora, swan eggs),
Ngai Tahu (tuna)
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Preface

Te Waihora/Lake Ellesmere is a special place and valued by many people. Many are concerned about the apparent decline in the health, recreational and cultural worth, and biodiversity of the lake in recent decades. A great deal of work is currently underway by many organisations and people to restore and improve the ecosystem health of the lake and its environs. It is important to regularly track the progress being made.

This report from Waihora Ellesmere Trust (WET) is an independent publication, bringing together data and recommendations from many agencies and individuals to report on the state of the lake and its environs. Since the first Te Waihora/Lake Ellesmere State of the Lake report in 2008, the aim has been to identify a small set of indicators and to report on these regularly. This is the first report using indicators.

Many of the indicators are part of established state of the environment reporting programmes. By bringing the indicator data together to report on the lake, we are providing an overview of Te Waihora/Lake Ellesmere in 2013. The report's purpose is to explain clearly and simply what we currently know about the lake – it is, in essence, a 'health report card' for Te Waihora/Lake Ellesmere including what influences the lake's health. Each section includes recommendations for future monitoring. We will use these recommendations to review and refine the indicator set for future reporting.

We hope in publishing this report to strengthen links between science and management, hence the symposium title: 'measure to manage'. We have certainly learned a lot in the process of compiling this report, building on many people's (and organisations) state of the lake monitoring efforts. Good science informs good management.

Hamish Rennie
Chair, Waihora Ellesmere Trust

Feedback on the report

Waihora Ellesmere Trust would like to hear your feedback on this report. What is missing, what do you want to know more about? What data exists that we have overlooked? If you have any comments please send them to manager@wet.org.nz.

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Section 1

Introduction

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead authors: Kenneth F. D. Hughey, Kirsty A. Johnston, Adrienne J. Lomax

The importance of Te Waihora/Lake Ellesmere

Te Waihora/Lake Ellesmere is one of New Zealand's most important wetland systems. The lake, New Zealand's fifth largest by area, is a brackish, shallow lagoon with an average depth of 1.4 metres. The lake bed covers around 20,000 hectares. The lake's catchment drains 276,000 hectares, and reaches from the foothills of the Southern Alps, to the Rakaia River, the hills of Banks Peninsula and the plains in between. The Waimakariri River has discharged to the sea several times through this area, possibly as recently as 5 – 600 years ago. Over many millennia, the area that is currently lake bed has switched back and forth between a lake and an estuary.

Since the second half of the 19th century, the lake has been situated in a predominantly agricultural catchment. The soils around Te Waihora/Lake Ellesmere are extremely fertile and from the 1880s the level of the lake was reduced and the wetlands surrounding the lake were drained and reclaimed for agriculture. The lake level has been managed since by cutting channels through the Kaitorete Spit – a gravel barrier that separates the lake from the sea.

To Ngāi Tahu, as Kaitiaki, Te Waihora represents a major mahinga kai and an important source of mana. Te Waihora is a descriptive name, meaning spreading out waters. Under the Ngāi Tahu Claims Settlement Act 1998, ownership of the crown-owned lake bed was returned to Te Rūnanga o Ngāi Tahu.

Te Waihora/Lake Ellesmere is an area of cultural, natural, historic, recreational and commercial importance to many people. The outstanding values of the lake are recognised in a National Water Conservation Order as: habitat for wildlife, indigenous wetland vegetation and fish; and as being of significance in accordance with tikanga Māori in respect of Ngāi Tahu history, mahinga kai and customary fisheries. Internationally Te Waihora/Lake Ellesmere is significant for its birdlife abundance and diversity.

Different people hold different values for the lake and its environs. This brings challenges for the lake system and its resilience as an ecosystem, and for managing the important values people hold.

What is this report about?

This report presents a 'health report card' for Te Waihora/Lake Ellesmere as it is in 2013, and information about the area surrounding the lake, including what influences the lake's health.

It is widely acknowledged that water quality, both in the lake and the surrounding tributaries, has declined over past decades due to increasing

inflows of nutrients and sediment. A turning point in the health of the lake occurred in 1968 with the 'Wahine' storm which resulted in the loss of the lake weed beds which had created sheltered areas around the lake margins. This event helped cause the lake to 'flip', changing the ecology of the lake and further impacting on water quality and appearance.

In 2005 Judge Smith, in an Environment Court case, talked about the concerns over water quality in the lake. The media reinterpreted this as declaring the lake 'technically dead', which is very far from the truth given the lake's productivity and the range of species that make it their home.

In 2007, Waihora Ellesmere Trust held the first of the 'Living Lake' symposia at Lincoln University – an opportunity to set the record straight and look at the state of the lake and catchment and its management. A 'State of the Lake' report was published following the first symposium. A 'Living Lake' symposium has been held every two years since and this report, prepared for the 2013 symposium, provides an update to the 2008 report.

This report is for anyone with an interest in the lake – people who work and play in the area, decision makers and managers, industry and interest groups, and the wider community. The intention is, for organisations involved, to collaborate, improve where necessary, and repeat the health report card every two years, identifying trends and reporting on the many Te Waihora/Lake Ellesmere restoration initiatives underway.

Why do we need this report?

This report aims to show how the lake is changing, raising awareness of lake management issues and what is being done in response, including whether or not restoration actions are working. Importantly, we are aiming to strengthen links between science, monitoring and management.

How has this report been compiled?

Topics – Nine topics have been included in the report as sections based on topics identified, and reported on, in Te Waihora/Lake Ellesmere State of the Lake and Future Management, 2008.

Outcomes – There are many plans and policies (both statutory and non-statutory) which guide the management of Te Waihora/Lake Ellesmere. Outcomes have been included for each topic to summarise these. First we asked "how will we know when we have achieved success?" Then we expressed an outcome relative to plan and policy goals.

Indicators – indicators have been selected to enable regular reporting on progress towards achieving outcomes. We acknowledge some need further refinement.

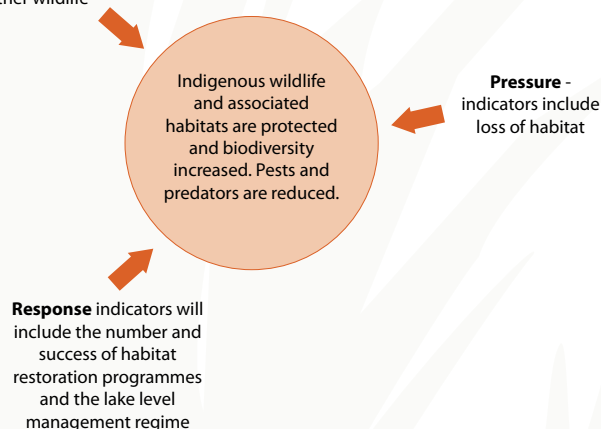


Topic	How will we know when we have achieved success? - main themes from a variety of planning documents
- Governance and management	The role of Ngāi Tahu and kaitiakitanga is recognised in governance of the lake and catchment; there is integrated management of land and water use, with all activities operating at good practice or better, and the wider community included in decision making.
- Economy	Sustainable water use supports economic development and lake/water related tourism opportunities increase.
- Land use and land cover	Land use and development is integrated with water management; natural and cultural values are respected; all land use activities operate at good practice or better; communities are viable and growing.
- Water quantity and water quality	Water quantity: Ecosystem and cultural health is restored and safeguarded; over allocation is reduced; water users have reliable water supplies, including for customary use, and recreational activities. Water quality: Water quality is improved to sustain cultural values; indigenous and wildlife species are supported; drinking water is safe and water quality suitable for recreation.
- Vegetation	Significant indigenous vegetation of the lake margin and tributaries streams is protected and restored, including wetland restoration and planting of riparian margins; pests are controlled.
- Wildlife	Indigenous wildlife and associated habitats are protected and biodiversity increased. Pests and predators are reduced.
- Fish	Native fish populations and associated habitats are protected and restored.
- Recreation	Compatible recreation needs are provided for, including good access, water quality, and habitat for wildlife, including for sports fisheries.
- Cultural health	Customary rights and use are recognised and mahinga kai species abundance and diversity is restored to a level to enable customary use. Note: For the purpose of this report, the selection of indicators is specifically linked to the objectives for Te Waihora articulated in the Mahaanui Iwi Management Plan 2013.

Framework - State of Environment Reporting takes a variety of forms, many of which are built around variations of the OECD's Pressure-State-Response framework. We have adapted this framework and will report on the state for each topic, and also consider the pressures (and, as appropriate, driving forces) and the range of responses in place. For state, pressure, and response we have identified indicators and, where possible, how those are being measured and any apparent trends over time.

Indicators are simply recognised as time-bound measures of change that are relevant to the topic being considered and which relate to desired outcomes. Indicators should be specific, measureable, attainable, relevant, time-bound and, if possible, already being measured. For this report we are including the relevant national and regional indicators already in use. Our focus is the lake, so the indicators selected relate to impacts on the lake or, in some cases, to the people using the lake.

State - abundance and distribution of wetland birds and other wildlife



To illustrate with a wildlife example, an agreed outcome is to protect indigenous wildlife and associated habitats.

Consistent with this desired outcome, an indicator of state is abundance and distribution of wetland birds (one species we have focused on is wrybill, which is a national indicator species). The measure of this will be data collected by surveying bird populations. Pressure indicators include loss of habitat, which can be measured by area of different habitat types. The response indicators will include the number and success of habitat restoration programmes and the lake level management regime.

In many instances the state indicators for one topic will be linked to the pressure and response indicators for another. For example, the topic of vegetation includes, as a state indicator, area of different habitat types. The loss of preferred habitats is a pressure indicator for wildlife.

Individual authors, with expertise in the different topics, have produced the report cards, integrated here into one report to give an overview of the current state of the lake and its environs and, where possible, trends in selected indicators. Each report card has been reviewed.

Each report card draws on a more detailed report or set of reports, some of which have been produced in conjunction with the report card and others which are already available elsewhere. These more detailed sources are all listed on the Waihora Ellesmere Trust website (www.wet.org.nz).

Recommendations are made in relation to the indicators – are we measuring the right things? Where are the gaps? What information is needed for good management? Leading up to the next symposium in 2015 the indicators will be reviewed and we will continue to report on the progress being achieved towards the desired outcomes.



Section 2

Governance and management

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead author: Karen Banwell, Environment Canterbury

How will we know when we have achieved success?

The role of Ngāi Tahu and kaitiakitanga is recognised in governance of the lake and catchment; there is integrated management of land and water use, with all activities operating at good practice or better, and the wider community included in decision making.



Tā Mark Solomon, Kaiwhakahaere, Te Rūnanga o Ngāi Tahu; Terrianna Smith, Chair, Te Waihora Management Board; Hon Amy Adams, Minister for the Environment; Dame Margaret Bazley, Chair of Commissioners, Environment Canterbury



looking along Kaiterete spit towards Taumutu

Context

The importance of Te Waihora/Lake Ellesmere is recognised in a National Water Conservation Order, which lists the lake's outstanding features as wildlife habitat, habitat for indigenous wetland vegetation and fish, and significance in relation to tikanga Māori in respect of Ngāi Tahu history, mahinga kai and customary fisheries. All regional policy statements, regional plans and district plans must be consistent with the provisions of the Water Conservation Order.

A significant amount of lake margin land, approximately 35%, is administered by the Department of Conservation (DOC) and, under the Ngāi Tahu Claims Settlement Act 1998, ownership of the non-DOC administered crown-owned lake bed was returned to Te Rūnanga o Ngāi Tahu. All of these lands are managed under the Te Waihora Joint Management Plan prepared by Te Rūnanga o Ngāi Tahu and the Department of Conservation.

The catchment for the lake is large and activities throughout the catchment may impact on the lake and its tributaries. Many organisations play an important role in the governance and management of Te Waihora and its catchment. These include organisations with a statutory role (namely, Environment Canterbury, Selwyn District Council, Christchurch City Council, Department of Conservation, Ministry for Primary Industries, Fish & Game NZ, and Te Rūnanga o Ngāi Tahu), non-statutory organisations, and a range of interest groups whose views are taken into consideration. A diagrammatic explanation of the key parties involved in the governance and management of the lake and catchment is available on the WET website.

Ngāi Tahu and Environment Canterbury and the Co-Governance arrangement for Te Waihora

Ngāi Tahu as tangata whenua have special status within Canterbury with respect to Environment Canterbury's resource management activities. The Resource Management Act (1991) (RMA) gives regional councils specific obligations for Kaitiakitanga, the principles of the Treaty of Waitangi, the relationship between Māori and their culture and their traditions with their ancestral lands, sites, wāhi tapu and other taonga. Ngāi Tahu are not just another interest group.

As well as the RMA, Environment Canterbury has obligations under the Local Government Act (2002) (LGA) and specifically the Canterbury Water Management Strategy (CWMS). Through these, Environment Canterbury has committed to work with Ngāi Tahu to improve relations and work together better across all areas. The way this is done falls under the umbrella of the partnership joint work programme - Tuia. The governance group, Te Rōpū Tuia is made up of the chairs of the 10 Ngāi Tahu Papatipu Rūnanga and Environment Canterbury Commissioners.

In addition to Tuia and in also giving effect to specific targets in the Canterbury Water Management Strategy, the Te Waihora Co-governance Agreement was agreed between Te Waihora Management Board (representing the tribal and Papatipu Rūnanga interests of Ngāi Tahu) and Environment Canterbury Commissioners. This is focused on how to achieve the rehabilitation and restoration of Te Waihora/Lake Ellesmere. Te Waihora is a tribal taonga, an important source of mana and a major source of mahinga kai for Ngāi Tahu and those who came before them. These values are recognised in the Ngāi Tahu Claims Settlement Act 1998 (NTCSA), the Te Waihora Joint Management Plan and more latterly in the 2011 amendment to the National Water Conservation (Te Waihora/Lake Ellesmere) Order 1990 (WCO). Establishing a co-governance agreement for the active management of Te Waihora is a specific goal contained within the CWMS.

This Co-Governance Agreement establishes a dedicated framework for the active management of Te Waihora and its catchment. Te Waihora Co-governance concerns a range of decision-making that directly relates to Te Waihora and its management and includes the joint oversight of Whakaora Te Waihora, co-drafting of statutory plans for the lake and catchment and the review of regional and Selwyn-Waihora Zone Implementation Programmes, as well as the appointment of hearing commissioners. Whakaora Te Waihora is the shared restoration programme between Environment Canterbury, Ngāi Tahu and the Te Waihora Management Board and the Ministry for the Environment.

Other key organisations

Many other organisations play an important role in managing Te Waihora and its catchment. The Selwyn District Council and Christchurch City Council play a pivotal role in the management of the physical resources of the lake and catchment. All parties are working closely with these councils to ensure the special relationship is recognised and provided for appropriately under the new arrangements.

The Department of Conservation has specific responsibilities for Te Waihora. In addition, to their responsibilities to promote the conservation of natural resources under the Conservation Act 1987, DOC has functions under the NTCS Act to prepare and administer the Joint Management Plan. This statutory plan was completed in 2005. As noted above, DOC is also responsible for managing several reserve areas around the lake.

There is also provision for discussions with key stakeholders and community groups on the part they will play in the long term management of Te Waihora.

Organisation	What they do	Some relevant management instruments
Te Rūnanga o Ngāi Tahu Te Waihora Management Board	<ul style="list-style-type: none"> Owner of the lake bed Aboriginal/customary rights and interests Joint holder lake opening consent Manage commercial fishing activities on lakebed Represent Papatipu Rūnanga Joint Management Plan implementation Whakaora Te Waihora Joint Plan implementation Statutory Advisor to Fish & Game Councils Advocacy 	Whakaora Te Waihora (WTW) Co-governance agreement Mahaanui Iwi Management Plan 2013 (IMP) Lake opening consent Te Waihora Joint Management Plan WTW Plan
Environment Canterbury	<ul style="list-style-type: none"> Joint holder lake opening consent Manage drainage & flood control schemes Administer reserves and land management Implement regional pest management strategy Resource consents and compliance monitoring Monitoring and investigations Biodiversity enhancement work Regulation of navigation Whakaora Te Waihora Joint Plan implementation 	WTW Co-governance agreement Lake opening consent Flood Protection & Drainage Bylaw WTW Plan Land & Water Regional Plan Monitoring and response protocol for cyanobacteria
Department of Conservation	<ul style="list-style-type: none"> Joint Management Plan implementation Land management Species management – Wildlife Act Administration of the whitebaiting regulations Conservation advocacy 	Canterbury Conservation Management Strategy Te Waihora Joint Management Plan
Selwyn District Council	<ul style="list-style-type: none"> Land management / stormwater Manage drainage schemes Administer reserves Land use resource consents and compliance monitoring Biodiversity enhancement work 	District Plan Monitoring and response protocol for cyanobacteria
Christchurch City Council	<ul style="list-style-type: none"> Land management / stormwater Administer reserves and land management Land use resource consents and compliance monitoring Biodiversity enhancement work 	City Plan Monitoring and response protocol for cyanobacteria
Fish and Game North Canterbury	<ul style="list-style-type: none"> Hunting and shooting access and licences Administer Maimai Agreement with TRoNT & DoC Manage reserve Conservation advocacy Trout fishery management and monitoring 	Te Waihora Joint Management Plan, Maimai Agreement
Community and Public Health, Canterbury District Health Board	<ul style="list-style-type: none"> Water warnings – drinking and recreation 	Monitoring and response protocol for cyanobacteria National Environmental Standard for Sources of Human Drinking Water
Ministry of Primary Industries	<ul style="list-style-type: none"> Customary fisheries and associated regulations Administer Quota Management System 	
Universities & Crown Research Institutes	<ul style="list-style-type: none"> Research to inform policy and management decisions (relevant research is also carried out by Ministry for Primary Industries, DOC, Environment Canterbury and others). 	

More information

Links to key documents and other relevant information are available from the WET website.

For background, context and information about other values associated with Te Waihora Ellesmere please see the other sections of the 2013 State of the Lake Report www.wet.org.nz/projects/2013-state-of-the-lake/



Section 3

Economy

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead author: Ross Cullen, Lincoln University

How will we know when we have achieved success?

Sustainable water use supports economic development and lake/water related tourism opportunities increase.

Context

The Te Waihora/Lake Ellesmere catchment lies mainly in Selwyn District. The District population and economy are growing faster than in any other New Zealand district. There is significant change occurring in the mix of enterprises present as dairy farming and milk processing expand. Employment growth in Selwyn District was the strongest in New Zealand in 2012 at 9.5%, approximately 1200 new jobs. Availability of water for irrigation impacts pastoral production levels. The Central Plains Water scheme will increase the area that can be irrigated from 2015 onwards. There is significant daily out and in migration as Selwyn residents commute to work in Christchurch and tertiary students, and employees commute to study or work in Selwyn District.

A small set of economic indicators has been identified. These can be used to report on at regular intervals, to describe the current economic state of the catchment, to identify trends, and to discuss pressures and responses in a general sense. While most of the Te Waihora/Lake Ellesmere catchment is within Selwyn District, small areas to the east do lie within Christchurch City. This analysis considers only the Selwyn component. Selwyn District is a recognised statistical region. Some time series data are available as economic activity indicators.

Sustainable development is an overarching goal of the Council on behalf of residents in the Te Waihora/Lake Ellesmere catchment. Income is an important contributor to human well being, but other factors also contribute to well being including quality of the nearby physical environment. Degrading parts of the environment may lower short-term production costs but eventually reduce resident's well-being. An economy that is on track to sustainable development will enable citizens in the relevant region to have non-declining levels of welfare over time.

Data sources, availability and state

A limited number of indicators of economic activity and drivers of economic activity in Selwyn District are readily available from Statistics New Zealand, Infometrics, DairyNZ and other sources. The first nine indicators in the table below provide a range of measures to track economic activity levels in Selwyn district. They include a comprehensive activity measure (GDP); input measures (employment, business units, number of cows); demand indicators (new residential consents, average house price); a measure of inactivity (number of working age beneficiaries); and a measure of public sector activity (SDC total operating expenditure). Data are expressed as percentage change over previous year.

Water is a critical input to production and consumption in the district. Area irrigated and water use is likely to increase in the next few years as supply is augmented by completion of the Central Plains Water scheme. Tracking water use would allow calculation of ratios including: GDP/water use and total employment/water use. Change in these ratios over time will indicate if there is any evidence of decoupling.

Three indicators are included that are more tightly centred on Te Waihora/Lake Ellesmere. The first two capture commercial activity near the lake that contributes to income and well-being for nearby residents. The final indicator is an estimate of the amount of recreation near or at the lake. Regular updates for the final four measures in the table should be completed biennially to help track sustainable development in the catchment.

Selwyn census 2013

Kelvin Coe, Selwyn District Mayor

“Selwyn is well placed to absorb the growth that we are currently experiencing”.

Selwyn was a participant in the Greater Christchurch Urban Development Strategy in 2007 along with Waimakariri and Christchurch City in planning for growth through to 2041 but unlike them Selwyn's infrastructure and residentially zoned land remained intact following the earthquake - no 'red zones' - so the planning for growth is already in place.

Kelvin Coe acknowledges that growth comes at a cost. “Upgrades to the roading network, stormwater systems to filter pollutants, improved recreational facilities and a new waste water treatment and disposal system at Rolleston to allow for the sustainable discharge of treated sewerage to land have been needed. There is enough land set aside to cater for 80,000 people equivalents in this scheme”.

Recent census data, shown in figures 3.1 and 3.2, illustrate the significant changes in Selwyn's population.

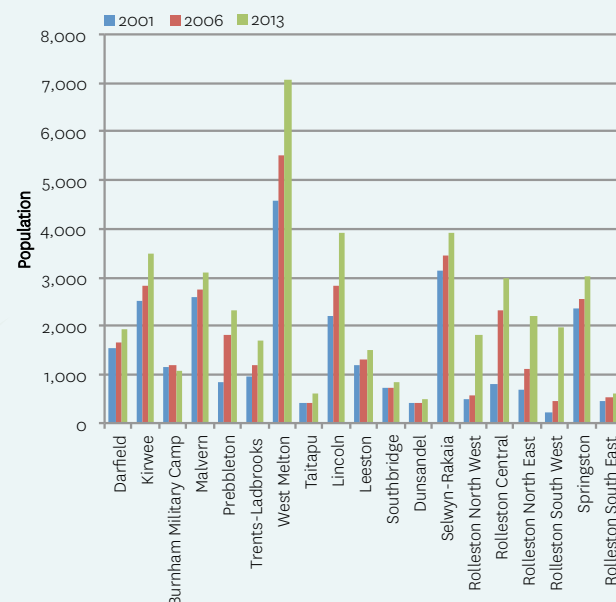


Figure 3.1 Selwyn township growth 2001–2013.

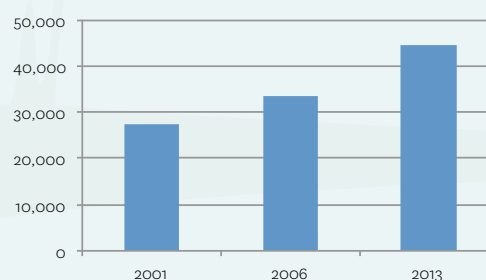


Figure 3.2 Change in the Selwyn District's population 2001–2013.

Economic Indicator (and date data is available from)	Selwyn District	One year percent change	Source
GDP (March 2012)	\$820 m	1.1	Infometrics 03.2012
Total population (30/6/2012)	42,300	2.9	STATS, DPE052AA
Total employment (February 2012)	13,920	8.6	TABLECODE2310#
Income tested benefit recipients age 18–64, June 2013 quarter	815	10.6	MSD TLA Benefit Factsheets
Business units (February 2012)	5407	1.1	TABLECODE2310#
Total cows (2011/12)	145,202	4.9	DairyNZ 2012
SDC total operating expenditure 2012	\$67,368,000	20.7	STATS, LAF003AA
New residential consents, annual September 2012	\$206,535,054	70.3	STATS, BLDo63AA
House price average, July 2013	\$469,825	10.3	WWW.QV.CO.NZ
Total irrigated area	99,120	↑	Williams 2010, p.20
Agriculture output - closest 14,250ha,	\$34 million	↑	Butcher 2009, p.105
Waihora-Ellesmere associated quota value	\$1,830,000	↓	MPI, Butcher 2009
Recreation visits est. (26,950 x \$40/day)	\$1,078,000	↑	Hughey, 2013

Pressures

Economic activity in Selwyn District is buoyant and driven by population increase, new businesses commencing, enterprise conversions to dairy farming, and business expansions. Planned water infrastructure schemes will irrigate a further 30,000 ha of land in Selwyn.

Economic activity surrounding the lake is influenced by water levels, amount of land reserved for conservation or recreation, output prices, costs of production, and fluctuations in biological productivity. More broadly, many factors drive economic activity levels in Selwyn District including population growth, new business startups, water availability, investments in irrigation, commodity prices, relocation of people and businesses following the Christchurch earthquakes. Growth of population and economic activity increases demand (pressure) on labour, buildings, urban infrastructure, electricity supply, water supply, commercial and residential land.

Responses

Proposals to tackle water quality and nutrient levels in Te Waihora/Lake Ellesmere (groundwater/surface water balance, on farm nutrient management, lake and riparian management) are likely to impact agriculture, fishing, mahinga kai and recreation. Estimation of the latter four indicators in the table will provide basic measure of the impacts on those four activities.

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Williams, H. (2010) Groundwater resources in the Te Waihora/Lake Ellesmere catchment: management issues and options. Report R10/05, Environment Canterbury, Christchurch.

Conclusions and recommendations

Statistics New Zealand regularly compiles and releases business and economic data including for Selwyn District. A detailed study of economic capability and activity in Selwyn was completed in 2009 (AERU 2009). Quarterly monitoring of economic activity in Selwyn (and all New Zealand TLAs) is completed by Infometrics, and BERL. Environment Canterbury (ECan) should fund access to a quarterly report to ensure timely, consistent economic activity indicators are available. ECan should annually calculate total irrigated area in Waihora-Selwyn catchment. ECan should fund two-yearly calculation of the four indicators focused on economic activity around or on Te Waihora/Lake Ellesmere so that activity is measured at a finer scale than at District level.



New Subdivision in Lincoln

More information

Additional information and links are available from the WET website.

For background, context and information about other values associated with Te Waihora Ellesmere please see the other sections of the 2013 State of the Lake Report www.wet.org.nz/projects/2013-state-of-the-lake/



Section 4

Land use and land cover

Te Waihora/Lake Ellesmere – State of the Lake 2013

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How will we know when we have achieved success?

Land use and development is integrated with water management; natural and cultural values are respected; all land use activities operate at good practice or better; communities are viable and wellbeing is enhanced through sustainable development.

Context

Measures of land cover and land use are often talked about interchangeably. Both are descriptive indicators for state of the environment reporting. Land cover is the physical material at the earth's surface, such as forests, pasture, water, or asphalt. Land use is the activity or economic function to which people put the land, such as forestry, sheep or beef farming, recreation, or urban settlement.

Land cover is a **state indicator**, describing quantity and quality. It reflects changes in land use. Land use is a **pressure indicator** and tells us something about the driving forces that change environmental conditions. Measuring and reporting changes in land cover and land use, over time, are fundamental to understanding and managing the driving forces contributing to the state of Te Waihora/Lake Ellesmere. Catchment land use and land cover, past, present and future, are inextricably linked with the state of the lake and its environs.

State: Land cover

Changes in land cover in the Selwyn District, including the current state, reflect changes in land use influenced by population growth and shifts in business enterprise (refer Economy section). The Land Cover Database (LCDB), derived from satellite photography, reports standardised land cover classes. Figure 4.1 shows the percent change in land cover class for the Selwyn District between 1996/97 and 2007/08 (i.e. between LCDB1 and LCDB3). Figure 4.2 shows the LCDB3 mapped for the Selwyn District, plus the area of the Te Waihora catchment which is within Christchurch City (the eastern part of the lake, including Kaitorete Spit). The total area mapped represents the Selwyn Waihora Zone of the Canterbury Water Management Strategy (CWMS). Notable changes in land cover between 1997 and 2007 can be summarised as follows:

- Forest harvested (large increase: 1343%)
- Built up area (moderate increase: 38%)
- Transport infrastructure (small increase: 11%)
- Mixed exotic shrubland (moderate decrease: -33%)
- Orchard, vineyard and other perennial crops (moderate decrease: -29%).

LCDB4 (2012/13 satellite imagery) is due for release in 2014, at which time further changes in land cover since 2007 can be analysed and reported.

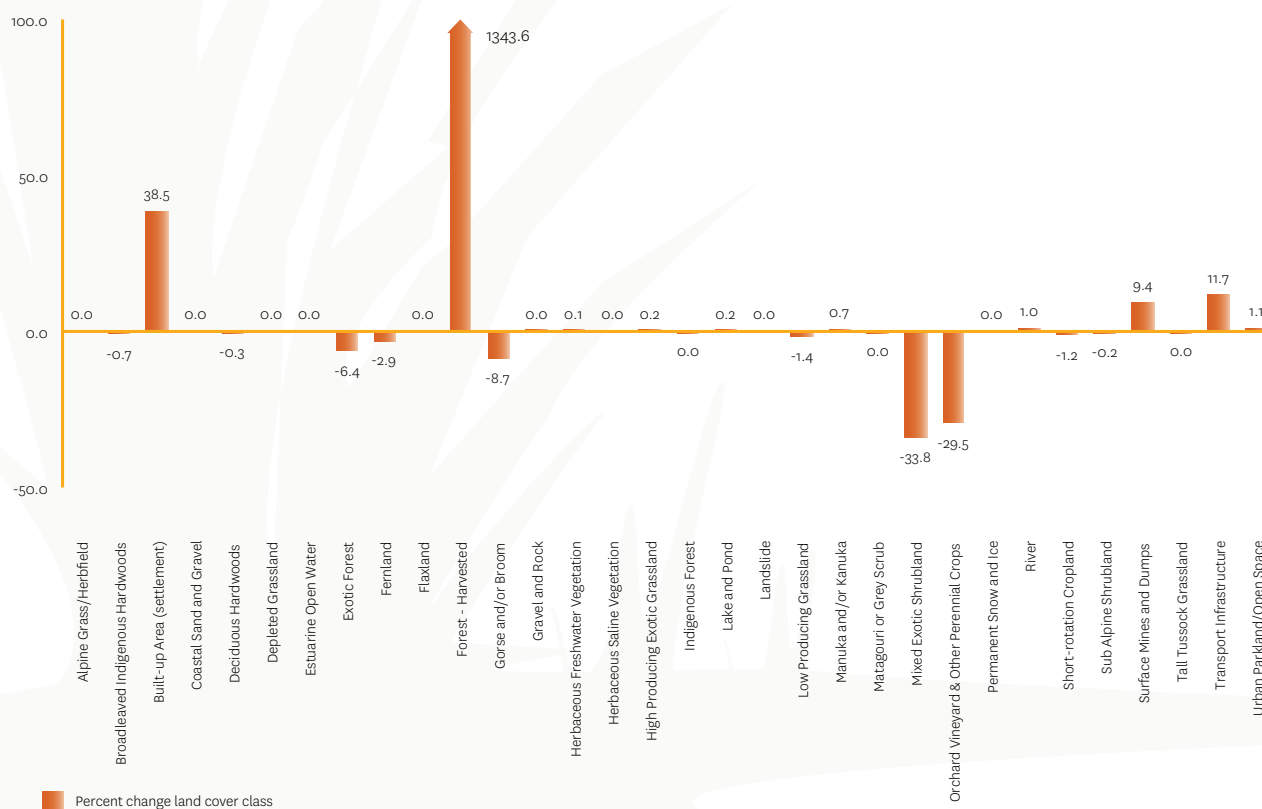


Figure 4.1: Percent change for each land cover class between LCDB1 (1996/97) and LCDB3 (2007/08)

Source: Environment Canterbury 2013; LCDB1 and LCDB3 statistics.

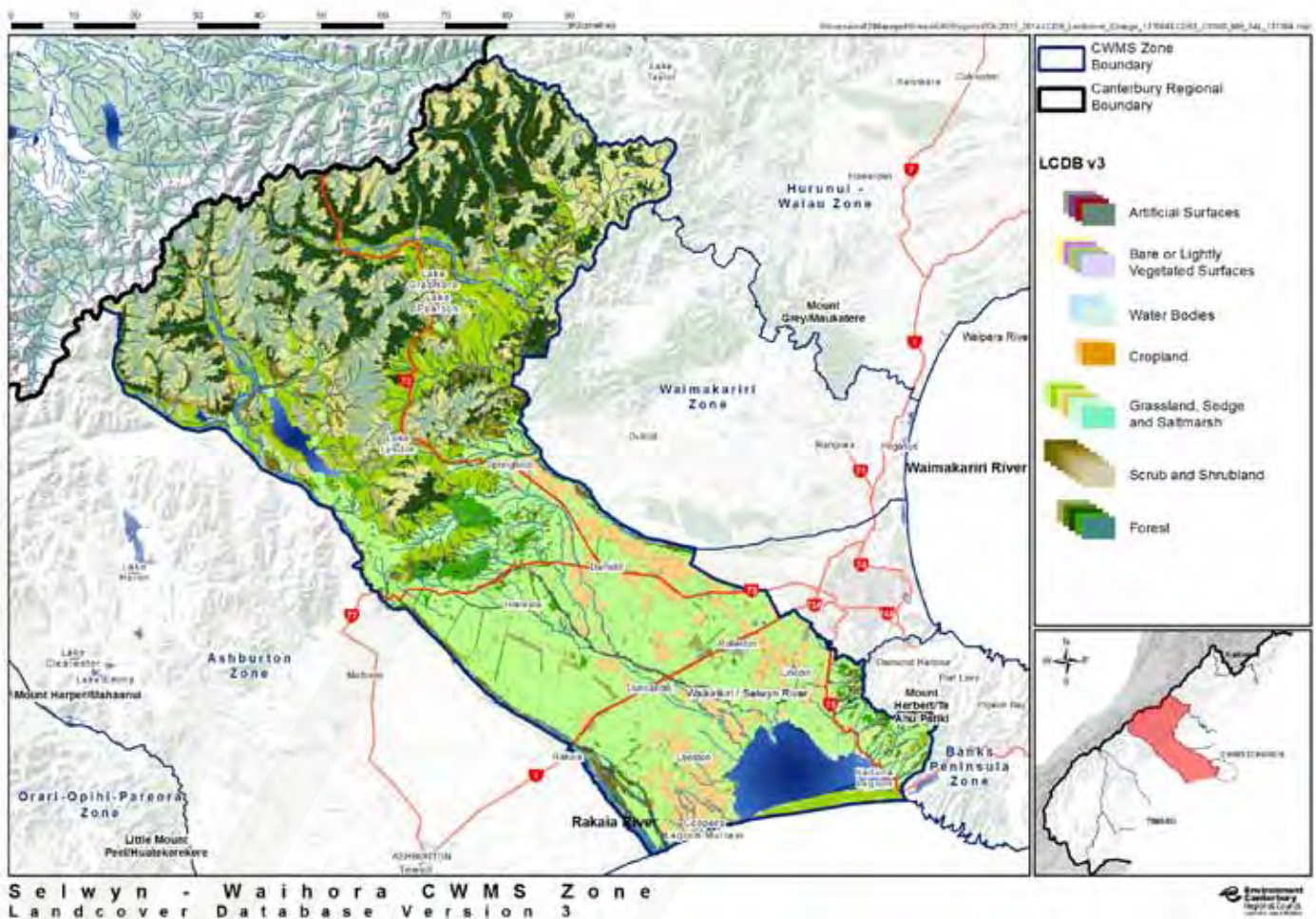


Figure 4.2: Land Cover Database 3 (2007/08) mapped for the Selwyn District/ Selwyn Waihora CWMS zone.

Source: LCDB3; Environment Canterbury 2013.

Pressures: Land use change

Pressure indicators describe the factors which change environmental conditions, including factors causing environmental problems. For Te Waihora/Lake Ellesmere, land use change is a primary pressure indicator. Pressures from land use on the lake and its environs include:

- Contaminants from point and non-point sources making their way off land and into the lake through various pathways, e.g., soils, surface water, groundwater.
- Urban/rural expansion leading to loss of indigenous/mahinga kai plants, animals and habitats, including for lake wildlife, e.g., vegetation clearance.
- Cumulative impacts from diffuse sources of contaminants over large areas where there is a lag time between the leaching of contaminants and the appearance of symptoms in the lake, or its tributaries, e.g., catchment nitrogen and phosphorus loads from agriculture.
 - Contaminants include nutrients (nitrogen and phosphorus), micro-organisms and other toxic or harmful contaminants (e.g. organic compounds such as sewage effluents, pesticides), and sediments (Land and Water Forum. 2012).
 - Rivers and lakes receive nutrient inputs from sources such as fertilisers, grazing stock and sewage discharges. Microbial inputs are received from stock, municipal sewage, urban stormwater, birdlife and some industrial discharges. Toxic or harmful compounds, including metals, pesticides and hydrocarbons, are released into rivers and lakes particularly from residential and industrial stormwater, industrial discharges and some agricultural activities, for example pesticide use. Sedimentation can occur as a result of reduced riparian protection and from activities such as stock access to waterways, bank erosion and land development. Channel modifications and maintenance for land development also have impacts (Canterbury Regional Council. 2009).

Te Waihora: Rural land use change



Comparison of 2003 and 2013 AgriBase® datasets.

The land use classes were inferred using the dominant farm enterprise. Farms often contain multiple enterprises.

Only the areas described in both the 2003 and the 2013 AgriBase® datasets were included in the analysis, representing approximately 75 % of land in the study area.

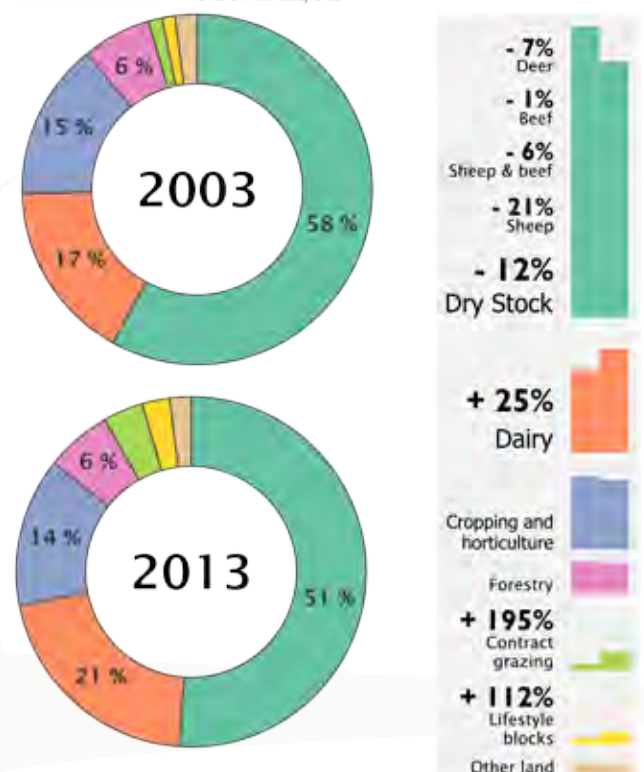


Figure 4.3: Rural land use change in the Selwyn Waihora catchment between 2003 and 2013

Source: AgriBase,ASUREQuality, 2003; 2013. Environment Canterbury 2013.

Figure 4.3 shows the percentages of changes in rural land use between 2003 and 2013 for the Te Waihora/Lake Ellesmere catchment.

Figures 4.4 and 4.5 map rural land use for the Te Waihora/Lake Ellesmere catchment in 2003 and 2013, showing the changing mix of farm activities across the catchment.

Figures 4.6 and 4.7 show the changes in livestock numbers in the Selwyn District between 2007 and 2012.

Figure 4.8 shows changes in irrigated area (indicative only) between 1960 and 2011 for the Ellesmere-Waihora irrigation area based on consented groundwater allocations. This time frame is used because these years comparisons are what is available to provide an indication of trend.

(Colours in figures 4.4 and 4.5 match those in the key for rural land use change in Figure 4.3)

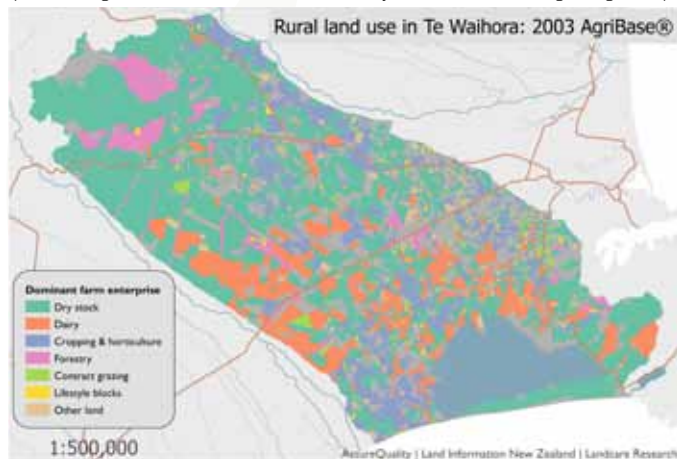
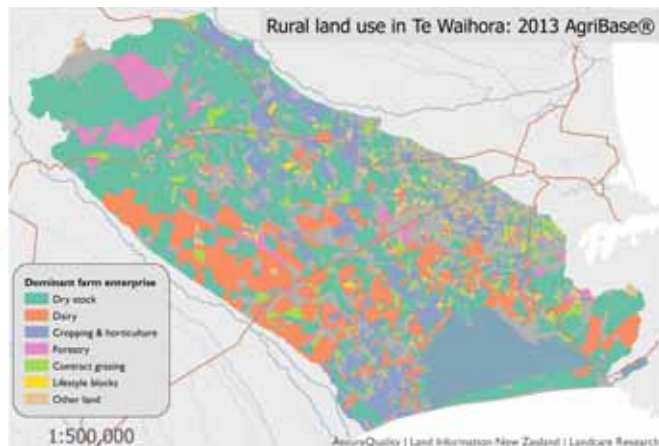


Figure 4.4: Rural land use in the Selwyn Waihora catchment 2003

Source: AgriBase,ASUREQuality, 2003; 2013; Environment Canterbury 2013.



Figures 4.5: Rural land use in the Selwyn Waihora catchment 2013

Source: AgriBase,ASUREQuality, 2003; 2013; Environment Canterbury 2013.

Change in livestock numbers Selwyn-Waihora

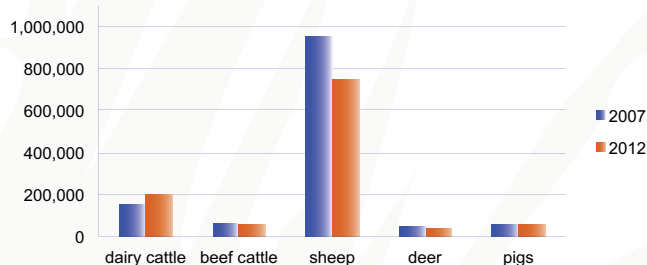
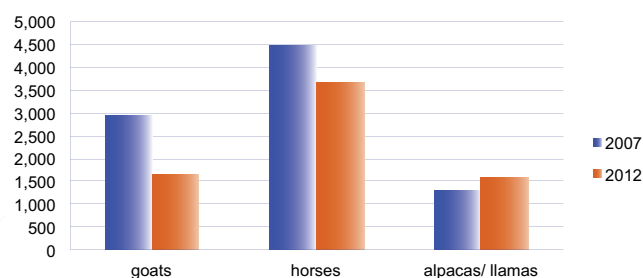


Figure 4.6: Changes in livestock numbers between 2007 and 2012

Source: Statistics New Zealand Agricultural Census 2007; 2012: Livestock Numbers by Type and Territorial Authority.

Change in livestock numbers Selwyn-Waihora



(Note scale for goats, horses, alpacas/llamas is different)

Figure 4.7: Changes in livestock numbers between 2007 and 2012

Source: Statistics New Zealand Agricultural Census 2007; 2012: Livestock Numbers by Type and Territorial Authority.

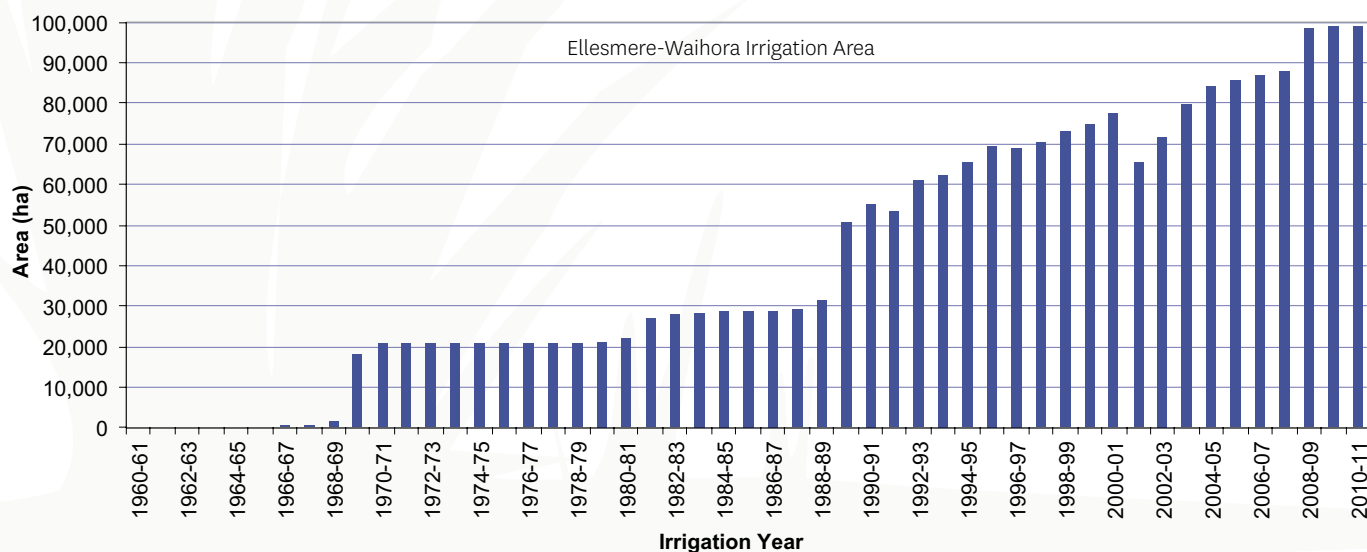


Figure 4.8: Changes in irrigated area 1960 to 2011 – indicative only

(Irrigated area calculated by summing estimated groundwater allocation on the face of issued resource consents. Actual water use will differ and is likely to be in the range of 40 to 50% of consented allocation. Data should be treated as annual estimates to summarise the change in irrigation area and allocated groundwater for the combined Selwyn Waimakariri and Rakaia Selwyn groundwater zones for the years reported).

Source: Environment Canterbury 2011.

Which driving forces?

Driving forces influence changes in land use, and are reflected in land cover. Driving forces have social and economic links. Social links include things like population changes, income levels and distribution, education, peoples' values and environmental attitudes. Economic links include market forces (commodity prices, exchange rates), employment, economic growth and sectorial trends.

Driving forces influence overall levels of production and consumption which, in turn, apply pressures on the environment (Ministry for the Environment, 2007). This can be through changes in land use. Indicators that report statistics about sectorial trends in the catchment from which pressures arise are particularly important for reporting on the state of the lake and its environs.

The indicators in the economy chapter include driving forces. Mapping land use and land cover change, and interpreting this together with driving forces statistics, provides context for state of the environment reporting on the lake, including for land and water management.

What responses?

Response indicators demonstrate the efforts people make to solve environmental problems, including mitigating pressures and the impacts that arise from these. For Te Waihora and its environs, responses include, for example:

- setting water allocation limits
- setting catchment nutrient loads from agriculture
- excluding stock from waterways
- the use of farm environmental plans
- providing for ecological flows in waterways
- establishing riparian buffer margins
- the use of lake interventions such as lake openings
- funding and projects for restoring and protecting native vegetation and biodiversity.

Discussion and recommendations

"Measure to manage" implies that the right information is available at the right time for management purposes. For state of the environment reporting this means that information about driving forces, and changes in state, pressures and impacts must be regularly available over time, and at a relevant scale, to inform responses. Identifying what information is the right information is the challenge, together with being very clear about the 'measuring' (and reporting) purpose (in this case, for land and water management).

Through Te Waihora living lake symposia, measures have been identified and reported concerning values for the lake: cultural health, recreation, lakeshore vegetation, fisheries, wildlife, water quality, etc. For land,

measures have included information about its economic value and the impacts on these values from proposed changes to the management of the lake and inflowing waterways (Hughey and Taylor et al. 2008). Five years on, it is important to consider land not simply from the perspective of its economic value, but also from the perspective of the pressures that arise from deriving such value. A systems approach to thinking about the complexity of relationships associated with the lake must include measures giving useful detail of land cover, land use and land use intensity.

Have we got the right information?

Yes, but improvements could include:

- Combine social, cultural, economic and environmental data for reporting purposes to better effect. In this way, we can enhance our understanding of what drivers and activities across the catchment influence changes in the state of Te Waihora, and regionally over time.
- Better match geospatial boundaries for monitoring data. For example, some data are available for the Selwyn District, other for the Te Waihora/Lake Ellesmere catchment. The two are different but closely related.
- Consider the need for other land use indicators, e.g. soil erosion, soil health, nutrient budgets and land use capability. Are they important for state of the lake reporting, and if so, why? Or are they more appropriate for operational monitoring and scientific investigations.
- Make more use of geographic information systems to map monitoring data for reporting purposes. In this way, people can see how various driving forces, pressures, changing states and responses relate 'on the ground' to where people live, work and enjoy leisure and recreation activities.
- Progressively fill information gaps for state of the lake indicators which, as yet, have minimal data available for reporting. For example, many of the response indicators for land relate to more recent actions and initiatives. It will be important that 'response' monitoring is planned and implemented as these initiatives get underway.



What should be measured?

The suggested minimum set of land indicators for state of the lake reporting is listed below.

Driving forces	State	Pressures	Responses
<ul style="list-style-type: none">● Population changes and economic growth in the District● Commodity prices; primary production and sectorial trends in the catchment● People's values for land, and environmental attitudes about the lake.	<ul style="list-style-type: none">● Change in land cover for each land cover class, both around the lake shore, in the wider catchment, and for the district/ CWMS zone.	<ul style="list-style-type: none">● Change in land use for each major land use class, both around the lake shore, in the wider catchment, and for the district/ CWMS zone● Change in livestock numbers in the District● Change in irrigated land area in the wider catchment.	<ul style="list-style-type: none">● Number and coverage of farm plans, including number audited, by land use type● Change in length of riparian buffer margins along waterways, and around the lake shore● Area of land protected around the lake shore, in the lake catchment, and for tributary streams.

References

Canterbury Regional Council. 2009. Canterbury Regional Environment Report 2008. Christchurch. Canterbury Regional Council. <http://ecan.govt.nz/publications/Pages/regional-environment-report.aspx>

Land and Water Forum. 2012. Third Report of the Land and Water Forum: Managing Water Quality and Allocating Water October 2012. Wellington: Land and Water Trust. <http://www.landandwater.org.nz/>

Land Cover Database series (LCDB) - a geographically spatial (satellite) map of New Zealand's land cover that is compiled at 5-yearly intervals from 1996/97. <http://lris.scinfo.org.nz/file/330-lcdb-cover-class-change-summary/>

Ministry for the Environment. 2007. Environment New Zealand 2007. Wellington: Ministry for the Environment. <http://www.mfe.govt.nz/publications/ser/enzo7-deco7/index.html>

More information

Additional information and links are available from the WET website.

For background, context and information about other values associated with Te Waihora Ellesmere please see the other sections of the 2013 State of the Lake Report www.wet.org.nz/projects/2013-state-of-the-lake/



Section 5 Water

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead author: Kimberley Robinson and Tim Davie, Environment Canterbury

How will we know when we have achieved success?

Water quantity: Ecosystem and cultural health is restored and safeguarded; over allocation is reduced; water users have reliable water supplies, including for customary use, and recreational activities.

Water quality: Water quality is improved to sustain cultural values; indigenous and wildlife species are supported; drinking water is safe and water quality suitable for recreation.

Context

Te Waihora/Lake Ellesmere is a large coastal lake formed behind a coastal beach, intermittently open to the sea. Surface water inflow is largely from groundwater flowing into the lake's catchment, in turn sourced from rainfall recharge and seepage from rivers. Being a lowland lake, Te Waihora not only receives inputs that affect water quality within the immediate vicinity of the lake, but also from the wider catchment across the plains up to the foothills (Hughey and Taylor et al. 2008). The Te Waihora outlet occurs at a narrow section at the southern end of Kaitorete Spit. The artificial opening of the lake, at this outlet, is a critical management intervention that has impacts upon the water quality, fish populations (both in the lake and in tributaries) and water levels on and under surrounding land. The water balance of the lake is dominated by rainfall, tributary inflows, outflows through the opening cut and, evaporation (figure 5.1).

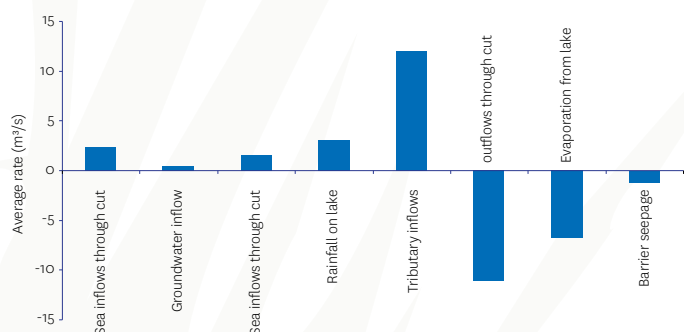


Figure 5.1: Average water balance for Te Waihora/Lake Ellesmere 1987-2007 (from Renwick et al., 2010).

Rainfall and lake levels

In the previous two years there have been four months where rainfall has been significantly above average (October 2011, August 2012, May 2013 and June 2013 – see figure 5.2). The largest rainfall was in June 2013 which resulted in significant flooding around the lake as it took several days to get the lake open.

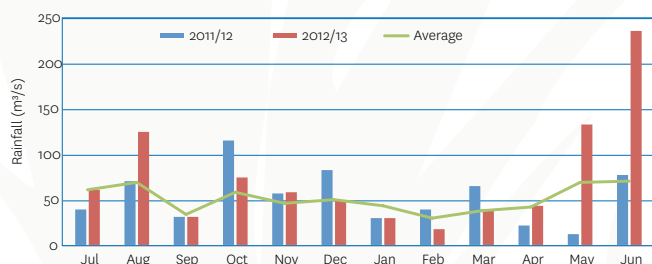


Figure 5.2: Rainfall at Tai Tapu (Environment Canterbury Ryans Bridge recorder).

Rainfall is a major driver in the lake water balance through both what falls on the lake and the additional water coming in via tributaries. This can clearly be seen in figure 5.3. Also evident from figure 5.3 is the long period in early 2013 when the lake stayed open and low.

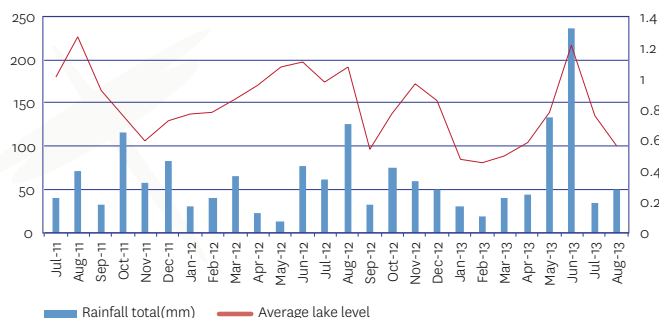


Figure 5.3: Average monthly lake level and monthly rainfall (Tai Tapu) from July 2011 to August 2013.

State: Water quality and ecosystem health

Environment Canterbury routinely monitors surface water quality at a number of sites in Te Waihora/Lake Ellesmere and its tributary streams (figure 5.4). Five lake sites are sampled monthly by boat, with additional shore sites monitored during periods of potentially toxic cyanobacteria blooms. Tributary streams, including a number of recreational water quality sites, are monitored monthly for water quality and aquatic ecosystem health. Groundwater quality is sampled annually as part of a region wide monitoring programme which includes approximately 50 wells in the Te Waihora catchment.



Figure 5.4: Routine surface water monitoring sites for Te Waihora/Lake Ellesmere and its catchment.

Lake Trophic Status

The lake trophic status for Te Waihora/Lake Ellesmere is measured by the Trophic Level Index (TLI), and is an indicator of enrichment based on measurements of nutrients, algae and water clarity. Note, the trophic level index does not describe the water quality of the lake, rather the condition of the lake.

Te Waihora/Lake Ellesmere has consistently been in a hypertrophic state for the 20 years that it has been sampled. There has been a small decrease in TLI (figure 5.5) since the lake was identified as having the highest TLI in the country (Verburg et al., 2010). In the most recent year of monitoring, unusually low nutrient and chlorophyll a (a measure of algae/phytoplankton) concentrations, in response to prolonged periods of lake openings, have seen a shift in trophic state to supertrophic (figure 5.5). Prolonged periods of seawater intrusion may however have detrimental effects on lake and associated wetland ecology.

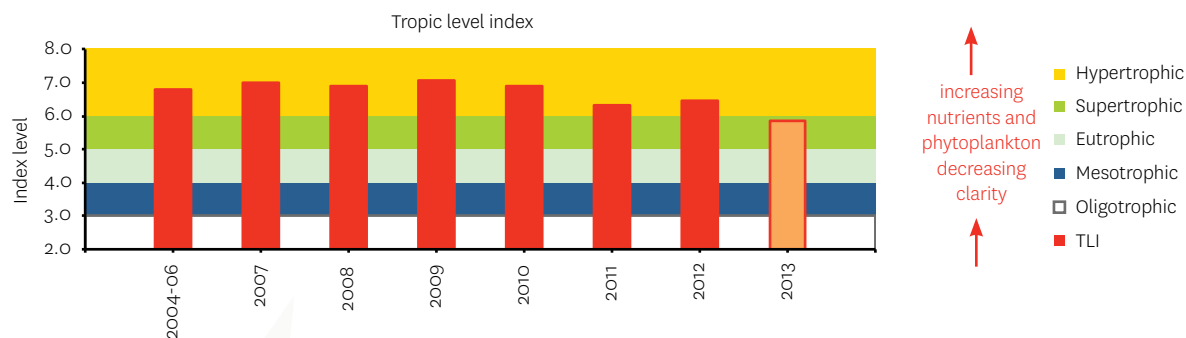


Figure 5.5. Te Waihora/Lake Ellesmere trophic status.

Water Quality of Tributary Streams

For tributary streams in the Te Waihora/Lake Ellesmere catchment parameters such as nutrients, clarity and bacteria are measured and used to calculate the water quality index.

In the Te Waihora/Lake Ellesmere catchment, tributary streams are generally of poor to fair water quality according to the water quality index, however, in recent years, the Waikewai Creek site has improved to "Good" (figures 5.6a and 5.6b).

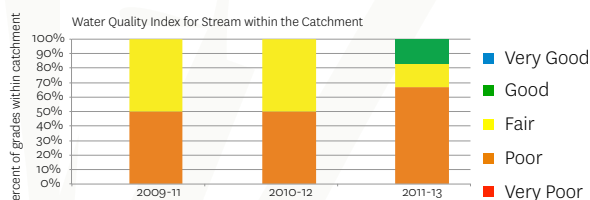


Figure 5.6a. Percentage of Water Quality index grades for streams within the Te Waihora/Lake Ellesmere catchment.

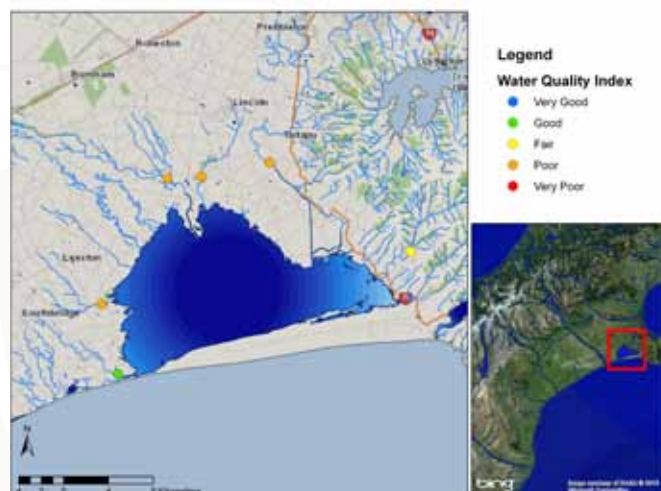


Figure 5.6b. Current Water Quality Index grades for streams within the Te Waihora/Lake Ellesmere catchment.

Aquatic Ecosystem Health of Tributary Streams

Aquatic ecosystem health is measured by habitat grades and invertebrate grades. Invertebrates, which live in the stream year round, are a good indicator of stream health as they respond to changes in water quality and their physical habitat, e.g., increases in sediment or algae. Some species of invertebrates are more sensitive to water pollution and are therefore not present in abundance in streams of degraded water quality.

Aquatic ecosystem health is variable in tributary streams in the Te Waihora/Lake Ellesmere catchment. In the 2012 monitoring season, sites with poor or very poor invertebrate grades generally reflected sites with poor or very poor habitat grades (figure 5.7). However, in most recent years (2010-2012), there has been a trend of increasingly poor habitat grades throughout the catchment. Poor sites are dominated by pollution tolerant invertebrates typical of soft-bottomed sites, such as worms, snails and midges; sites of good or very good invertebrate quality typically have more generalist/pollution sensitive species.

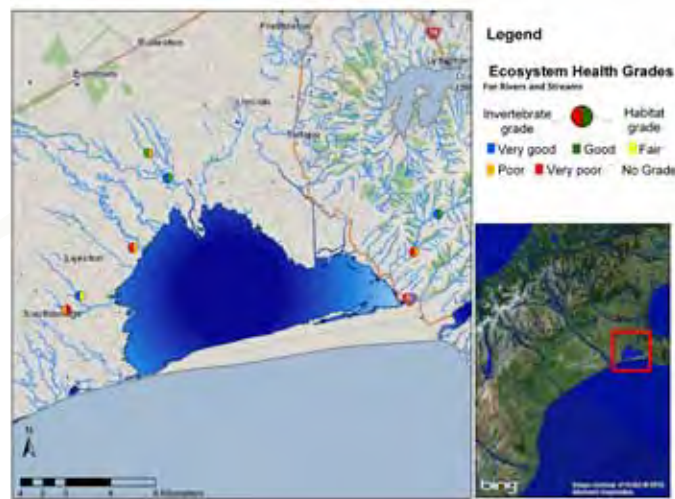


Figure 5.7. Current aquatic ecosystem health for streams within the Te Waihora/Lake Ellesmere catchment (December 2012).

Causes of poor ecosystem health may include high sediment inputs to the basin streams as a result of stock access and run off, lack of intact riparian vegetation, excessive in-stream plant growth as a result of high nutrient inputs, and reduced or intermittent flows for significant portions of the year.

Recreational Water Quality

Recreational water quality is monitored over the summer months at popular bathing sites along the Waikirikiri/Selwyn River and for Te Waihora/Lake Ellesmere. Suitability for recreation grades are calculated from microbiological results (*Escherichia coli*) and a qualitative risk assessment (sanitary inspection category) for each site, describing the general recreational condition of a site. Sites graded 'poor' and 'very poor' are generally considered unsuitable for contact recreation.

Suitability for recreation decreases moving downstream for the Waikirikiri/Selwyn River with the upper stream site graded good, and the two downstream sites both unsuitable for recreation with grades of poor and very poor (figure 5.8, Table 5.1).

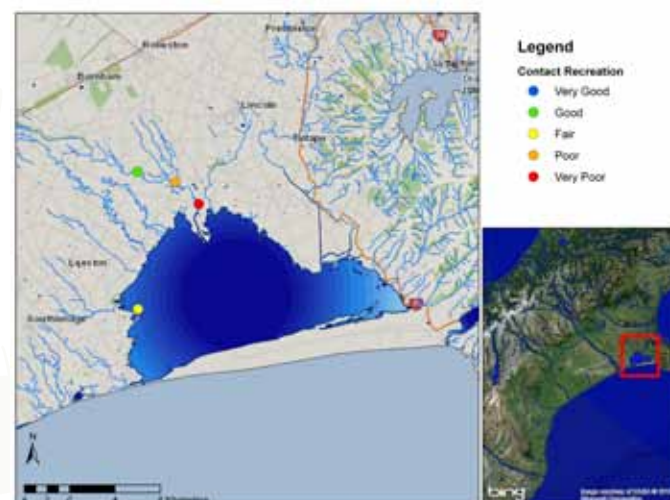


Figure 5.8. Current suitability for recreation grades for Te Waihora/Lake Ellesmere and Waikirikiri/Selwyn River.

Table 5.1: Suitability for recreation grades for Te Waihora/Lake Ellesmere and Waikirikiri/Selwyn River

	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Te Waihora/Lake Ellesmere	Poor	Fair	Fair	Fair	Fair	Good	Good	Good	Good	Fair
Waikirikiri/Selwyn River - Chamberlains Ford	Good*	Good	Good	Good	Good	Fair	Good	Good	Good	Good
Waikirikiri/Selwyn River - Coes Ford	Poor*	Fair*	Poor	Very poor	Very Poor	Very Poor	Very Poor	Poor	Poor	Poor
Waikirikiri/Selwyn River - Upper Huts	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Very Poor	Very Poor	Very Poor

Potentially Toxic Cyanobacteria

While recreational water quality in Te Waihora/Lake Ellesmere is graded fair or good when based on *E. coli*, there is potential for the lake to become unsuitable for recreation in the presence of harmful cyanobacteria blooms. Cyanobacteria blooms can pose a risk to human and animal health due to the production of cyanotoxins. In the presence of cyanobacteria blooms, a public health warning is issued for the lake.

Potentially toxic cyanobacteria is monitored as part of the routine monitoring programme by boat in Te Waihora/Lake Ellesmere, with additional shore sites monitored in response to bloom warnings for the lake. Cyanobacteria blooms generally occur during the summer months in Te Waihora/Lake Ellesmere, especially at the Kaituna, Fishermans Point and Lakeside Domain sites. These three sites are monitored from the shore in response to a bloom status from routine sampling. In the summer of 2012–13, the lake was open to the sea for a prolonged period, resulting in an increased salinity of the lake which produced less favourable conditions for algal blooms to grow. The typical *Anabaena* or *Nodularia* blooms were not observed, however, concentrations of potentially toxic picocyanobacteria exceeded the threshold (figure 5.9), and hence the lake had a public health warning issued.

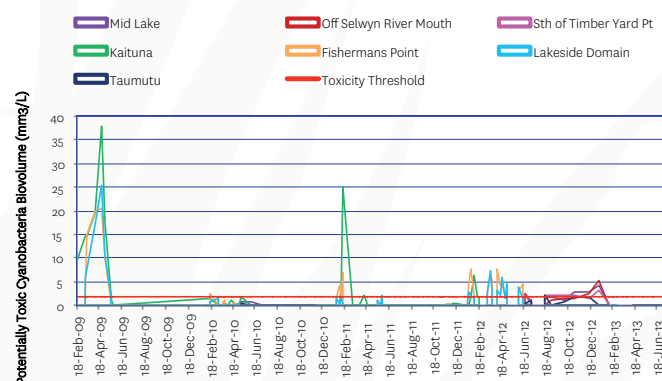
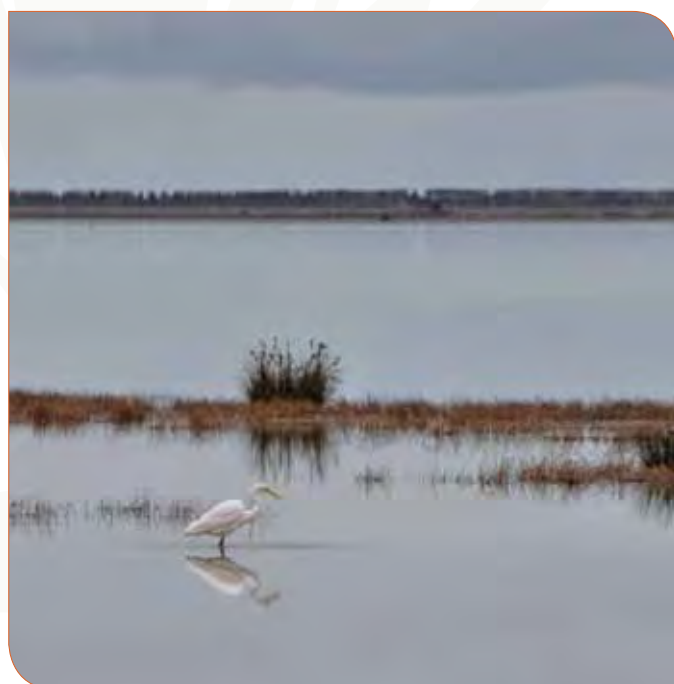


Figure 5.9: Potentially toxic cyanobacteria biovolumes for selected sites in Te Waihora/Lake Ellesmere.



Groundwater quality

Groundwater is used extensively in the Te Waihora catchment for drinking water. Results from the Spring 2012 groundwater quality survey showed no wells where *E. coli* was detected. The majority of wells are less than 50m in depth.

The nitrate nitrogen concentrations shown in figure 5.10 indicate that near the lake the groundwater is at close to natural concentrations (less than 2.8 mg/l). Further up towards SH1 the nitrate nitrogen concentrations were higher.

No monitoring of groundwater fauna is undertaken at this time.

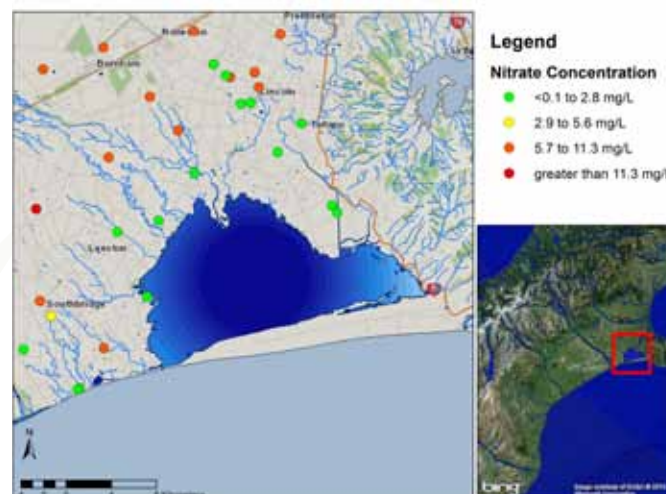


Figure 5.10: Nitrate nitrogen concentrations recorded in groundwater during Spring 2012.

State: Water quantity

Stream and river flows are measured continuously on five tributaries of the lake, and lake level is recorded at two sites (Taumutu and Kaituna).

Lowland stream flows

The current state of lowland streams in the Te Waihora catchment has been impacted by the long term effects of abstraction. Many of the streams which currently go dry are, anecdotally, reported as previously flowing year round. The streams have been affected to varying degrees depending on their location and the major source of flow. The flows in the L-2 and Harts Creek have higher baseflows than the Selwyn, Irwell and Halswell (Figure 5.11).

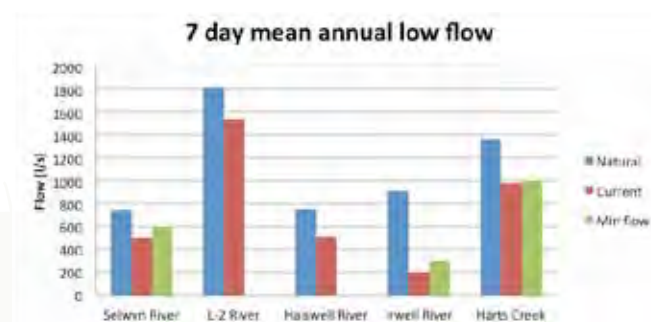


Figure 5.11: Modelled Mean Annual Low Flow (7day) statistics for 5 streams. The current minimum flows (irrigation restriction flow) are plotted alongside.

Pressures and responses

Te Waihora continues to be a lake under considerable pressure from surrounding land use (refer Land section), both near and far from the lake edge. The state of ecological health (as measured by invertebrate monitoring) continues to be poor in streams across the catchment and although the lake TLI has improved slightly it would be difficult to say that this is a significant improvement. The pressures that have led to this state (land use intensification combined with greater water usage by agriculture) continue to increase which has led to some major responses in the past 2–3 years from organisations with an interest in the lake's management.

The first major response (policy change) has been a rethinking of the lake opening regime. Changes made to the Water Conservation Order for the lake (on application from Ngāi Tahu and the Department of Conservation) allow a wider range of values to be managed for, in particular the importance of migratory fish as a key mahinga kai value. There is now an opening consent being applied for jointly by Ngāi Tahu and Environment Canterbury which incorporates the management for extra values. In recognition of the wider benefits from managing for a wider set of values the funding mechanism for opening has changed so that the costs are spread to a wider base of rate payers and less is asked from the land owners immediately surrounding the lake.

A second recent response to the pressures on the lake is the establishment of Whakaora Te Waihora, a joint project between Ngāi Tahu, Ministry for the Environment and Environment Canterbury aiming for restoration and rehabilitation of the lake. The initial part of Whakaora Te Waihora has focused on habitat improvements through large scale riparian planting (in September 2013 the 100,000th plant was planted) and drain management improvements plus a series of six science/engineering projects looking at ways of improving lake management.

A third major policy response is the Land and Water Sub-regional Plan for Selwyn-Waihora being developed by the community through Environment Canterbury. This is one of the first Resource Management Act (RMA) plans in the country that is putting into effect the National Policy Statement for Freshwater that requires limits to be set on both water quantity and quality. In conjunction with this RMA plan is a programme of work developed by the Selwyn-Waihora Zone Committee (a subcommittee of Environment Canterbury, Selwyn District Council and Christchurch City Council set up to implement the Canterbury Water Management Strategy) which aims to address the lake and catchment deterioration. This work programme, which incorporates many of the interventions of Whakaora Te Waihora, also starts to address nutrient management across the Canterbury Plains.

These policy and action-oriented responses offer considerable hope for an improvement in the state of Te Waihora but it is widely recognised that this is a long-term project and it will take many years before we see a fully flourishing lake ecosystem with high mahinga kai and recreational values.

Recommendations

The current water quality and quantity monitoring regime for Te Waihora/Lake Ellesmere and the catchment is well established and comprehensive. Monitoring, as described above should continue, with regular reviews undertaken as new research provides additional insight into the pressures and drivers of change, and to measure the effectiveness of lake and catchment interventions.

While the current monitoring information is satisfactory for assessing gradual change in state for the lake and catchment, it would require far more intensive monitoring to understand detailed processes occurring within the lake (e.g., denitrification and/or lake stratification). This would require much more frequent monitoring, at the scale of minutes rather than monthly, and in many places around the lake. This type of detailed investigation is being considered as part of the Whakaora Te Waihora Cultural and Ecological Restoration Programme but would be very expensive to maintain in the long-term. It may provide useful information to fine tune management options such as lake opening times but cost-benefit considerations would have to be looked at thoroughly before it became part of routine monitoring.

References/data sources

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Ground water fauna

The groundwater beneath the Canterbury plains supports a diverse but poorly understood fauna which plays an unknown role in the maintenance of ground and spring water quality. Over 100 species have been described, including water mites, amphipods, isopods, Syncaridae, molluscs, Oligochaeta, flat worms and copepods, and it is likely that many more species await discovery. Most are small and lacking in pigment, but some amphipods are up to 15mm in length.

There has been limited research into the role these animals play in the Selwyn-Te Waihora catchment. However, pressures on the groundwater biodiversity, which include contamination of groundwater and changes in water levels, risk reducing the capacity of the groundwater fauna to provide ecosystem services.

(Source: Te Waihora/Lake Ellesmere Catchment, Functional Significance and Sensitivity of Groundwater Fauna, Golder Associates 2013).



Paracrangonyx compactus, a stygofaunal amphipod crustacean inhabiting the Te Waihora catchment, c. 15mm. Photo: NIWA, Nelson Boustead.

More information

Additional information and links are available from the WET website.

For background, context and information about other values associated with Te Waihora Ellesmere please see the other sections of the 2013 State of the Lake Report www.wet.org.nz/projects/2013-state-of-the-lake/



Section 6

Vegetation

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead author: Philip Grove, Environment Canterbury

How will we know when we have achieved success?

Significant indigenous vegetation of the lake margin and tributaries streams is protected and restored, including wetland restoration and planting of riparian margins; pests are controlled.

Context - what do we measure?

Te Waihora/Lake Ellesmere lakeshore vegetation was mapped and described in the early 1980s by Clark and Partridge (1984). The same area, approximately 4,400 ha in total, was re-surveyed in 2007 (see tables 6.1, 6.2 and 6.3). Extent, location and type of habitats and vegetation cover from both surveys was entered into a spatial database allowing monitoring and analysis of trends in vegetation cover and wetland habitats around the lake shore. In 2007, an additional c. 1000 ha adjoining the original survey area was also mapped and described. At this stage it is planned to repeat the lake shore vegetation survey in 2017.

Table 6.1 Extent of the 14 most widespread wetland vegetation types around Te Waihora/Lake Ellesmere, surveyed in 1983 and 2007 (from Hughey and Taylor, 2008).

Vegetation	1983 (ha)	2007 (ha)
Saltmarsh herbfield (saltmarsh/brackish wetland; native)	2,405	2,253
Three square reedland (saltmarsh/brackish wetland; native)	123	401
Marsh ribbonwood shrubland (saltmarsh/brackish wetland; native)	256	387
Saltmarsh grassland (saltmarsh/brackish wetland; exotic)	536	331
Sea rush rushland (saltmarsh/brackish wetland; native)	271	155
<i>Juncus edgariae</i> rushland (freshwater wetland; native)	159	136
Mixed rushes and sedges (freshwater wetland; mixed native-exotic)	23	59
Wet pasture (freshwater wetland; exotic)	138	159
Crack willow-dominant forest and treeland (freshwater wetland; exotic)	39	70
Grey willow-dominant forest and treeland (freshwater wetland; exotic)	28	70
Harakeke flaxland (freshwater wetland; native)	23	9
<i>Oioi restiad</i> rushland (freshwater wetland; native)	36	11
Rāupo reedland (freshwater wetland; native)	28	39
<i>Bolboschoenus caldwellii</i> reedland (saltmarsh/brackish wetland; native)	14	8



Willows invading wetlands on western edge of Te Waihora.



Willow spraying Ward Williams Reserves by Dept of Conservation Jan 2012

Table 6.2 Changes in proportion of lakeshore habitats between 1983-2007 (from Hughey and Taylor, 2008).

Habitat	Proportion of lakeshore survey area	
	1983	2007
Brackish wetland	82% (3,606 ha)	80% (3,534 ha)
Freshwater wetland	10% (452 ha)	12% (555 ha)
Dryland	8% (332 ha)	8% (337 ha)
Miscellaneous	<1% (11 ha)	<1% (13 ha)
Total	4401 ha	4439 ha

Table 6.3 Changes in proportion of indigenous and exotic vegetation types within lakeshore brackish and freshwater wetland habitats between 1983-2007 (from Hughey and Taylor, 2008).

Vegetation type	Proportion of lakeshore survey area	
	1983	2007
Indigenous brackish wetland vegetation	85%	90%
Exotic brackish wetland vegetation	15%	10%
Indigenous freshwater wetland vegetation	54%	35%
Exotic freshwater wetland vegetation	46%	65%

Within the 4,400 ha re-surveyed area, there was an increase in total extent of freshwater wetland habitats and a corresponding decline in cover of brackish wetland or saltmarsh vegetation. Although the overall area of brackish wetland habitat had declined by about 100 ha, there had actually been an increase in extent of indigenous saltmarsh vegetation. And while there had been a corresponding increase in freshwater wetland habitat, there was a marked decline in extent of indigenous freshwater wetland vegetation over the monitoring interval. Causes included the lower average lake levels and reduced lake salinity of recent years (up to 2007), reduced stock grazing pressure along parts of the shoreline, the spread of exotic plant species, particularly willows in freshwater wetlands, and human disturbance (Hughey and Taylor, 2008).

Some developments since 2007

In the years since 2007 there have been higher inflows and more frequent lake openings than in the early 2000s. These will likely have reversed the trend of reduced lake water salinity recorded in the years leading up to the 2007 survey. In particular, the unusually long (more than six weeks) opening of January-February 2013 introduced large amounts of sea water into the lake. This was followed by a period of very high lake levels and flooding during June 2013. Effects of these recent events on lake shore vegetation are yet to be assessed.

There have been some further changes to grazing regimes on parts of the lake shore, for example, removal of cattle grazing from the Christchurch City Council reserve on Kaitorete Spit, and exclusion of stock from Department of Conservation reserves and adjoining private land in the Selwyn Delta-LII River mouth area. However, some sections of the lake shore are still grazed, by sheep, cattle or both.

The spread of exotic willows in lake shore freshwater wetland habitats was described in more detail in an Environment Canterbury technical report and the Department of Conservation also developed a willow control strategy for its lake shore reserve land (Walls 2009).

Reed canary grass (*Phalaris arundinacea*) was recorded in Te Waihora lake shore wetlands for the first time in 2009. This invasive wetland grass species is abundant on the margins of Wainono Lagoon where it forms dense stands excluding indigenous plants, and is likely to have a high potential for further spread at Te Waihora. Other weeds of concern which are present, but not yet abundant, in lake shore wetlands or in catchment tributaries are yellow flag iris (*Iris pseudacorus*), beggars tick (*Bidens frondosa*) and purple loosestrife (*Lythrum salicaria*). Environment Canterbury's Weed of the Month website page features information on each of these species.

From 2011 the Canterbury Water Management Strategy 'Te Waihora Regional Flagship' project has provided funding for weed control, protection fencing and indigenous restoration planting at sites around the lake.

Pressures

Present lake shore vegetation patterns have developed under the artificial lake opening regime of the last 150 years. Indigenous vegetation has adapted or can respond to the temporal and spatial variations in water level and salinity which characterise the lake shore environment. However, various pressures related directly or indirectly to human disturbance can have adverse effects on indigenous lake shore vegetation and wetland habitats, including alteration to wetland hydrology by construction of drains and stopbanks; vegetation clearance, damage by stock and vehicles; changes to water quantity and quality of lake and tributaries from catchment land use; and the spread of introduced plant species.

What pressure indicators do we measure?

- Construction of new drains and stopbanks is recorded in the CRC Consents Database.
- Change in land use, both around lake shore and in wider catchment, e.g., stock type, stocking rates, nutrient inputs (refer Land Cover, Land Use section for details).
- Change in quantity and quality of lake and tributary waters (refer Water section for details).
- Change in abundance and distribution of environmental weeds on lake shore. Measured by recording location and extent of infestations of targeted species, e.g., reed canary grass (found particularly around the lower reaches of the Selwyn and the LII—see Figure 6.1) and willows (Figure 6.2).



Grey Willow catkins - female



Grey Willow catkins - male

What response actions are underway

- Willow and other weed control programmes are now underway in lake shore wetlands. Focus to date has been on control of willows invading areas of significant indigenous freshwater wetland habitats.
- Areas of public and private land on the lake shore continue to be retired from grazing. While removal of grazing generally benefits indigenous vegetation, willow control may be required in newly-retired freshwater wetland habitats.
- Native restoration planting projects have been undertaken at several lake shore sites. Focus of most lake edge restoration planting effort has been the adjoining terrestrial and tributary riparian habitats, rather than wetlands. These help restore natural ecological sequences from lake shore wetland to riparian and terrestrial habitats.
- More recently, the Whakaora Te Waihora Joint Cultural and Ecological Restoration Programme has begun to undertake restoration planting on key tributaries and is identifying priority projects around the lake margin.

What do we measure?

- Area (ha) of willow controlled.
- Area of lake shore retired from grazing and/or formally protected.
- Location of restoration projects.

Several organisations have recently contributed to a mapping project which shows the location of restoration projects in the Selwyn-Waihora area and provides some basic information about the nature of each project (Figure 6.3). This will be updated and added to on a regular basis.

Recommendations

What other pressure indicators should we measure?

- Frequency and extent of drain maintenance works in tributaries (affects hydrology, water quality, riparian vegetation cover).
- Indigenous vegetation clearance around lake shore and in tributary catchments.
- Impacts of vehicles on lake shore vegetation and wetland habitats.
- Loss of rare/threatened indigenous plant populations from lake shore habitats

What other response indicators should we measure?

- Area (ha) and type of indigenous vegetation restored at planting sites.
- Survival rate of plantings after 2-3 years (rather than just number of plants put in the ground).
- Area (ha) of wetland and riparian habitats restored in tributary catchments.
- Persistence or recovery of rare/threatened indigenous plant populations in lake shore habitats.

Future survey and measurement of state of lake shore vegetation indicators will allow assessment of pressures and effects of response actions.



Reed Canary Grass



Figure 6.1 Location of reed canary grass, lower reaches of the Selwyn and the LII.

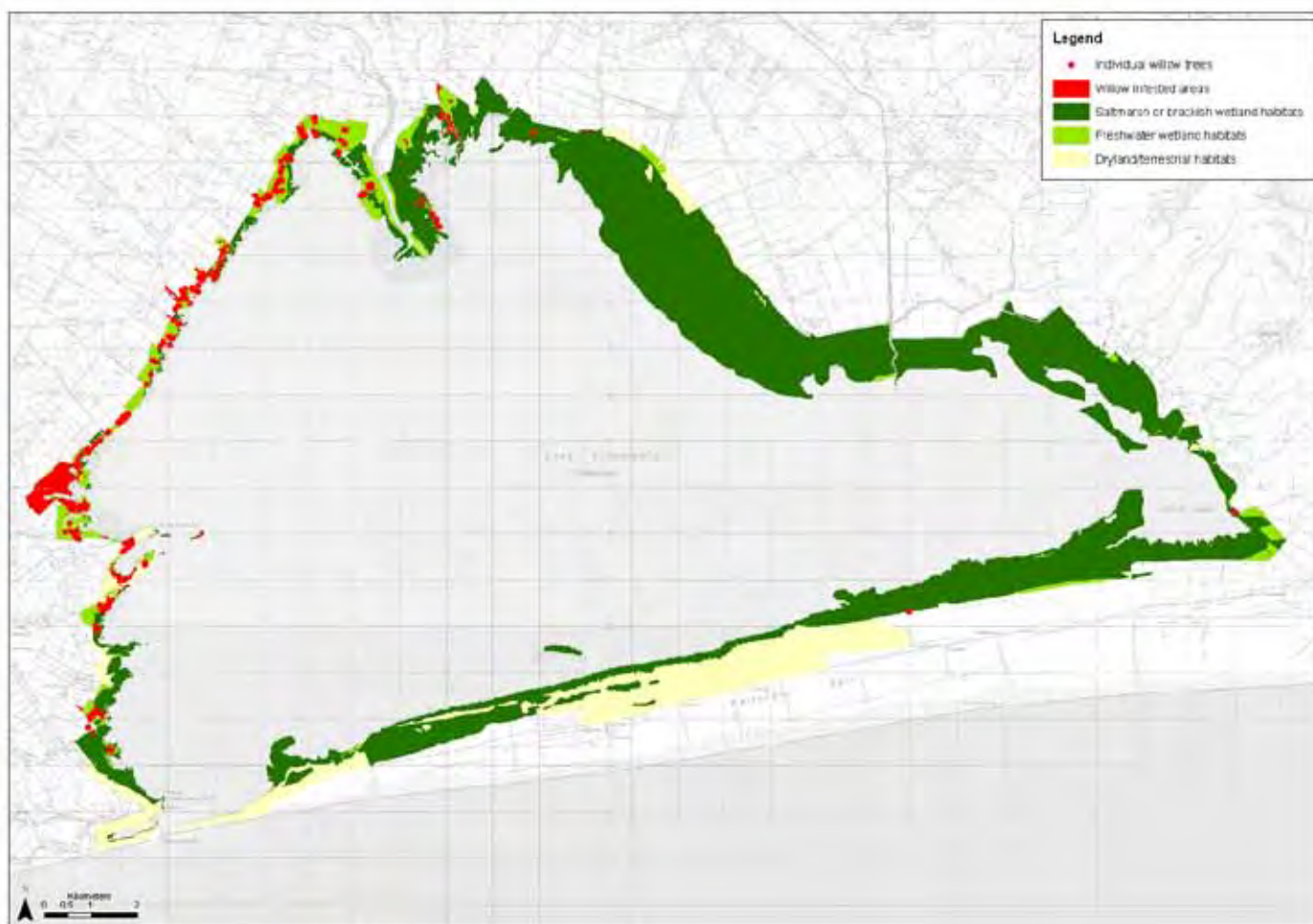


Figure 6.2 Location of willows around Te Waihora, shown in red.

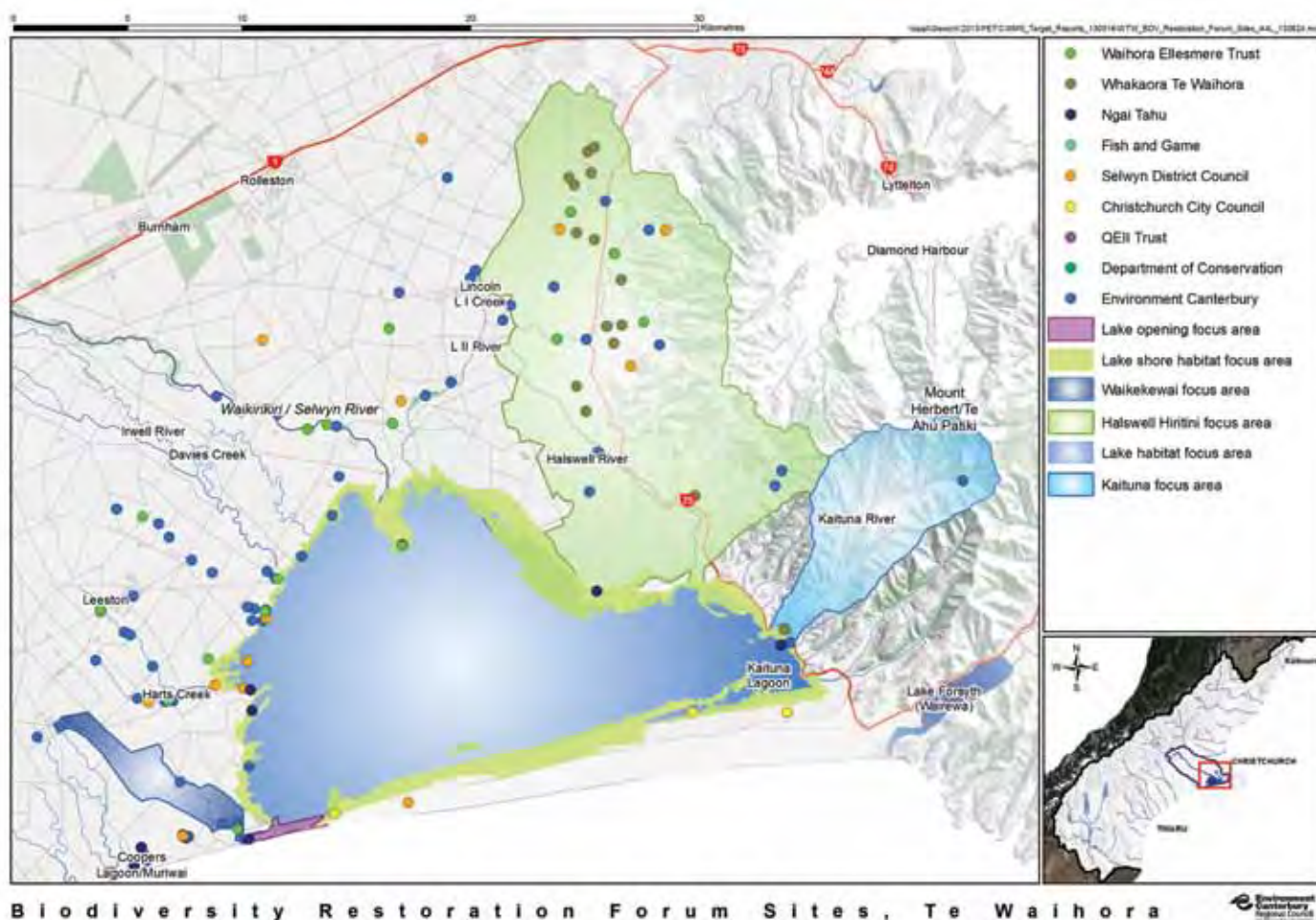


Figure 6.3 A version of this map is available from www.canterburymaps.org.nz (look for the Selwyn-Waihora featured map).

Mapping restoration projects

Several organisations (see figure 6.3) are involved in undertaking and supporting projects to restore native biodiversity in the Selwyn-Waihora catchment – by providing advice and funding to landowners, helping with planning, or carrying out planting, sometimes with the help of volunteers. For many projects, there has been little information available on the area planted, plant survival rates or project follow up to see if regular weed control, essential for new plantings, has been carried out. Information on projects is held by several organisations (although this doesn't include all initiatives undertaken by private landowners). To help let people know about the restoration work a mapping project got underway in 2013. The aim was to collate project information and to make this available to the public. The organisations involved will continue to update the information and look at ways to monitor project success.



Kate Ufton, Green Footprint planting 2013



Te Ara Kākāriki's Canterbury Plantout 2013

More information

Additional information and links are available from the WET website.

For background, context and information about other values associated with Te Waihora Ellesmere please see the other sections of the 2013 State of the Lake Report www.wet.org.nz/projects/2013-state-of-the-lake/



Section 7 Wildlife

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead author: Kenneth F.D. Hughey, Lincoln University/ Waihora Ellesmere Trust

How will we know when we have achieved success?

Indigenous wildlife and associated habitats are protected and biodiversity increased. Pests and predators are reduced.

Context

Te Waihora/Lake Ellesmere wildlife encompasses wetland birds, lizards, and terrestrial and aquatic invertebrates. Aquatic invertebrates are also covered in part by the discussion of aquatic ecosystem health included in the water section of this report. The birdlife of Te Waihora/Lake Ellesmere has been researched considerably, and the lake is internationally regarded for its value to birdlife, but relatively few studies have been undertaken on lizards or invertebrates. Consequently, this state of the wildlife report is dominated by birdlife, although recommendations are made for further research into lizards and invertebrates (aquatic and terrestrial).

Birdlife

Most bird monitoring data has been collected by volunteers, many from the Ornithological Society of New Zealand. Total bird counts during February of each of the survey years for which data is available are presented in Figure 7.1. The abundance of nine indicator species, representing the key guilds present on the lake and its associated wetlands, is presented in Table 7.1. to indicate the state of birdlife during February of each surveyed year. February has been chosen as the month to best represent changes in bird 'values' associated with the lake. Note that bittern are not yet formally monitored at the lake – occasional sightings during surveys do however occur and are recorded.

Table 7.1. Abundance of indicator bird species during February bird counts from 1985 – 2013

Species	Year								
	1985 ^{1,2}	1986 ^{1,2}	1987 ¹	1988 ^{2,5}	1989 ^{2,5}	2006 ^{2,3}	2007 ^{2,3}	2008 ^{2,3}	2013 ^{2,3,4,5,6}
Australasian Crested Grebe	0	0	0	0	0	5	11	6	9
Black Cormorant	129	121	191	150	233	233	254	89	396
Australasian Bittern	0	11	2	1	0	0	0	0	1
Black Swan	2928	5694	12682	10385	5717	10006	10651	9011	8598
Australasian Shoveler	272	79	6075	541	263	3405	1946	1161	5173
Pied Stilt	1300	7362	2212	2067	2776	2937	2566	5776	3726
Wrybill	19	81	38	5	37	230	459	146	429
Red-necked Stint	200	137	71	0	99	26	63	18	34
Caspian Tern	15	29	18	18	15	63	38	96	405

Surveys undertaken by: ¹New Zealand Wildlife Service; ²Ornithological Society of New Zealand; ³Christchurch City Council; ⁴Waihora Ellesmere Trust; and ⁵Department of Conservation, ⁶others

* Although bittern are not formally monitored at the lake, occasional sightings during surveys have been recorded

It is also possible to look at total bird numbers from the full February trend counts undertaken (Figure 7.1).

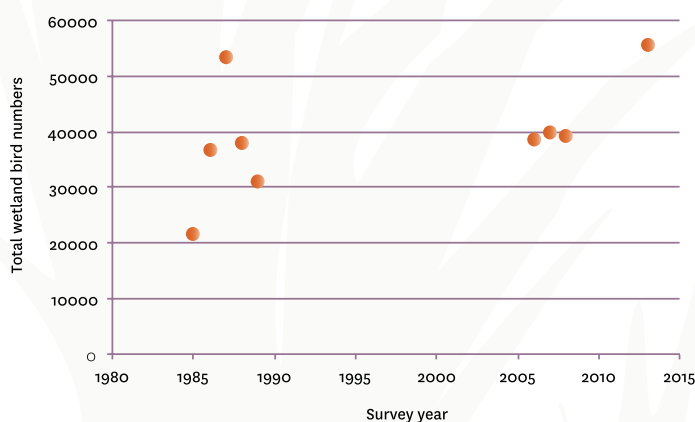


Figure 7.1. Total number of wetland birds at Te Waihora/Lake Ellesmere during February from 1985 – 2013.

There are some important points to note from this data:

- There are many years, especially in the 1990s and early 2000s when no overall wetland bird surveys were undertaken
- Total numbers are highly variable but large, most typically around 30–40,000 birds
- While a few over wintering Australasian crested grebe have been recorded for many years, it is only since around 2005 they have been breeding and regularly sighted year round
- Since the 1980s, numbers of Caspian tern (which breed at the lake) and wrybill (which stop over at the lake during their migration journeys) have increased dramatically
- Red-necked stint numbers may have declined (but detailed research is required to confirm this)
- Other species are either roughly static or highly variable
- Although bittern are not formally monitored, an Environment Canterbury report by Peter Langlands (2013) has an overview of the status of this species in Canterbury, including Te Waihora/Lake Ellesmere.

Pressures (and driving forces where known) on the birdlife of Te Waihora/Lake Ellesmere come from a variety of sources, namely:

- predation by introduced mammals (and some native birds, e.g., harrier hawk and black-backed gull)
- wetland habitat loss as a result of:
 - land use intensification
 - invasion by exotic plant species, e.g., willows (see the vegetation report)
- lake opening and closing regime; different lake levels suit different guilds and it is unlikely that one lake level would suit all guilds
- physical disturbance, mainly from recreational users, both around the lake and on Kaitorete Spit

In response to predation, Christchurch City Council (CCC) and The Department of Conservation (DOC) are both undertaking mammalian predator control. DOC have monitored thirty lines of tracking tunnels twice yearly across Kaitorete Spit since in 2012. They also undertake predator control at Kaituna and Kaitorete Spit to protect birdlife and lizards. Predation has been seen as one of the major threats to grebes on the Kaituna River. CCC also undertake predator control on Kaitorete Spit mainly to protect birdlife. DOC anticipate analysing this data in the future to assess the benefits to wildlife of their predator control. In terms of bittern, while there is no active monitoring programme in place, it is likely the willow control programme will provide more habitat.

Lizards

Four species have been recorded and studied at Kaitorete Spit - *Woodworthia cf. brunnea* (Canterbury Gecko), *Oligosoma maccanni* (McCann's skink), *Oligosoma polychroma* (common skink), and *Oligosoma aff. Lineocellatum* "central Canterbury" (spotted skink). While the data collected to date is indicative of viable populations for the first three species, the spotted skink population has plummeted to almost undetectable levels (recorded using standard pitfall trap monitoring). Predator control and lizard monitoring are now undertaken by DOC on the Spit to determine the effectiveness of response efforts, but the programme is too new to detect any trends yet.

Invertebrates: terrestrial and aquatic

A range of terrestrial and aquatic invertebrate research has been undertaken within the lake environment. Most research has been on terrestrial insects, in particular the flightless moths on the dunelands of Kaitorete Spit, with the most recent work being undertaken by DOC (Patrick, 2012). Two threatened moth species on Kaitorete Spit have been monitored by DOC since 2012, although this data is yet to be analysed. Long term monitoring of the katipo spider has also been carried out by DOC since 2004 (A. Spencer pers. comm. 2013).

Probably the single most important lake insect is the lake fly, or midge (*Chironomus zealandicus*), a key food of native birds and fish including eels, especially during the larval/worm stages. Alison Evans, in a factsheet available on line (www.littleriverrailtrail.co.nz), notes that its life history is totally reliant on the lake edge. She reports that "The flies spend their juvenile stage as worms or larvae in the sediment of the lake and because of their red colour are commonly known as blood worms. Although blood worms normally comprise a significant portion of the invertebrate fauna in most lakes in New Zealand, they are particularly able to live in degraded water. This is due to the haemoglobin in their blood which enables them to live in oxygen-poor water and sediments." There is no monitoring undertaken at the lake of this key species in the food chain.



Lake flies

Discussion

The state of bird indicator species seems to be good, with a range of guilds present at the lake, although a high degree of variability in numbers has been observed. However, knowledge surrounding the state of lizards, and terrestrial and aquatic invertebrates, at the lake is poor, although improving rapidly with recently commenced monitoring programmes. The state of aquatic invertebrate fauna is especially important as they are a key component of the food web of the lake, yet they have been little studied and not specifically monitored. In particular, more information is required regarding pressure and response indicators of these fauna. Three of the four lizard species populations on Kaitorete Spit appear to be in good health. Current monitoring programmes for these lizards and flightless moths should provide more detailed information to managers within the next few years.

Recommendations

Birds

- Undertake, as agreed in the bird monitoring protocol, annual bittern monitoring, and link to development and implementation of a plan for bittern conservation efforts with appropriate response indicators included
- Record and report all data by total counts and also by survey areas
- Monitor predator numbers for key bird species/habitats and implement predator control where appropriate, including monitoring bird species for beneficial responses

Lizards

- Survey the lake margins for lizards
- Analyse and use adaptive management principles for data collected for lizard and moth monitoring, and predator control

Terrestrial invertebrates:

- Survey the lake margins for terrestrial invertebrates
- Continue with existing monitoring programmes, analyse data and report on how the data has driven adaptive management of desired species

Aquatic invertebrates:

- Develop and implement a monitoring protocol for lake flies around the lake that is linked to changes in the lake management regime

Te Waihora Wetland Bird survey

In February 2013, around 40 volunteers and staff from the Waihora Ellesmere Trust, Department of Conservation, Environment Canterbury, Christchurch City Council, Ngāi Tahu, Lincoln University and Selwyn District Council, joined experienced birdwatchers from the Ornithological Society of NZ to undertake a count of all wetland birds present on the lake. The lake margin was divided into sections and small teams spread out around the lake to identify and count the birds present. Over 55,000 birds, including several rare visitors and endangered native species, were counted on the day and the full results are available on the WET website www.wet.org.nz.



More information

This brief summary draws on a more detailed report, which is available from the WET website.

For background, context and information about other values associated with Te Waihora Ellesmere please see the other sections of the 2013 State of the Lake Report www.wet.org.nz/projects/2013-state-of-the-lake



Section 8

Fish

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead authors: Hamish G. Rennie (Lincoln University/Waihora Ellesmere Trust), Adrienne J. Lomax (Waihora Ellesmere Trust)

How will we know when we have achieved success?

Native fish populations and associated habitats are protected and restored.



Tuna/eel fishing

Context

A total of 47 species of fish have been recorded in Te Waihora/Lake Ellesmere. Some of these are long-term resident species tolerant of varying levels of salinity. Sixteen species are diadromous, meaning that they spend part of their life in the ocean. The lake supports important customary and commercial fisheries - key species are tuna/eels, patiki/flounder (black, sand, and yellowbelly), and aua/yellow eyed mullet. The lake provides an important conduit for recruitment of diadromous fish to the Selwyn River and other tributaries. The lower reaches of the many waterways which flow into the lake provide important fish habitat (Hughey and Taylor et al., 2008).

State of the fish populations

Selecting indicators for this report

The Whakaora Te Waihora (WTW) restoration programme has preliminarily identified the measure 'occurrence of selected native fish species' as an indicator of lake health. This may involve gathering data on the size, distribution and abundance of a range of indigenous species identified as being of particular importance. These species are likely to include tuna/longfin and shortfin eel, several species of pātiki/flounder, aua/yellow eyed mullet and inanga/whitebait. Other important species include the very abundant bullies and smelt, which are a food source for birds and larger fish. (N.B. the introduced brown trout, which is historically very significant, is discussed in the recreation section of this report).

Sources of data on the fish populations of Te Waihora and contributing tributaries

- Specific studies by Environment Canterbury, universities and others
- Occasional surveys by the Department of Conservation, including recent surveys of the threatened Canterbury mudfish in the drains flowing into the lake
- Monitoring by local runanga, including data held by the Ministry for Primary Industry (MPI) on customary harvesting
- Commercial fishing data collected by MPI.

Commercial fishing data

There are three main species of fish commercially fished within Te Waihora - tuna/eels, pātiki/flounder and aua/yellow-eyed mullet. These species are all managed under the MPI Quota Management System (QMS) to ensure sustainability of fish stocks. MPI has a commercial eel fishing monitoring programme, underway since 2009, which collates data on size, species composition, and fine scale catch location from individual eel landings. Catch Per Unit of Effort (CPUE) is calculated regularly for tuna/eels and pātiki/flounder. This measure can be used as a proxy for abundance of these species, based on the assumption that the fish are easier to catch if there are more of them. Therefore, an increasing CPUE should indicate an increasing population and vice versa. Also of relevance, the MPI Annual Review of Freshwater Fisheries, which covers management for tuna/eel fisheries, has identified and reported on objectives and indicators which have been identified in relation to use and environment.

What is reported?

Information in this section is drawn from: The MPI Annual review of Freshwater Fisheries 2011/12; Characterisation and CPUE analyses of the flatfish fishery (FLA 3) in 2010; Catch per unit effort (CPUE) analyses and characterisation of the South Island commercial freshwater eel fishery, 1990–91 to 2009–10, February 2013; Monitoring commercial eel fisheries: 2009–10 to 2011–12, MPI 2013. These reports are available from the WET website www.wet.org.nz/projects/2013-state-of-the-lake.

Tuna

Te Waihora eel fishers use fyke nets and the fishery season runs from about October to March. The eel fishery is almost entirely shortfin (*Anguilla australis*) and fishers actively return any longfin (*A. dieffenbachii*) they catch to the water. Historically, the longfin only ever constituted about 1% of the Te Waihora eel catch. There is currently no requirement to record the numbers of longfins released.

The South Island eel fishery was introduced into the QMS in 2000. Prior to this, Te Waihora was managed as a controlled fishery with a capped catch limit of 136.5 tonne, fished by 11 permit holders. Following introduction into the QMS, the Total Allowable Commercial Catch (TACC) was reduced to 122 tonne. With the exception of 2010, this quota has been 100% caught over the last decade.

Since implementation of the QMS in Te Waihora, shortfin eel CPUE has increased significantly, suggesting that population size has also increased. One factor considered in working out CPUE is the number of net lifts, which reduced significantly from 1991 to 2006. This coincided with fishers progressively reducing deployment of large numbers of small fyke nets in favour of fewer larger nets. This is likely to be one of a number of factors contributing to the increase in CPUE. However, commercial fishers on the lake confirm that catches are noticeably better in recent years, consistent with the steep increase in CPUE.

From the MPI Annual Review of Freshwater Fisheries 2011/12, the objectives and indicators reported on for the tuna/eel fishery show gaps in the data available, with no information for trends in real quota value or amateur participation. Information available from customary reporting for eel stocks for Te Waihora suggests fulfilment of authorisations for these stocks is stable or increasing, indicating that customary fishing needs are being met. CPUE analysis, as noted above, indicates increasing abundance. Habitats of significance and policy objectives for managing effects of fishing on the environment have not been determined, although areas of significance to Ngāi Tahu for eel fishing are identified in the Canterbury Regional Coastal Environmental Plan.



Pātiki/flounder fishing

Pātiki/flounder

Specific abundance of flounder species in Te Waihora has not been monitored. The lake is part of the FLA 3 Quota Management Area and is in the Banks Peninsula-Canterbury Bight statistical area, making it difficult to determine the catch from the lake.

Annual landings of flatfish in this area fluctuate more than two-fold and have averaged about 1700 tonne since 1986. The TACC has never been exceeded; this value was originally set high because flatfish growth is fast and recruitment is variable, and a high TACC allows fishers to take advantage of years of high abundance.

Flatfish species in the lake include black flounder (*Rhombosolea retiaria*), yellowbelly flounder, (*R. leporina*) and sand flounder (*R. plebeia*). Lake eel fishers switch to setnetting of flatfish in the winter months, when eels are not as vulnerable to capture. Black flounder have a limited distribution and tend to be confined to brackish estuaries. The Te Waihora black flounder fishery is the largest in New Zealand. Yellowbelly flounders and sand flounders are found coastally and within estuaries throughout New Zealand. Sand flounders make up only a small proportion of the flatfish setnet catches in Te Waihora.

Setnet CPUE analyses for flounder show large fluctuations in the annual CPUE indices with no clear trends, and wide confidence limits around the indices, reflecting the small number of participants (around seven) in the fishery and the variability in catch from year to year.

There are large annual fluctuations for all three lake flatfish populations which is typical of a fast growing, short-lived species. It is unknown if black flounder, which is confined to brackish waters, exhibits any spawning-related migration in or out of the lake when the lake is open. Therefore the lake opening regime may be less important for this species than for other species. Abundance in the lake of the yellowbelly flounders and the sand flounders is likely to be dependent on conditions off the coast and on the timing of lake openings, which will determine recruitment success into the lake. The black flounder abundance may be controlled by environmental factors within the lake.

Other important species

No recent data for aua/yellow eyed mullet, inanga/whitebait, bullies and smelt are readily available. Aua/Yellow eyed mullet has had commercial and recreational importance, but biomass estimates are not available and the most recent stock assessment in 2010 notes it is not known if the catch is sustainable.

Pressures and responses

There are many different factors that influence freshwater fish communities in Te Waihora, but the main pressures are most likely to be associated with negative effects on recruitment and habitat. Recruitment of juvenile fish into Te Waihora is essential for maintaining a healthy and abundant fish community and this is particularly true for diadromous fish that recruit into the lake each year, and are dependent on the lake being open during recruitment times. Different fish prefer different habitats and areas in Te Waihora. For example, studies have shown that the reserve area around Harts Creek supports a population with a larger proportion of big shortfin eels, compared to the non-reserved area at Timbervard point. Whether this reflects the area being a reserve or the environmental factors that led to it being reserved is unclear.

More information

This brief summary draws on a more detailed report, which is available from the WET website.

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Responses are varied and may include:

Restrictions and permits – e.g., closing specific areas to all or some types of fishing, restrictions on gear which is permitted, and restricting access to fish.

For Te Waihora, Ngāi Tahu have identified areas within the lake as kōhanga (recreational and customary fishing only). Nets are not allowed to be used at specified river mouths, and there are restrictions on the nature and amount of gear to be used. Permits are required for customary fishing, administered by Tangata Tiaki, and commercial fishers require a commercial fishing permit and availability of fish quota.

Habitat Management – e.g., managing the lake level, implementing rules to protect water quality and water quantity, riparian improvements (e.g., shade and food sources), and pest control.

The National Water Conservation (Lake Ellesmere) Order 1990 was amended in 2011. This order now allows for the management of habitat of indigenous fish, and for management of values of significance in relation to tikanga Māori in respect of Ngāi Tahu history, mahinga kai and customary fisheries. Discharges to water and water takes are regulated through the Resource Management Act and associated planning mechanisms, and riparian restoration projects around the lake margin and in key tributaries are expected, over time, to lead to an improved in-stream habitat quality.

Research - increased knowledge of the fish populations will assist management. Specific research currently underway includes trials on the re-establishment of macrophyte beds and artificial habitat creation in the lake, and investigations of fish restocking/recruitment and a review of fisheries management, particularly in the kōhanga areas.

Aquaculture - the development of aquaculture may remove some pressure on the wild populations and facilitate restocking. This has been considered for Te Waihora/Lake Ellesmere but is not currently under investigation.

Fisheries Management Outputs - these include restrictions placed on fishing activities, such as limiting the size of fish which can be taken, the numbers, the tonnage and the species. Fishing activities in Te Waihora are subject to a range of restrictions through the Quota Management System, and bag and size limits on recreational and customary fishing. In addition, in Te Waihora, commercial fishers voluntarily release any longfin eels caught.

Recommendations

Although there is a good deal of data available on different aspects of the fish populations and their habitats, there is a clear need for a coherent, consistent and integrated monitoring programme which gathers data on the size, distribution and abundance of key species. Regular monitoring of pest species and their impact on indigenous fish and habitat would also be beneficial, including changes in habitat health. All data gathered should be publicly accessible. Finally, habitat requirements for key species need to be identified and monitored.

Surveys have indicated the presence of Rudd (*Scardinius erythrophthalmus*), and Catfish (*Ameiurus nebulosus*), both introduced pest species. Goldfish (*Carassius auratus*) are also present in the lake but are not officially a pest species. They were particularly evident in the summer of 2012/13 when the lake was open to the sea for an extended period and large numbers of goldfish sought refuge from the saline water by moving into the tributaries. Although not designated as pests, goldfish are likely to be affecting the indigenous species by competing for food and habitat.



Goldfish



Section 9

Recreation

Te Waihora/Lake Ellesmere – State of the Lake 2013

Lead author: Kenneth F.D. Hughey, Lincoln University/Waihora Ellesmere Trust

How will we know when we have achieved success?

Compatible recreation needs are provided for, including good access, water quality, and habitat for wildlife, including for sports fisheries.

Context

Both historically (from at least the 1880s) and in contemporary times Te Waihora/Lake Ellesmere and environs has provided for a wide range of water-based recreation activities, e.g., trout angling, waterfowl hunting, whitebaiting, powerboating, windsurfing, rowing, kayaking and swimming, and also a more limited range of land-based activities, e.g., cycling, picnicking, bird watching and walking. Unfortunately, apart from waterfowl hunting and trout angling, and more recently for biking on the Little River Rail Trail, there is virtually no quantitative data on numbers of users, quality of experience, or other data that is easily assembled to assess the state of recreation at the lake. Consequently, much of what is presented is based on limited published material and much anecdotal information, and represents a subset of the total range of user activities.



State of recreation activities



There are at least two major potential indicators of the state of recreation – level of use and quality of experience. Quantitative data are lacking for both indicators although there is some that can be used regarding level of use – it is this measure that is relied on below.

Activity		Highest historic levels of use – recreation user days per annum	Estimated level of use 2013 – recreation use days (range)
Trout angling		100,000 – probably in the 1960s	3300–5100
Cycling on Rail Trail		6000 – 7000 – contemporary activity	6000–7000
Waterfowl hunting		5000 – 10000 – probably much more activity before habitat loss	4000–6000
Boating, including windsurfing		10000 – 20000 – huge regattas held in 1920s through to 1940s	1500–3000
Bird watching		1000 – 1980s onward	500–1500
Other – whitebaiting, walking, picnicking, other (e.g., eeling, floundering, photography, 4WD driving camping at Lakeside and geocaching)		10000 – 20000 – likely to have been very large numbers in 1920s through to early 1980s, esp picnickers	0–2000
			1000–5000
			1000–5000
			1000–2000
Total	Lower range	132000	18300
	Mid range	145000	26950
	Upper range	158000	36600



Little River Rail Trail

The Christchurch to Little River Rail Trail mostly follows the route of a 19th century railway line which operated between Hornby Junction Christchurch, and Little River until its closure in 1962. It provides an opportunity for cyclists and walkers to gain access to Te Waihora/Lake Ellesmere and get a sense of its scale and wildlife. It is also one of the few recreation activities where some regular monitoring is undertaken (user counts by Department of Conservation).

Pressures (and driving forces)

on recreation activities and management responses

Pressures affect quality of activity (and as noted there are few measures of this for state) which then impacts on user levels. Most pressures and responses are related therefore to quality parameters.

Activity	Pressures (and Driving Forces, where identifiable)	Responses
Trout angling	<ul style="list-style-type: none"> Decline in fish numbers (bycatch, reduction in spawning trout numbers, and lack of good spawning habitat) Poor water quality (agricultural intensification) 	<ul style="list-style-type: none"> Managed access points – available for angling around the lake Advocacy programmes – Fish and Game advocate for improved quality and quantity of water in the tributaries of the lake. If this is successful then the quality of the angling experience should improve, which in turn should be reflected in an increase in angler numbers Proposed Land and Water Regional Plan (PLWRP) and Canterbury Water Management Strategy (CWMS) efforts to improve water quantity and quality.
Cycling on Rail Trail	<ul style="list-style-type: none"> Access/facilities: Currently there is no off-road cycling connection between the trail and Christchurch (on-going planning issues). Wind and lake flies can be annoying to cyclists (Natural events, poor water quality) 	<ul style="list-style-type: none"> The trail is progressively being linked to others so that there is a continuous largely off-road connection to Christchurch
Waterfowl hunting	<ul style="list-style-type: none"> Conflicting values: Bird watching (Government change to status of Canada goose meaning year round hunting allowed); restrictions on 4-wheel drive use (vehicle impacts on native vegetation). Lake level: Fluctuating lake levels affect waterfowl hunting (management regime) Water quality - Toxic algae warnings: Perceived very seriously by duck hunters especially those using dogs Access points/visitor facilities: Duck hunters now have restricted access, for driving, to some parts of the lake (impact on native vegetation); Signage in poor condition (resources) - causes confusion 	<ul style="list-style-type: none"> None, from a hunters' perspective From other perspectives: plan rules restricting off road driving; DOC signage, management of maimais and the funding from the maimai fees is used for habitat restoration; lake opening protocol group that considers timing in relation to duck shooting season PLWRP and CWMS efforts to improve water quality
Boating, including windsurfing	<ul style="list-style-type: none"> Water levels: Bad boating conditions occur when the lake is open to the sea for an extended period of time and the lake 'bottoms out' (management regime) Water quality: Algal blooms, occasional bad smell, poor water clarity (agricultural intensification) Access/facilities: Lack of launching sites for kayakers and rowers on rivers like the LII (Lack of recreational planning) 	<ul style="list-style-type: none"> PLWRP and CWMS efforts to improve water quality
Bird watching	<ul style="list-style-type: none"> Conflicting values: Hunting scares birds and bird watchers (Government change of status for Canada goose means hunting year-round); Off road driving Lake level: not being managed in a way that is appropriate for migratory wading birds (management regime) 	<ul style="list-style-type: none"> Lake level management: Water Conservation Order seeks to manage lake levels in a way that meets the needs of all native bird species, but also has to manage for fish and indigenous vegetation
Whitebaiting	<ul style="list-style-type: none"> Timing of lake opening: When lake openings do not occur at the right time there is effectively no whitebait run - it appears October-November could be the best time for a lake opening (management regime) 	<ul style="list-style-type: none"> Management action: A spring lake opening provided for (WCO) and so lake likely to be open more often during the whitebait season

Conclusions and recommendations

Te Waihora/Lake Ellesmere remains an important recreational resource in Canterbury, and for bird watching is of international significance. However, most activities declined in use through to the 1970s/80s and have remained roughly static since – the main exception being the increase in cycling (because of the Rail Trail). Due to the fact there is little quantitative information about trends in numbers, quality of activity, and other related matters, it is important given proposed changes to management of the lake that the following are measured:

- User days per annum statistics for the main activities – trout angling, waterfowl hunting, whitebaiting, cycling, bird watching, walking and picnicking, i.e., user days per year – perhaps undertaken on a bi- or triennial basis;
- Quality of activity measures – size and number of trout, number of waterfowl, access and other visitor-related facilities and provisions including improved signage, 'walk ways', boat ramps including for kayaks on the L2, water level and quality parameters by activity: perceived quality can be gauged during the user days surveys;

Two other issues became apparent during development of this report:

1. There are conflicts between some recreation groups, e.g., Canada goose hunters and the needs of bird watchers and the birds themselves – a facilitated discussion forum is required to clarify and attempt to resolve these issues;
2. Along with the lack of indicator data there is a general lack of information about recreational opportunities and how best to manage them. An ongoing strategy to improve and share information could well be developed alongside the proposed case for constructing and developing a visitor/research centre.



More information

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How will we know when we have achieved success?

When the 11 objectives, taken from the Mahaanui Iwi Management Plan 2013 and listed in the table below, are achieved.



Tuna/eels



Swan eggs

Context

A critical feature of this report card, which relates directly to the tangata whenua objectives for Te Waihora as articulated in the Mahaanui Iwi Management Plan 2013 (mkt.co.nz/mahaanui-iwi-management-plan). Indicator selection was driven primarily by the knowledge of existing indicators that are already in use by tangata whenua and are feasible to monitor, the availability of existing data, the degree to which the indicators are representative of the eco-cultural system of Te Waihora that is valued and used by Ngāi Tahu, and the likelihood that the indicators would continue to be monitored in the future.

Colour coding is used to highlight the scores awarded for each of the components.

- This outcome has been achieved.
- Processes are being implemented, work is in progress and there is a likelihood that this outcome will be achieved.
- This outcome has not been achieved. There are processes in place that could realise this objective.
- This outcome has not been achieved. Processes are still being developed that could realise this objective.
- This outcome has not been achieved. There are no processes in place that are likely to realise this objective.

The data that informs the assessment is drawn from the evidence presented by Ngāi Tahu whanui at various hearings (including Central Plains Water and the amendments to the National Water Conservation Order), the report “Cultural Values, Flow & Water Management Issues for the Waikirikiri/Selwyn - Te Waihora Catchments” (prepared in April 2013 by Tipa and Associates and available from Environment Canterbury), the report “Cultural Values, Flow & Water Management Issues for the Waikirikiri/Selwyn - Te Waihora Catchments”, and the data that has been considered by the Selwyn Te Waihora Zone Committee.



Te Waihora

Objective	Indicator	Grade
Ngāi Tahu are active co-governors of Te Waihora and its catchment.	1. Yes / No to formal co-governance arrangement in place for the catchment as a whole.	●
	2. Yes / No to formal long term commitment to Whakaora Te Waihora	●
Land and water management in the catchment effectively provides for the Treaty partner status of Ngāi Tahu, and the taonga status of Te Waihora.	3. Yes / No to Te Rūnanga o Ngāi Tahu/Papatipu Rūnanga being joint holders of the consent for the lake opening.	●
	4. Yes / No to Te Rūnanga o Ngāi Tahu/Papatipu Rūnanga being the joint consent authority for the catchment	●
	5. Yes / No to Ngāi Tahu approval being sought for activities involving the lake bed	●
The cultural health of Te Waihora is restored, including the restoration of mahinga kai species abundance and diversity to a level to enable customary use.	6. Good health of, and physical access to, mahinga kai sites and places within the Te Waihora catchment is restored, including but not limited to: <ul style="list-style-type: none"> a. Muriwai; b. Greenpark Sands; c. Pākoau; d. Kaitōrete; e. Horomaka kōhanga f. Waikirikiri; g. Waiwhio; h. Halswell River; j. Ahuriri Reserves; and k. Yarrs Lagoon. 	●
	7. Mahinga kai species traditionally gathered still found across historic range	●
The customary rights of Ngāi Tahu whānui associated with mahinga kai and Te Waihora are protected mō tātou, ā, mō kā uri ā muri ake nei.	8. Satisfaction of whanau that Te Waihora and its tributaries are managed as a customary fishery including but not limited to: <ul style="list-style-type: none"> a. A lake opening regime the reflects the needs of the customary fishery; b. Tributary water quality and quantity that enhances cultural health and mahinga kai, and enables customary use; c. The use of exclusion zones for commercial fishing / non-commercial fishing areas. 	●
	9. Whanau can access sites to gather where they wish, and how they wish.	●
	10. Iwi specific flow preferences identified and provided for in catchment flow regimes.	●
Land and water use in the catchment respects the boundaries, availability and limits of our freshwater resources and the need to protect soil and water resources for future generations.	11. Level of extraction (groundwater, surface water)	●
	12. Number of inter-catchment transfers	●
Lake management, including lake level management, reflects living with the lake, rather than forcing the lake to live with us.	13. Satisfaction of whanau with lake level management – including openings that allow for: <ul style="list-style-type: none"> a. Increased fish recruitment; b. Higher and fluctuating lake levels; c. Salinity maintained at a higher level than current regime allows; d. Longer duration of openings when required for fish values; and e. Allowing the lake to be tidal for longer periods of time. 	●
	14. The investigation of opening the lake at the southern end of Te Koru, in addition to, or instead of, the current site.	●
	15. Water quality (TLI)	●
The relationship between land use, groundwater, surface water and Te Waihora is recognised and provided for according to the principle of Ki Uta Ki Tai.	16. Groundwater quality	●
	17. Quality of drinking water at the marae	●
	18. % of land use change	●
The cultural health of lowland waterways is restored, through the restoration of water quality and quantity and riparian margins.	19. Water quality parameters	●
	20. Water quantity parameters	●
Wetlands and waipuna are recognised and protected as wāhi taonga, and there is an overall net gain of wetlands in the catchment.	21. Area of wetlands (ha) restored as habitat	●
	22. Yes / No and number of restoration initiatives spread across the catchment.	●
	23. Satisfaction of whanau with the level of protection afforded waipuna (springs)	●
All waterways have healthy, planted riparian margins, and are protected from stock access.	24. Index of Riparian Condition*	●
	25. Kilometres (%) of river/waterway length without stock access*	●
	26. Kilometres (%) and/or hectares of river/waterway length with riparian protection*	●
The discharge of contaminants to the lake and waterways in the catchment is eliminated.	27. Water quality parameters	●

*This measure is unable to be reported on at this time. However, in the interim we are able to draw on the assessments undertaken by whanau who, during 2011/2012, assessed sites in 16 streams across the Te Waihora Catchment

More information

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Discussion

Te Waihora/Lake Ellesmere – State of the Lake 2013

Kenneth J. W. Taylor, Environment Canterbury

At the time of the 2007 Living Lake symposium, assessments of the state of the lake by various experts, a number of whom have provided material for this report, were collated by Hughey and Taylor (2008). This represented the first attempt since the early 1990s to assess lake condition across a range of values, and to indicate, at least qualitatively (in many cases), the direction and magnitude of change in those values, over the preceding 15-20 years. In a synthesis at the end of the report, Hughey et al. (2008) concluded that:

Some indicators suggest a reasonable state of health, some show decline, and one indicates a part of the system (brown trout fishery) which has virtually collapsed. While the lake is probably in better health than some scientists would have predicted prior to this research, there are caveats, and actions needed to prevent further decline and lead to overall improvements...it is possible to conclude, and despite water quality and quantity issues and other management concerns, that the lake is a remarkably resilient system.

That was six years ago. Has sufficient time passed, and enough data been collected to confirm or update those conclusions? In that regard, Hughey et al. noted that lack of resilience to disturbances in the lake system could take years to manifest itself, citing lake level manipulation as an example of a disturbance which could take many cycles before adverse effects were observed.

For each of the nine topic areas summarised here, statements of “success” have been provided, along with descriptions of current state, usually updated from 2007, and a discussion of pressures and responses, or at least the identification of indicators that would usefully inform such analysis. In the table below I have taken the information on state (in the form of a key sentence or two from each summary) and posed two questions: does the summary provide sufficient information to compare state between 2007 and 2013, and if so, has there been a discernible change?

Value /topic area	Key finding	Sufficient data to compare state?	Has state changed? (~ = no change, + = enhanced/ improved value, -= degraded value)
Governance and management	<i>“This co-governance agreement establishes a dedicated framework for the active management of Te Waihora and its catchment. Te Waihora co-governance concerns the range of decision-making that directly relates to Te Waihora and its management and include joint oversight of Whakaora Te Waihora, co-drafting of statutory management plans for the lake and catchment, and the review of regional and Selwyn-Waihora Zone implementation programmes, as well as the appointment of commissioners”</i>	Yes	+
Land use and land cover	<i>“Notable changes in land use between 2003 and 2013 can be summarised as follows: drystock farming (sheep and beef, beef, deer) decreased; cropping and horticulture decreased; forestry decreased; contract grazing increased; lifestyle blocks increased; dairy farming increased”</i>	No	?
Economy	<i>“Economic activity in Selwyn is buoyant, driven by population increase, new businesses commencing, enterprise conversions to dairy farming, business expansions”</i>	Yes	+
Water	<i>“Te Waihora continues to be a lake under considerable pressure from surrounding land use, both near and far from the lake edge. The state of ecological health (as measured by invertebrate monitoring) continues to be poor in streams across the catchment and although the lake TLI has improved slightly, it would be difficult to say this is a significant improvement.”</i>	Yes	+ for some aspects - for others ? Overall
Vegetation and wetland habitats	<i>“In the years since 2007 there have been higher inflows and more frequent lake openings than in the early 2000s. These will likely have reversed the trend of reduced lake salinity recorded in the years leading up to the 2007 survey... Effects of these recent events on lake shore vegetation are yet to be assessed”</i>	No	?
Wildlife	<i>“Overall, the state of the bird indicator species (apart from bittern where we do not have appropriate data) which represents the range of guilds present at the lake, seems to be good, but with a high degree of variability present. Three of four lizard species on Kaitorete Spit appear in good health...”</i>	Yes (for birds)	+
Fish	<i>“Although there are a good deal of data available on different aspects of the fish populations and their habitats, there is a clear need for a coherent, consistent and integrated monitoring programme which gathers data on the size, distribution and abundance of key species”</i>	No (with possible exception of short-finned eels)	? + for short-finned eels?
Recreation	<i>“Te Waihora/Lake Ellesmere remains an important recreational resource in Canterbury, and for bird-watching is of international significance. However, most activities declined in the 1970s/80s and have remained roughly static since- the main exception being the increase in cycling (because of the Rail Trail)”</i>	No (except for cycling)	+ for cycling only
Assessment of cultural health	<i>Abundance of taonga species (including mahinga kai) is the ultimate indicator of cultural health. Populations of the indigenous fish species (eel, flounder, mullet and whitebait) may not be adversely affected currently as these species are tolerant of the current enriched state in the lake and appear to form productive populations if there is the opportunity for successful recruitment from the sea.”</i>	No	?

At face value, this summary suggests that, at least in the short term (i.e., over six years), there are no obvious indications of on-going deterioration in values or well-beings supported by the lake and its environs. However, lack of progress in addressing cultural health outcomes is a reminder that the current state of the lake disenfranchises Tangata Whenua. Moreover, as noted above, in a complex system with inherent time lags, it may take a number of years for the consequences of processes of decline to become apparent.

Is there any cause for optimism? In 2007, Hughey et al. postulated three possible scenarios for the future of the lake and its catchment, each with a set of management actions. These, in increasing order of enhanced environmental outcomes, were:

1. *An improved status quo incorporating on-going management initiatives and their maintenance*
2. *A realistic and resilient environmentally enhanced future which is built around a set of achievable short, medium and longer term goals and is based on a compromise between the enhancement of "natural" values and technical and economic feasibility*
3. *An idealised future based on strict conservation principles."*

In the intervening years three significant policy responses, taken in combination, provide an approximate match to the actions specified for Scenario 2. Outcomes for this scenario include improvements to Ngāi Tahu values, indigenous vegetation, indigenous fisheries, wildlife, recreational fishing, and water quality and quantity. Full implementation of the policy initiatives as currently specified would support all of these outcomes. The policy changes are:

- Amendments to the Water Conservation Order for the lake to provide for a wider range of values to be managed for, including indigenous fish. A new lake opening consent (held jointly by Ngāi Tahu and Environment Canterbury) will give effect to the opportunities provided by the order.
- Whakaora Te Waihora, a joint initiative of Ngāi Tahu, Environment Canterbury and the government, is a five year project, which commenced in 2012, with the aim of restoring lowland tributary streams and riparian habitats, restoring and enhancing specific cultural sites and mahinga kai, improving catchment management practices, and monitoring and investigations to help promote adaptive management. A number of these investigations encompass, at least in part, research needs identified by Hughey et al. (2008).



- The Canterbury Water Management Strategy has provided a framework for the development of the Selwyn-Waihora management zone implementation programme. One outcome of that programme is the development of a "sub-regional" plan for the management of the water and soil resources of the zone. This plan sets water quality and quantity limits for the lake and catchment and has an associated work programme to address lake and tributary issues, which are consistent with Whakaora Te Waihora aims and actions.

Realisation of these policies and programmes will make significant steps towards a "resilient, environmentally enhanced future" for the lake and its catchment. Future assessment of state, pressure and response indicators of lake values, such as those identified in this report, should reflect that progress.

More information

Additional information and links are available from the WET website.

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