When Two Worlds Collide:

Mātauranga Māori, Science and Health of the Toreparu Wetland

A thesis submitted in partial fulfilment of the requirements for the degree of

Master of Science

at

The University of Waikato

by

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KO TE TANGATA

THE UNIVERSITY OF WAIKATO

Te Whare Wānanga o Waikato

2014

Abstract

Much of our understanding of wetland health and function comes from scientific-based monitoring and methodologies. However, there is a wealth of knowledge to be gained from Māori-value based assessment methods for monitoring wetlands in New Zealand. I used the Wetland Cultural Health Index (WCHI) and a variety of scientific wetland survey methods to examine how these two approaches complement each other. For this research, I worked with the people from Mōtakotako marae at the Toreparu wetland (Waikato), developing a set of site specific cultural indicators.

Comparative analysis revealed a range of similarities and differences between the WCHI indices and scientific parameters. We found that as Wetland Cultural Health Measure (WCHM) scores increased, there was also an increase in dissolved oxygen concentration, SQMCI-sb values, and total nitrogen concentrations. Cultural indices provided an overall indication of site health. It was apparent, however, that scores of contributing indicators could vary markedly at any one site. As such, high scores for some indicators (e.g., vegetation values) may obscure low values for other variables (e.g., water quality), providing an index that depicts site health as being of average condition.

Capacity and resourcing issues were also highlighted as being an issue for Māori to be able to successfully carry out wetland monitoring, but also for staff in councils and other research and environmental governing bodies to build and maintain relationships with tangata whenua. Other challenges around site access provided a unique opportunity to develop and trial new WCHI assessment techniques. The use of video assessment to carry out WCHI monitoring was of varying success. Indicators that could be scored by visual assessment were useful, but indicators that relied on sound or felt sensation were difficult to assess. The use of mauri (life force) as an indicator had benefits when applied to the whole catchment, but the volunteer participants challenged its validity when used at the smaller site scale. Volunteers found assigning a numerical value to mauri very difficult,

and felt that reducing mauri to a single number may diminish the significance of this holistic and metaphysical concept. Mauri has been used successfully as a measure of environmental health but it is important to communicate and understand what mauri is and why it is measured.

Overall, the WCHI provided a wealth of information that could not be captured through scientific sampling, such as the presence of dye source, loss of bird/fish species and baseline information on the past condition of the Toreparu before the surrounding land was converted for agricultural use. This confirms that our understanding of wetland health is enhanced through the inclusion of cultural values.

As the New Zealand government and Māori move towards a future of collaborative research and management of freshwater ecosystems, there is a need for greater understanding around cultural values and priorities. By using both scientific and Māori-value based wetland monitoring methods, Māori can articulate a range of values, goals and priorities to help inform environmental decision makers and empower iwi and hapū to have a meaningful and sustainable role in the management of wetlands. There needs to be a foundation of mutual understanding and relationships built between environmental governing bodies and Māori for the future success of collaborative research and management of New Zealands wetlands.

Acknowledgements

I have so many people I want to thank as I could not have done this project alone. First, I would like to thank Mōtakotako marae. The marae has been a huge support, even before this work began. And I absolutely could not have done this without your guidance and knowledge. I have been partial to information and stories that are very special and see the Toreparu and surrounding landscape in a new light. I hope this thesis and future work at the Toreparu does some justice to the information you have shared. And to Heather, I cannot thank you enough. Ngā mihi māhana, ngā mihi aroha ki a koutou.

To my wonderful supervisors, Ian and Shaun, your guidance, support, comments and insights were critical to this project. Ian, you made sure I was clearly communicating, what is a challenging and new topic, to the scientific audience and I really appreciate your clear and constructive comments. Shaun, your passion and knowledge as a Māori researcher has been amazing. Always sending me the latest literature, reassuring me that what I had to say was not stupid, and providing constructive feedback all the way through. I feel really lucky to have been your first student, and to be continuing the journey as work colleagues.

To my wonderful whānau, Mum, Dad, Granny, Te Kawa and Moana. You have all been there for me, always providing positive reassurance and sometimes the much needed home truths. But always encouraging me to keep going, even when its hard. Especially you mum. Your determination and commitment as a Māori researcher, to do good things for our people is an inspiration. I feel so blessed to be part of our whānau, especially when the going gets tough.

And to all my beautiful friends and support crew near and far. Thank you all for keeping me sane, listening to me talk about a topic you probably didn’t understand half the time, for accepting me as a wetland nerd and helping me out with donations of food, drink, support and encouragement from start to finish. In particular, I want to thank my amazing friend

Rebecca. Without you, I would probably still be fluffing around not knowing where to begin. You went out of your way to show me what to do in the field, shared your incredible wealth of knowledge on wetlands and provided an understanding and supportive home environment. I don't know what I would have done without you.

To the staff at Kessels Ecology, you have all been amazing, particularly Gerry. You gave me the time and support as an employer and friend to begin the MSc journey, always encouraging me and pushing me to do my best. I am forever grateful for that. The staff at Landcare Research, you have gotten me to the finish line. Thank you for seeing potential in me as an emerging Māori researcher and providing me with a space and the support to get through. Especially you Garth. As your work was a major catalyst to this project, I feel blessed to be working alongside you and appreciate everything you have done, from the beginning. I look forward to contributing to the work this organisation does, and working alongside people that I hold in such high regard.

And last, but definitely not least, I would like to thank the funders of my scholarships. The University of Waikato and Te Pūtea Whakatupu, thank you for the financial and moral support. It definitely helped me to get to where I am and I am so grateful for that.

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Glossary of Terms

Māori term	Meaning
Hapū	Sub-tribe
Iwi	Tribe
Kaitiaki	Guardians who practise kaitikitanga/ resource managers
Kaitiakitanga	To exercise guardianship of the environment and tikanga/ resource management
Kaumātua	Elder
Kaupapa	Topic/ agenda
Mahinga īnanga	Whitebait collecting
Mahinga kai	Place of food harvest/ gathering
Marae	Social cultural centre/ village
Mātauranga Māori	Māori knowledge
Mauri	Tangible and intangible life force
Pākehā	NZ European
Pā site	Habitation area
Pā tuna	Eel weir
Rāhui	Restriction
Raranga	Weaving
Rāwaho	Outsider/ person from elsewhere
Rohe	Tribal are
Tangata whenua	People of the land with ancestral links to an area
Taonga	Something treasured, iconic, highly valued
Tapu	Sacred
Te Ao Māori	The Māori world view
Tikanga	Customary rules/ values and practises
Tohu	Sign/ signal
Tuna	Eel
Wāhi taonga	Location of taonga
Wāhi tapu	Sacred site
Wai	Water
Wānanga	Discussion/ seminar
Whakapapa	Geneology
Whānau	Family

1. Personal Background

Ko Putauaki, ko Mauao ngā maunga
Ko Ōhinemataroa, ko Waikareao ngā awa
Ko Ngāti Pūkeko, ko Ngāi Tamarāwaho ngā hapū
Ko Ngāti Awa ko Ngāti Ranginui ngā iwi
Ko Mahuru Robb e tu nei
Tēnā tātou katoa

The best way to introduce this Masters research is by introducing myself. This project both begins and carries on beyond the confines of this document, as a physical manifestation of a personal journey. The challenges faced with this subject matter and the process of producing these words, are paralleled. The investigation of mātauranga Māori and science is very much a reflection of a journey within myself as a young woman with Māori and Pākehā parents, being educated and working as a freshwater scientist, living in New Zealand (Aotearoa) today. As I come to find peace within myself, so too I find peace within two conflicting world views through common goals, redressing balance and mutual respect for fundamental differences. This really is a story of how my two worlds collide.

I started on the education path at kōhanga reo in Wellington. Due to difficulty getting to the kura kaupapa in Seatoun, I attended Mt Cook Primary School then went on to Wellington Girls' College. I studied a BSc at the University of Otago and took some Māori papers over my 4 years there, with a 6-month exchange at the University of Toronto in my last year. At this point in my study and work life, my Māori world and mainstream Pākehā world did not directly mix.

It wasn't until I started working as a consultant ecologist here in the Waikato that I started to see some real power imbalances but did not know of any ways to help change that. Then I went to my first Freshwater Sciences Society conference in Christchurch in 2010, attending the stream of Māori scientist's talks – it absolutely blew me away. For the first time, I saw Māori scientists out there finding a balance between science and mātauranga Māori. As Gail Tipa spoke about cultural health indicators, I knew that I wanted to do this kind of work. The orbits of my two worlds were starting to meet.

Through my work as a consultant ecologist, I started to see a real communication gap when it came to the resource consent process and the ongoing monitoring that was carried out. Both Māori and local governing bodies were saying that there was a lack of Māori involved in freshwater monitoring, but were uncertain of how to change this. In reality, there was almost no Māori input and even less ongoing participation in freshwater management and monitoring in the Waikato. Staff from regional councils and the Department of Conservation identified this as a communication and knowledge gap in their respective organisations. In my time working with this consultancy, I came across only one example that had "involvement and training of local iwi" as one of the consent conditions, and at that point this condition was being breached. This is where the topic of my thesis started to evolve. I had a passion for freshwater and wetland environments, a toolkit (the Cultural Health Index), and a potential study site at the Toreparu wetland.

I have a personal connection to the Toreparu wetland, through my mother's partner, who is also the chair of the Mōtakotako marae environment committee. I spent the majority of my childhood holidays at the Toreparu wetland and stream, catching eels and white-baiting. I always wanted to give something back to the area and felt this research could be one way to do that. I talked to members of the marae who highlighted their desire to restore the Toreparu after many years of degradation attributed to surrounding land use and pest invasion. I gained the full support of the marae members, which was the foundation for the success of this project.

The parallels I see with the chronological process of mātauranga Māori being given the rightful platform alongside scientific methods for environmental monitoring are evident in my story above. An inherent knowledge and understanding of the environment was diminished or, in some cases, lost through disconnection as a result of land loss, loss of kaitiaki rights through policy and process, and through the power inequality between the European and Māori viewpoints. Since the mid-1990s, however, there have been positive steps in the right direction with regard to Māori values being used for environmental monitoring and management. I wanted to understand what this looked like not only at the practical level, but how we communicate different values across world views.

1.1. Research Outline

My thesis begins by reviewing current literature on scientific methodology and tools that have been developed to assess the health of freshwater and wetland environments. Advances in technology and the development of robust survey and monitoring techniques provide us with a wealth of knowledge on the health and function of freshwater systems. I also review current literature on Māori value-based environmental monitoring tools. I summarise the historical context and concepts that underpin kaitiakitanga and the effects of colonisation, policy, and legislation on kaitiakitanga. I discuss how Eurocentric processes have challenged mātauranga and the role of Māori in environmental management and monitoring, and suggest positive steps towards redressing this balance through the development of Māori value-based tools and formal recognition in policy. Using this information, the relevant tools and methodology were chosen.

A kaupapa Māori methodology, based on Māori self-determination and cultural aspiration principles, was the overarching framework used for the mātauranga Māori aspect of this research. Kaupapa Māori research is presented by Smith (2012) as the following:

- Is related to being Māori;
- Is connected to Māori philosophy and principles;
- Takes for granted the validity and legitimacy of Māori, the importance of Māori language and culture; and
- Is concerned with the struggle for autonomy over our own cultural well-being

Under the kaupapa Māori umbrella came the Wetland Cultural Health Indicator (WCHI) toolbox, which was chosen by Mōtakotako marae as their preferred method of wetland assessment. Indicators identified by tangata whenua for the WCHI assessment, guided the selection of corresponding science methods were chosen and discussed in more detail in the methodology chapter. Six main sites and six sub-sampling sites were surveyed within the Toreparu wetland between July and November 2013.

The results chapter examines the outcomes of the cultural and scientific surveys. Flora, fauna, biophysical and cultural aspects of the Toreparu were surveyed, and data were presented in a series of graphs and tables. A comparative analysis was undertaken using Pearson’s correlation, and similarities and differences between results from the two methods of assessment were identified. The results highlight the necessity of implementing mātauranga Māori tools as part of wetland assessment, particularly for culturally significant sites such as the Toreparu wetland.

The discussion chapter investigates similarities and differences in results from both the WCHI and science results. This chapter also explores issues and challenges with the methodology and the research process, identified throughout this project either by myself or by the volunteer participants from Mōtakotako marae. The points discussed in this chapter highlight the need for a collaborative approach to wetland monitoring and management and the benefits of including multiple bodies of knowledge.

2. Wetlands in New Zealand: Their Importance, the Value of Good Science and How to Protect Them

2.1. Introduction

Much of the understanding of wetland health and function is based on science-based research and methodologies. In the global context, many of the world's wetlands are under threat from drainage and conversion to agricultural and horticultural use or pressure from urban development (Finlayson, Davidson, & Stevenson, 2001; Junk et al., 2006). Due to changes in physical and hydrological regime, combined with invasion of exotic species, many of the world's largest wetlands (e.g. Canadian Peatlands, Kakadu National Park and Okavango Delta) have low numbers of endemic species (Junk et al., 2006). In New Zealand, there has been a large decline in both the quantity and quality of wetlands, particularly in the Waikato (B. Clarkson, Merrett, & Downs, 2002; Leathwick, Clarkson, & Whaley, 1995).

Chapter two looks at why wetlands are important, how science has informed our understanding and appreciation of wetland habitats, and examines current environmental policy and legal recognition of wetlands and how these mechanisms seek to protect and enhance wetlands, mainly in the Waikato. The formal recognition of the importance of wetlands by national and local governing bodies is supported by an increased number of research and monitoring projects. Community-led restoration projects appear to be gaining momentum, which has driven development of easy to use guides and toolkits. Unfortunately, there are currently no formal guides or easy-to-use resources for cultural monitoring tools, so many of these community projects lack mātauranga Māori input or ongoing engagement.

2.2. The Importance of Wetlands in New Zealand

Wetlands are considered to be one of the most important aquatic ecosystems (B. R. Clarkson, Sorrell, et al., 2004). Wetlands function to improve water quality, control floods, regulate global carbon levels and provide habitat for a diverse range of plants and animals (B. R. Clarkson, Sorrell, et al., 2004; Harding, New Zealand Hydrological Society, & New

Zealand Limnological Society, 2004). Since the arrival of Europeans in New Zealand there has been a huge decline in wetland habitats (B. Clarkson et al., 2002; B. R. Clarkson, Sorrell, et al., 2004; Harding et al., 2004; Watts, Rohan, & Thornburrow, 2012), which has put many wetland species on the New Zealand threat classification system list (Hitchmough, Bull, & Cromarty, 2007; Watts et al., 2012) and led to a decline in water quality in many of our rivers, streams and lakes (Harding et al., 2004). These are trends that are also recognised as global issues, as many of the world’s wetlands and the species that reside in them are under threat (Finlayson et al., 2001; Junk et al., 2006). Advances in scientific understanding have shed light on a huge range of issues affecting our freshwater systems, including our wetlands, and have provided knowledge on how to restore and manage aquatic ecosystem function (Harding et al., 2004). A basic understanding of how freshwater systems function is fundamental to good management (Harding et al., 2004).

Understanding the importance of wetlands and the function of wetland environments has propelled the humble ‘swamp’ into the spotlight over the last two decades. What were once viewed as a ‘waste of space’ and hindrance to the booming agricultural industry in New Zealand, are now the focus of many research projects nationwide (B. R. Clarkson, Sorrell, et al., 2004; G. Harmsworth, 2002; Kessels, L., Thomson, & Thorpe, 2005; Landcare Trust, 2014; Robertson & Suggate, 2011; Watts et al., 2012). A few examples of recent wetland research projects range from community initiatives such as the Waikawau Bay Wetland Restoration Project (Moehau Environment Group, 2013), regional council led projects such as the scoping study of the Toreparu wetland (Kessels et al., 2005) and the Rotopiko Lake project (Frimmel, 2010), to large scale projects that are run by the Department of Conservation, such as the Arawai Kākāriki Project (Robertson & Suggate, 2011). Projects like these provide a wealth of knowledge, assisting in the successful management of wetlands in New Zealand.

2.1. Science and our Understanding of Wetlands

Much of our current understanding on wetland function and health is from science-based studies. Scientific understanding follows a pathway from definitions to theory to validation or application using data to test hypotheses (Harding et al., 2004). The ability to collect detailed information has been advanced through development of new technology and collection methods. Technology has allowed more robust data collection and the larger volumes of data to be collected, sometimes without the need for 'man-power'. Methods of data storage, transmission and analysis have been critical in the advancement of scientific knowledge. Remote sensing technology (Allan, Hamilton, Hicks, & Brabyn, 2011) and data loggers (Young, Quarterman, Eyles, Smith, & Bowden, 2005) are two examples that have allowed scientists to continuously monitor freshwater habitats and their surrounds with reduced physical effort, and may be applied to wetland habitats.

The scientific tools for monitoring the health of freshwater bodies and wetlands have been researched and developed both globally and in New Zealand by multiple public and private organisations. A brief overview of current freshwater monitoring methodologies and research projects provide examples from government entities such as the Ministry for the Environment (MfE) (B. Biggs & Kilroy, 2000; Stark & Maxted, 2007; United Nations Environment Programme, 2004), the Department of Conservation (DOC) (D.G. Dawson & P.C. Bull, 1975; Department of Conservation, 2010), Landcare Research (B. R. Clarkson, Sorrell, et al., 2004; Leathwick et al., 1995), the National Institute of Water and Atmospheric Research (NIWA) (Clayton & Edwards, 2006), and local governing bodies such as the Waikato Regional Council (K.J. Collier & Hamer, 2012; David & Hamer, 2010), and Auckland Regional Council (Lockie & Neale, 2012). These documents include protocols and methods for monitoring fish, birds, aquatic invertebrates, water quality, aquatic plants and periphyton, vegetation, and physical habitat. The methods used depend on the habitat and species that are being studied, or the aims of the research. In general, the 'Handbook for Monitoring Wetland Condition' (B. R. Clarkson, Sorrell, et al., 2004) is commonly used and can be combined with survey methods for fish (David & Hamer, 2010; Ling, O'Brien, Miller, & Lake, 2009), birds (Department of Conservation, 2010; O'Donnell, 2012; O'Donnell & Williams, in press) and invertebrates (Suren & Sorrell, 2010), which are discussed in more detail below and in Section 5.4. It is important to note that as new technologies and techniques are discovered, these methods continue to be refined and developed.

A variety of methods for assessing wetlands exist, though many of them were not developed specifically for wetlands, but for generic population monitoring methods, such methods developed for vegetation (R. B. Allen, 1992), birds (D.G. Dawson & P.C. Bull, 1975), fish (McDowall & Richardson, 1983) and various water quality testing methods. A ‘Handbook for Monitoring Wetland Condition’ (B. R. Clarkson, Sorrell, et al., 2004) compiled methodologies for surveying vegetation, substrate, foliage, water quality, pest species along with physical and hydrological features of wetlands. This handbook was produced as part of a larger ‘*Coordinated Monitoring of New Zealand Wetlands*’ project for the Ministry for the Environment (Ward et al., 1999). It was through this project that the development of Māori wetland indicators began (G. Harmsworth, 2002), which signalled a new vision for Māori engagement and involvement in monitoring of freshwater environments, which will discussed in detail in Section 5.3.3.

2.2. Threats to Wetlands in the Waikato

In the Waikato, there has been a significant reduction in wetland habitats (Leathwick et al., 1995). The protection and rehabilitation of remaining wetlands is of regional priority. Leathwick *et al*. (1995) provided a detailed report on the change in vegetation cover and type in the Waikato region between 1864 and 1995. Wetlands once covered 4% of the Waikato region according to data from 1840. Data from 1995 suggests that wetlands now cover around 1%, with much of this in the Hauraki and Meremere ecological districts (Leathwick et al., 1995).

The total area of freshwater wetlands that has been lost in the Waikato region is approximately 79,356ha (Leathwick et al., 1995). The ecological districts with the greatest loss of wetland habitat were Meremere (12,123 ha), Hauraki (16,076 ha), Waipa (3,383 ha), Hapuakohe (349 ha) and Hinuera (467 ha). The Hūnua, Raglan and Pureora ecological districts had a combined loss of 149 ha. The Hamilton ecological district had the greatest loss of wetland habitat, with a reduction of 51,045 ha between 1840 and 1995. Habitat destruction has been identified as the primary environmental cause of biodiversity decline at local, regional and global scales (Dobson, Bradshaw, & Baker, 1997). This is a trend that is still observed today in the Waikato (B. Clarkson et al., 2002).

For swamps such as the Toreparu wetland, drainage is one of the greatest threats. Swamp wetlands are relatively scarce in the Waikato as they were never as extensive as restiad bogs prior to the arrival of Europeans (Watts et al., 2012). Due to their physical and hydrological qualities, they were also the easiest to drain and convert to grazed pasture (Watts et al., 2012). Although our understanding of wetland function and their importance increases, wetlands are still at risk of drainage and infilling, particularly in the Waikato where farms are being converted to intensive dairy regimes. The operative Waikato District Plan seeks to address this issue and acknowledges that “drainage and riparian vegetation clearance continues to pose a threat to wetlands” (Waikato District Council, 2013).

Wetlands in the Hamilton and Waipa Ecological Districts have been almost entirely drained for agriculture, with less than 1% now remaining (Leathwick et al., 1995). Much of the loss of wetland habitat in the Waikato has been attributed to increased development both in the urban and rural setting (B. Clarkson et al., 2002). The spread of urban development around Hamilton City and surrounding provincial towns has seen the clearance or degradation of many wetlands (Leathwick et al., 1995). Hamilton city itself has a network of gully systems that connect to the Waikato River. Within these gullies are stands of indigenous vegetation, streams and wetland environments that provide habitat for a diverse range of flora, bird species and the nationally vulnerable long-tailed bat (*Chanilobus tuberculata*) (O'Donnell, Christie, Hitchmough, Lloyd, & Parsons, 2010). Infilling and drainage of gullies, including wetlands, has been an issue associated with urban development and results in a direct loss of habitat and biodiversity. As awareness around the importance of these habitats increases, the Hamilton gully system has been a focus of restoration efforts since 2000 (B. D. Clarkson & McQueen, 2004; Wall & Clarkson, 2006).

Another threat to wetlands, is the increased nutrient inputs from surrounding land-use, particularly from agricultural land (B. Clarkson et al., 2002). As noted above, the conversion to high intensity dairy farming not only results in the direct loss of habitat and riparian margins, but can lead to eutrophication of these delicate ecosystems (Harding et al., 2004). This can result in the invasion of woody vegetation such as willows (*Salix* spp.) (B. Clarkson et al., 2002; B. R. Clarkson, Schipper, & Lehmann, 2004), as seen at the Toreparu wetland. These tall invasive species can quickly dominate the canopy and displace lower growing native plant communities which can have negative impacts on some native invertebrates, birds and fish species. For example, in a study of how beetle communities respond to grey willow invasion, beetle communities were found to shift in response to vegetation change (Watts et al., 2012). Wetlands with native vegetation had higher proportions of native beetles, and willow dominated wetlands had more introduced beetle species (Watts et al., 2012).

The loss of wetlands and changes in wetland function have multiple negative effects on ecological integrity (B. R. Clarkson, Sorrell, et al., 2004; Harding et al., 2004), so a halt to any further decline in both wetland quality and quantity is critical. In the Waikato region, the loss of wetland and forest habitats has been recognised and steps towards effective management and protection are being taken. This has been carried out through the Waikato Regional Plan (2011) and Regional Policy Statement (2007) which provide some legislative support for halting any further decline in wetlands and their condition.

The Waikato Regional Council, through policy and legislation, has responded to these threats and pressures by attempting to work in partnership with landowners and the community to manage land in ways that minimise negative environmental impacts on significant habitats such as wetlands. The council envisage working in partnership with landowners, interest groups and other agencies to further investigate significant indigenous habitats to inform decisions around the future goals and management of wetlands. (Waikato District Council, 2013). Protecting the integrity of existing wetland habitats is not just an issue for the Waikato, but a national issue highlighted in some of our high level environmental policies (Ministry for the Environment, 1991, 2013).

2.3. Protecting Wetlands through Policy

Wetlands have been acknowledged as not just regionally significant habitats in the Waikato, but habitats that are a matter of “national importance” (Ministry for the Environment, 1991). Wetlands are defined within the Resource Management Act as “permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions” (Ministry for the Environment, 1991). Wetlands have been recognised in the RMA as key environments worthy of protection. Legislation seeks to sustain the amenity and intrinsic values of these water bodies in their natural state, or be protected (Ministry for the Environment, 1991). According to the RMA (1991), wetlands are habitats considered to be “outstanding”. This prioritises wetlands as habitats that warrant protection from inappropriate subdivision, use and development.

In the Waikato Regional Plan, there are set criteria for water bodies, including wetlands, to be considered as “outstanding” habitats. The wetland must provide habitat for terrestrial or aquatic organisms, have fishery values, and have wild, scenic or other natural characteristics (Waikato District Council, 2013). Outstanding habitats may also be valued scientifically or ecologically or have recreational, historical, spiritual or cultural purposes (Waikato District Council, 2011). There are specific regulations and management practises proposed in local policy that enables these habitats to remain in their current condition. For example, amenity and intrinsic values are sustained through regulation of biotic and abiotic factors. This includes maintaining high water quality and sufficient water quantity to maintain integrity and function of aquatic habitats (Waikato Regional Council, 2007). This is preserved through the setting of flows, control of contaminant discharge, limiting the use and allocation of water and the maintenance of habitat to allow indigenous flora and fauna to persist (Waikato District Council, 2011).

More specifically, Objective 2.2.1 in the Waikato Regional Plan (2011) seeks to maintain and enhance indigenous biodiversity and the life-supporting capacity of indigenous ecosystems. The associated policies include the maintenance and enhancement of indigenous habitat through the creation of linkages and buffers. Wetlands are mentioned specifically in Policy 2.2.3 where "priority should be given to protecting and restoring threatened habitats and habitats of threatened species such as coastal and lowland forest, riparian areas, wetlands, dunes and peatlands" (Waikato District Council, 2011). Policy 2.2.5 also identifies that areas of significant indigenous vegetation and habitats, such as wetlands, require management to maintain long-term ecological functioning and biodiversity (Waikato District Council, 2011). The above policies are evidence of attempts by one council to conserve and protect wetland habitats. Even though there are clear policy objectives, there are challenges with regard to compliance and monitoring and some land owners continue to ignore the regulations as was seen in Piopio when a farmer drained an internationally recognised wetland for more pasture (Twentyman, 2012).

2.4. Current Wetland Research

In summary, we have discussed the importance of wetlands, how science is adding to the knowledge base around wetlands and how this information has assisted policy makers in prioritising wetland research and protection at the national and regional level, with a focus on efforts made by the Waikato Regional Council. But what does wetland research look like on the ground and in our communities? There are many success stories associated with wetland research in New Zealand, and more specifically in the Waikato. The numbers of research projects has increased as our knowledge of wetlands and their importance has also increased as touched on in Section 2.1. If we look more closely at some of the more well-known success stories, we see a variety benefits that have resulted from projects conducted at various spatial and temporal scales. The

Arawai Kākāriki Programme, Rotopiko Lakes, and Waikawau Bay Wetland project are some great examples of wetland research in action.

The Department of Conservation has identified three nationally important wetlands as part of the Arawai Kākāriki wetland restoration programme. One of these wetlands is located in the Waikato, the Whangamārino wetland. The aim of the wider project is to conduct research to guide wetland restoration and development of best-practise management and monitoring tools. The Arawai Kākāriki project has provided a wealth of information to help meet these objectives. The Whangamārino wetland has been a site where methods for assessing populations of matuku (Australasian bittern) (O'Donnell & Williams, in press) and fernbird (O'Donnell, 2012) has been tested, along with studies on hydrological manipulation (Blyth, 2011) and methods for monitoring black mudfish (*Neochanna diversus*) (Ling et al., 2009). As a national wetland project seeking to address best practise methodologies, involvement of Māori and application of cultural monitoring is essential. There are tangata whenua involvement in terms of consultation and approval at all sites, and ongoing involvement of Māori is an objective. Cultural monitoring is currently taking place at the Ō Tū Wharekai wetland, carried out by Ngāi Tahu (Sullivan, Robertson, Clucas, Cook, & Lange, 2012) but does not appear to be taking place at the Whangamārino wetland or Awarua-Waituna Lagoon.

2.4.1. Current Science-based Wetland Monitoring Tools

In the Waikato many of the smaller, council and community led wetland research projects have resulted in positive gains for biodiversity and wetland function. Through capacity building, education and reconnecting communities with their environments, there has been an increase in restoration projects led by communities. This has resulted in the development of tools and monitoring practises that do not necessarily require specialised technical training and/or expensive equipment. Clear and easy to follow guides such as the “WETMAK Wetlands Monitoring and Assessment Kit” (Denyer & Peters, 2012) and “Wetland Restoration: a handbook for New Zealand freshwater systems” (Peters & Clarkson, 2010), which provide communities with frameworks, methods and guidelines for restoring and monitoring wetland habitats.

Both these resources are primarily built for measuring and monitoring ecological and biophysical parameters, but do not include tools for monitoring wetlands using cultural values. The WETMAK guide does highlight and provide link to the WCHI and other Māori tools. The lack of easy-to-use cultural monitoring resources such as the WETMAK and wetland restoration handbook makes it difficult for Māori to partake in wetland monitoring from a cultural perspective or even know that such monitoring methods exist. By including cultural monitoring alongside scientific based methods, Māori too can build capacity and have meaningful engagement beyond consultation and/or providing a purely historical perspective on wetlands. I believe Māori monitoring and wetland assessment tools would enhance current projects and add new information to current scientific and community monitoring methods.

3. Mātauranga Māori and Environmental Management

Kei raro i ngā tarutaru,

ko ngā tuhinga a ngā tūpuna.

Beneath the herbs and the plants,

are the writings of our ancestors.

3.1. Introduction

The aim of this chapter is to provide a historical and contemporary context for Māori methods of environmental monitoring. First, I examine the fundamental values and world view that support Māori and our responsibilities as kaitiaki (resource managers). I look at what kaitiakitanga (resource management) looks likes today and the challenges that Māori face in the environmental space, particularly with regard to current legislative frameworks and policy. To do this, I have reflected on the historical context and power imbalances that persist, and how Māori can use the current system to exercise kaitiakitanga. This has led to the use of iwi (tribal) environmental management plans and other formal documentation that clearly define what kaitiaki rights and responsibilities are to tangata whenua groups. Due to the location of the Toreparu wetland (Te Mata, Waikato), there will be a focus on what kaitiaki rights and responsibilities mean for the wider iwi of Waikato-Tainui, and more specifically for the hapū (subtribe) at Mōtakotako marae. I will explore how Māori world views are communicated through the use of iwi/ hapū environmental management plans. From here, I review current Māori environmental monitoring tools, and the pros and cons of different methods that are available for Māori.

3.2. What is Mātauranga Māori?

To understand cultural monitoring of environments, there needs to be a basic comprehension of the fundamental concepts of Te ao Māori (the Māori world view), which underpins mātauranga Māori (Māori ways of knowing) in the environmental space. The holistic world view that Māori have, is what is missing from the current, science-based understanding of wetland health. By appreciating the Māori world view, I believe that scientists can start to see and accept the value that mātauranga Māori based monitoring tools bring to the bigger picture. Through this process of acknowledging and accepting, comes successful collaborative research and co-management of wetlands.

Māori see the world as interconnected and built on relationships; whether it is between people, place, with other species, everything is connected (Selby, Moore, & Mulholland, 2010). This holistic world view, with a solid foundation built on relationships, is the fundamental driver of tikanga (customs) and therefore the ways of knowing, or mātauranga. This can be explained by two key, underlying concepts. First, the concept of whanaungatanga (kinship), which describes these interconnected relationships between people, natural resources, place and bodies of knowledge. This is explained through whakapapa (genealogy) which can be thought of as the "practical manifestation of the kinship principle" (Waitangi Tribunal, 2011). Secondly, there is the value of kaitiakitanga which is often likened to resource management. This is not just a practical concept, but has a strong spiritual core that guides traditions and behaviours, summarised during the Waitangi Tribunal Case (WAI 262) when kaitiakitanga was described as being "a product of whanaungatanga – that is, it is an intergenerational obligation that arises by virtue of the kin relationship" (Waitangi Tribunal, 2011).

Mātauranga Māori has been loosely defined as Māori knowledge. There are other terminology used that can be associated with mātauranga such as māramatanga (to understand), mōhiotanga (to know) and akona (to learn) (Muru-Lanning, 2012). In the context of this research, all of the above concepts come under the wider umbrella of mātauranga. One definition that sums up mātauranga Māori to include the dynamic and evolving nature of knowledge (Joseph, 2008), while maintaining the values and ethics that underpin Te Ao Māori (the Māori worldview), has been summarised by Mead as:

> Mātauranga Māori is thus made up of a core of traditional knowledge plus the values and ethics that go with it and new

> knowledge, some of which we have added as a result of our discoveries and research, and some we have borrowed outright from western knowledge and from our experiences of living with exponents of other belief systems and other knowledge systems. We are now reshaping, rebuilding, reinterpreting and reincorporating elements of mātauranga Māori to make it fit the world that we live in today *(H.M. Mead, 2012, p. 14)*

As we begin to delve into what mātauranga Māori is, particularly in post-colonial New Zealand, we are confronted with issues around loss of knowledge and how we communicate mātauranga Māori within a resource management framework that more often than not, does not align with Te Ao Māori (Chambers, 2009; H.M. Mead, 2012; H.M Mead & Mead, 2003; Muru-Lanning, 2012). The current legislative framework around environmental management has strong roots in Eurocentric world views, which partly explains regular exclusion of Māori throughout the environmental planning and monitoring phases (Muru-Lanning, 2012). This is an issue that spreads beyond the confines of environmental management and monitoring. For the purpose of this study, I will solely focus on how mātauranga Māori is communicated within the environmental management context.

It is worth noting that there are continuing debates around what mātauranga Māori actually is and how it is both taught and learnt (Royal, 2012; Smith, 2012). There is extensive literature on this topic e.g. Mika (2011); Royal (2012); Smith (2012). However, further investigation of these debates is beyond the scope of this research.

3.3. Mātauranga Māori and Kaitiakitanga

Mātauranga Māori is a broader concept that describes Māori ways of knowing and relating to the world. If we look more specifically at the environment and the management of resources, the concept of kaitiakitanga is of paramount importance and guides the development of environmental monitoring tools. Kaitiakitanga is often roughly translated as guardianship or in some cases, resource management (M. Kawharu, 2000). Kaitiakitanga is much more than that, as it embraces not just environmental, but spiritual and social dimensions (M. Kawharu, 2000; Marsden & Henare, 1992; Selby et al., 2010) and “has its root deeply embedded in the complex code of tikanga” (Awatere in:R. Walker, Jojola, & Natcher, 2013). Kaitiakitanga is a collective role of protecting and guarding the mauri of particular taonga, which safeguards them for present and future generations (Tomas, 1994; Whangapirita, Awatere, & Nikora, 2003).

> Kaitiakitanga is not an obligation which we choose to adopt or to ignore; it is an inherited commitment that links mana atua, mana tangata and mana whenua, the spiritual realm with the human world and both of those with the earth and all that is on it (Selby et al., 2010, p.g 1).

Mōtakotako marae hapū have their own Iwi Environmental Management Plan, which was released in April 2008 (Mōtakotako Marae, 2008). The plan identifies key values for tangata whenua, including environmental resources, customary practises, places, events, relationships and taonga of significance. The document also discusses the significance of kaitiakitanga and implications for Mōtakotako marae. These values and goals were what helped shape this reasearch at the Toreparu and the choice of Māori monitoring tools used.

Mōtakotako state in their hapū management plan that “Kaitiakitanga is based on Māori values and tradition and is practiced by Māori people who are geneologically linked to the resource and recognised as knowledgeable about the resource and kaitiakitanga. The ethic of kaitiakitanga requires people to pause, reflect, discuss and demonstrate care for the environment and seeking to live in union with it” (Mōtakotako Marae, 2008). From this definition of kaitiakitanga, there are specific duties that kaitiaki from Mōtakotako marae are responsible for and can enforce. Kaitiakitanga practises can include the implementation of methods such as rāhui, mātaitai (reserves for non-commercial fishing management), tatau pounamu (peace agreements) and can involve kawa (protocols, practices and behaviours) that can provide for mutually acceptable agreements between affected parties (Mōtakotako Marae, 2008). The plan also provides guidance on consultation, including guidelines for councils, developers and land owners. This includes information on who to talk to, when to consult, why and how the consultation process will occur when dealing with Mōtakotako marae hapū.

This intricate knowledge of the environment and everything in it, combined with Māori concepts of whakapapa and whanaungatanga guided kaitiakitanga which ensured balance and sustainable harvest of natural resources (Williams, 2001). However, this was not well understood by many of the early European settlers. What appeared to be lush forests, abundant fish and bird life, convinced many that these resources were easily taken (Marr, Hodge, & White, 2001). This mentality, combined with the very European concept of 'unproductive' forests requiring conversion to agricultural and horticultural lands, led to the destruction of much of the native forest, forest species and huge declines in populations of our aquatic species and their habitats (B. Clarkson et al., 2002; Harding et al., 2004; Hitchmough et al., 2007).

The relationship between Māori and the environment is one that has developed since arrival to New Zealand. Māori customary law and practises with regard to the natural environment, otherwise known as kaitiakitanga, has been modified and developed from ancestral knowledge from our Polynesian heritage and adapted to life in New Zealand (Marr et al., 2001; H.M Mead & Mead, 2003). Kaitiakitanga practises continued to evolve in New Zealand, utilising natural resources while constantly changing, adapting and responding to new needs, challenges and ideas (Marr et al., 2001). Through this process, Māori gained broad knowledge of the biotic environment including detailed information on flora and fauna species, such as seasonal patterns and life history stages (Marr et al., 2001). This, coupled with an understanding of the physical environment, weather patterns and celestial knowledge informed Māori practises and tikanga to successfully manage and monitor species and their habitats (Selby et al., 2010).

One widely known example of tikanga associated with kaitiakitanga and conservation is the practise of rāhui (ritual prohibition), when a resource or area is set aside from normal use, or made tapu (sacred) (M. Kawharu, 2000). The conservation rāhui was used to protect and restore the products of the land and water (H.M Mead & Mead, 2003), allowing the mauri (life force) and physical dimensions to be restored (M. Kawharu, 2000). There are oral traditions around rāhui that were used to conserve taonga species pre-colonisation, with many of these practises still carried out today. One example of this is from a whakatauki (proverb) from Te Matau-a-Māui (Hawkes Bay). "Ka pa a Tangitu, ka huaki a Maungahahuru, ka pa a Maungahahuru ka huaki a Tangitu… When Tangitu (the deep-sea fishing ground off Tangoio) is closed, Maungahahuru (a mountain range prolific in bird life) opens, when Maungahahuru closes, Tangitu opens" (M. Kawharu, 2000). This whakatauki describes a seasonal rotation of resource use which is one way of ensuring species have time to recover. Such practises were, and still are, commonly used across New Zealand with variation between iwi, hapū and even whānau groups.

There has been documentation of rāhui being carried out during the earlier years of colonisation. Though there is much controversy surrounding the works of Elsdon Best, his documentation of rāhui does provide some insight to life in New Zealand during the early years of Pākehā contact. He described the use of a pou rāhui (rāhui post) or marker that may be painted with ocre, a bunch of ferns or suspending a garment belonging to the local chief as a sign the area was under rāhui (Best, 1904). Otherwise, the message was sent orally (Best, 1904). Best also described situations under which rāhui occurred, including times when the productivity of the land, forest or water had decreased (Best, 1904). Best recounted that "the caretaker of the rāhui will fetch the kapu from it's place of concealment, and bear it to the ahi taitai, a sacred fire much used in olden times in rites connected with the forests and waters, and their productions, with first fruit ceremonies, and rites performed in order to retain the vitality, health vigour, etc, of man, lands, birds and fish" (Best, 1904). The local tikanga surrounding rāhui was generally well understood by tangata whenua as part of everyday life pre-colonisation and during the early contact years. However, with a shift in population dynamics and power around resource management in contemporary New Zealand, Māori are having to adapt how we communicate and assert our kaitiaki rights. The creation of iwi or hapū Environmental Management Plans is one example of this which will be discussed later in Section 3.5.1.

3.4. Challenges for Mātauranga Māori in the Environmental Space

Much of New Zealand's Eurocentric policy and legislative frameworks have led to the disempowerment of Māori in environmental management and monitoring. Marginalisation through alternate values and knowledge systems have thus far prevented meaningful engagement and dialogue between Māori and Pākehā knowledge systems (Joseph, 2008; Tipa & Welch, 2006). Through a combination of legislation and social inequality, Māori values, issues and knowledge have been undermined and diminished (Hall, 2012; H.M. Mead, 2012; Selby et al., 2010).

> This clash of cultures remains, with Māori communities smarting from the impact of one hundred and seventy years in a democratic system which is resolute in practising a 'majority rules' version of democracy. Māori kaupapa and values have been smothered as the development of New Zealand and the decisions made about the value of the environment by local and regional councils have done more damage to the environment in that one hundred and seventy years than was done in the previous one thousand years prior to occupation by the descendants of British and European colonists (Selby et al., 2010, p. 2).

There have been some positive steps in the right direction, particularly in recent years, to acknowledge kaitiaki rights and responsibilities in current environmental policy and legislation. Commitments have been made by some local governing bodies, for example the Waikato Regional Council (Waikato District Council, 2013), Auckland Council (Auckland Regional Council, 1999) and Greater Wellington Regional Council (Wellington Regional Council, 1999), to work in partnership with tangata whenua with regard to environmental management.

There are a number of examples that demonstrate the lack of recognition of Māori values historically in planning and policy. Before discussing the contemporary context surrounding environmental policy and mātauranga Māori, I think it is important to briefly touch on the history and the colonial mechanisms which have alienated Māori from mainstream environmental management. I will focus on Te Tiriti o Waitangi (The Treaty of Waitangi) as the founding document for collaborative management and some of the issues around this. This is only a brief summary of Te Tiriti, and what is a very complex and dynamic subject. There is extensive literature available by researchers such as Claudia Orange, Ranginui Walker and Ian Kawharu who have written about the historical and legal aspects of the Treaty. For further reading see Orange (2011), Walker (2004) or Kawharu (1989).

The 1970s and 1980s heralded the Māori Renaissance, when Māori challenged the Crown to honour Te Tiriti in legislation (Orange, 2011; R. Walker, 2004) and vocalised the need for engagement over a multitude of issues, including environmental issues. This was seen in the Waitangi Tribunal Claim process through well known cases such as the Manukau Claim (Waitangi Tribunal, 1985). Eventually, this helped shape current national policy on environmental management such as the Resource Management Act (Ministry for the Environment, 1991). Once the national context has been discussed, the focus will move on to examples from the Waikato, particularly Māori led initiatives around freshwater management, iwi and hapū environmental management plans and relationships between local governing bodies.

3.4.1. Te Tiriti o Waitangi

The signing of the Te Tiriti o Waitangi (The Treaty of Waitangi) in 1840 was a significant moment in time for both Māori and Pākehā in New Zealand. In terms of environmental management, Article Two was considered significant as it supposedly outlined that Māori would have exclusive and undisturbed possession of properties (Marr et al., 2001; Orange, 2011; R. Walker, 2004). And in the Māori text, the guarantee is of ‘te tino rangatiratanga o rātou taonga katoa’- translated as Māori authority and control over all treasured things (Orange, 2011; Waitangi Tribunal, 2011). However, land and resources were lost through legislation, confiscated by the Crown and retained or sold to Pākehā settlers both before and after the signing of the Treaty (I. H. Kawharu, 1989). The impacts of alienation from land are still felt today.

Disconnection with the land goes far beyond the physical removal from ancestral area; it affects the spiritual, mental and physiological aspects of Māori (Waitangi Tribunal, 2011; Williams, 2001). Connection with the environment is a huge aspect of identity and indigeneity. Mason Durie (2005) describes five secondary characteristics of indigeneity that are influenced by relationship with place or the environment:

> The first of these characteristics reflects the dimension of time and a relationship with the environment that has endured over centuries; the second, also derived from the environmental relationship, is about culture, human identity, and group structures and processes that celebrate the human– ecological union. The third characteristic is a system of knowledge that integrates indigenous worldviews, values, and experience, and generates a framework for a distinctive environmental ethic. Application of that ethic to natural resources provides a basis for the fourth characteristic, economic growth balanced with environmental sustainability. Finally, indigeneity is also characterized by a language so strongly influenced by the environment that it is not spoken as a first language in other parts of the world (Durie, 2005).

Loss of indigenous knowledge is an issue that is well documented in New Zealand. The loss or degradation of mātauranga Māori with regard to the environment can be attributed to disconnection with the land. The environment can be thought of as the foundation for knowledge, influencing attitudes and patterns of thinking (Durie, 2005). Many of the details on the effects of land loss and alienation from tribal lands came out during historic land court hearings, and more recently during Waitangi Tribunal claim hearings.

3.4.2. Waitangi Tribunal Cases

One of the landmark Waitangi Tribunal Cases was 'The Manukau Claim (WAI-8)' (Waitangi Tribunal, 1985), brought forth by Nganeko Minhinnick. The claim compiled experiences and evidence from multiple hapū groups around the Manukau Harbour, revealing brutal treatment by British troops and land confiscation in "punishment for a rebellion that never took place" (Waitangi Tribunal, 1985). The direct effects of land loss, combined with loss of customary rights in the harbour and lack of consultation and recognition through the RMA and environmental legislation process have negatively impacted the harbour, disadvantaged tangata whenua on many levels and left Manukau hapū with a "deep-seated sense of injustice" (Waitangi Tribunal, 1985). Manukau hapū sought recognition of historic and contemporary injustices through the claims process.

The positive result of this case, in favour of the claimant was a turning point for the Waitangi Tribunal Claims process and gave hope to many future claimants. The recommendations to the relevant Ministers by the Chief Judge Eddie Durie, included revisiting existing environmental management and laws around the Manukau Harbour with the aim of "restoring the ownership of the Crown and expressing therein the Crown's fiduciary responsibilities to the local tribes in terms of the Treaty of Waitangi, and with a view to rationalising existing control anomalies and providing integration with other planning statutes" (Waitangi Tribunal, 1985, p. 149). This included revisiting issues and policy around customary fishing rights, land access, wāhi tapu and sites of significance, maintaining environmental and ecological integrity of waterways and the harbour, and acknowledging and integrating Māori values into future planning and legislative processes (Waitangi Tribunal, 1985).

As Māori put historical grievances to rest and the Crown is reminded of its responsibilities as a Treaty partner, how do both Māori and governing bodies encourage meaningful engagement and participation of Māori within our current environmental management and decision making framework?

3.5. Contemporary use of Mātauranga Māori in Environmental Management and Monitoring

As positive steps towards integration of mātauranga Māori into environmental management and monitoring are being made, we see more examples of practical engagement, the building of collaborative relationships and examples of Māori led environmental initiatives. Through the formulation of Iwi Environmental Management Plans and other formally recognised plans and agreements, combined with Māori monitoring tools, there are successful collaborative research projects currently underway. I look briefly at what Māori environmental monitoring tools are available, and how they work within the current legislative framework, to enable groups such as Mōtakotako marae to successfully manage and monitor the Toreparu wetland.

3.5.1. The RMA and Iwi Management Plans

The Resource Management Act (RMA) (Ministry for the Environment, 1991), acknowledges kaitiakitanga and defines it as “the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Māori in relation to natural and physical resources; and includes the ethic of stewardship”. By defining kaitiakitanga as above, a “fundamental Māori principle has been redefined by the New Zealand authorities to fit into a simplified worldview consistent with English common terms and meanings” (Awatere in,R. Walker et al., 2013). So how do iwi and hapū groups exercise their kaitiaki rights? The RMA currently identifies Māori as having some legislative power through the implementation of Joint Management Agreements (JMAs), Statutory Management Agreements (SMAs) and Iwi Management Plans (IMPs). Both Waikato-Tainui and Mōtakotako marae have release environmental management plans for their tribal lands.

Waikato-Tainui iwi released their Iwi Environment Plan in August 2013. The Waikato-Tainui Environment Plan clearly sets out what the plan is, what it is for, who can use it and what the applicable statutory and planning agreements are (Waikato-Tainui, 2013). One of the plan’s overarching purposes is to provide tangata whenua or kaitiaki with a guideline to what the iwi goals and objectives are around environmental management and monitoring, and how it may complement hapū or marae IMPs (Waikato-Tainui, 2013). This plan makes specific provision for customary environmental management practises such as rāhui, which is defined as ‘the imposition of restrictions, from time to time, on all or part of an activity, or the use of a resource, or rohe (tribal area). Rāhui may be imposed for the purpose of conservation protection, spiritual or physical well-being, or other purpose as from time to time determined’ (Waikato-Tainui, 2013). More specifically, Waikato-Tainui has highlighted the need for rāhui on wetlands during fish spawning seasons, or if a resource has been over-used or misused (Waikato-Tainui, 2013). This may include a temporary ban on gathering particular species, or gathering resources from a particular area or possessing resources that were gathered from a particular area during the time the rāhui was in force. The plan also provides a tool to assist tangata whenua participating in resource and environmental management and planning processes and their rights within the RMA framework (Waikato-Tainui, 2013).

Iwi based documents such as IMP’s, may highlight issues of particular significance at a larger and broader scale but it is important to remember the kaitiaki rights of smaller, more localised communities such as hapū groups. As discussed in Section 3.3, Mōtakotako marae has an Environmental Management Plan which provides tangata whenua, governing bodies and any developers in the area a document with key values for tangata whenua, including environmental resources, customary practises, places, events, relationships and taonga of significance (Mōtakotako Marae, 2008). The document also discusses the significance of kaitiakitanga and the rights and responsibilities that Mōtakotako marae members have as kaitiaki and tangata whenua in the area.

3.5.1.1. Mātauranga ā hapū at the Toreparu Wetland

Section 3.2 described what mātauranga Māori was and how it is understood in the environmental context. The concepts that were highlighted are broad and widely understood. It is important to recognise and understand the importance of mātauranga at a more local scale. Mātauranga ā hapū (sub-tribe knowledge), in this case, describes the local knowledge held by hapū members from Mōtakotako marae. It is an essential aspect of management and monitoring of the Toreparu wetland and was one of the key pillars of this research project.

For Mōtakotako marae, one aspect of mātauranga ā hapū is knowing and understanding the environment and their connection to it. In general, Māori believe that "to live in harmony with the environment and each other, and to ensure our long term survival, we must respect and protect the environment" (Selby et al., 2010). The Toreparu wetland is considered a significant site for tangata whenua and marked by three boundary markers, Te Kōwhatu, Te Ruataniwha and Te Kaitiaki (Thomson, 2013). In the northern end of the wetland is Horokawau, a significant waterfall and the 300 acre Reserve allocated to Ngāti Whakamarurangi after the sale of the Ruapuke block to the north (Thomson, 2013).

The Toreparu is rich in cultural history with numerous pā (fortified habitation) and kāinga (village) sites overlooking the wetland, which was considered an abundant food and resource basket by tangata whenua (Kessels et al., 2005; Thomson, 2013; Vernon & Buckeridge, 1973; Volunteer A, 2013). There were once two large pā tuna (eel weirs), Te Kōkiri and Te Awa a Heketoru, which provided a reliable source of food, along with locations within the Toreparu that were used for setting hīnaki (nets) (Thomson, 2013). Along with historical information, tangata whenua from Mōtakotako have specific sites where other resources such as food, weaving materials, dyes, rongoa (medicines), and water for different rituals are collected.

The Toreparu was also a resource asset to a local Pākehā, James Bregman, who ran the Pākoka flax mill at Aotea. He received flax from the Toreparu, which was harvested and transported by local Māori, though; it is unknown whether there was payment made for its lease (Thomson, 2013). The intimate knowledge and understanding of environments, such as mātauranga ā hapū at the Toreparu, goes beyond the practical management of resources, but reflects the health and well-being of the people. The value that Māori place on freshwater environments goes beyond the provision of food and sustenance but is considered a "source of mana and spiritual sustenance, being intricately linked to, and reflective of, the well-being of tangata whenua" (Selby et al., 2010).

Tangata whenua of Mōtakotako marae are aware of the degradation of the Toreparu wetland and have identified the loss of native vegetation, weed invasion, land management practises, stock access and declines in water quality as being key issues affecting the health and function of the wetland (Kessels et al., 2005; Thomson, 2013; Volunteer A, 2013). The Toreparu was once an integral part of the lives of tangata whenua, but this has reduced as land ownership changed and connection with the Toreparu was compromised (Thomson, 2013). As a result, hapū were separated from the Toreparu and today most members have little knowledge about the poor state of Toreparu and the challenges of restoring the wetland (Thomson, 2013, p. 37). This viewpoint is not uncommon, and has been described by Māori from around the country (Muru-Lanning, 2012). The transformation and degradation of wetland ecosystems, as a consequence of ongoing drainage and conversion, represents ecological loss and physical disconnection that has contributed to the fragmentation and modification of Māori communities (M. Forster in: Selby et al., 2010, p. 205).

My research project was seen as an opportunity to not only strengthen tangata whenua knowledge and capacity around the Toreparu, but as an opportunity to build and strengthen relationships within the marae and between local council, landowners and the Department of Conservation. It was also seen as an opportunity to showcase the Toreparu to other Waikato-Tainui hapū, and be an example of successful collaborative management and an innovative solution to assessing wetland health in the Waikato.

3.6. Communicating Mātauranga Māori

One of the key issues identified in the conception of this research was the issues around communicating mātauranga Māori within a science dominated arena. There are inherent difficulties with describing concepts and values of te ao Māori using scientific language and scientific frameworks (W. Allen et al., 2011; Hall, 2012; G. Harmsworth, 2001; Joseph, 2008; Metge & Kinloch, 1978; Muru-Lanning, 2012; Townsend, Tipa, Teirney, & Niyogi, 2004). Te reo Māori (Māori language) has been shaped by Māori communities to express Māori culture and there are risks of this being 'lost in translation' (Joseph, 2008). Another issue that has been identified with cross-cultural research, is the risk of assimilating world views (Smith, 2012). As identified in Section 1.2, the aim of this research is not to validate one methodology over the other but identify where differences in perceived 'wetland health' occur and investigate the underlying values driving this.

One way forward for mitigating the risk of assimilating world views is by employing a collaborative research process. Successful collaborative research projects rely on a solid foundation of 'relationship' between partners (G. Harmsworth, 2001). Smith (2012) highlights some problems associated with the use of Westernized 'collaborative research' terminology as it may disguise the importance of indigenous values. It is essential that these values are not lost beneath layers of Eurocentric lingo, and the values driving the research and desired outcomes benefit Māori 'collaborators' or research partners. In reality, there are often research outcomes and goals to be met which may be driven by non-Māori or government agencies. With this, come challenges in meeting these criteria and striking a balance, while maintaining Māori values, integrity and outcomes. According to Harmsworth (2001), successful collaborative research relies on both parties having the following attributes; trusted relationships, communication, resourcing/funding, research capacity and capability, understanding of Māori and non-Māori concepts/ frameworks and have the ability to meet the funders criteria, if applicable. For a full list of partner attributes, see *'A collaborative research model for working with iwi: discussion paper'* (G. Harmsworth, 2001).

Within the collaborative research framework, there are a number of tools that can be used to communicate mātauranga Māori for environmental management. The following section reviews some of these tools and their usefulness for assessing health of the Toreparu wetland.

3.6.1. Review of Tools for Integrating Mātauranga Māori in the Environmental Management Domain

Compared to scientific based wetland monitoring methods, cultural monitoring tools are a much more recent development in New Zealand (G. Harmsworth, Awatere, & Dixon, 2011). There are currently a variety of tools and methods that have been developed to monitor environments, using mātauranga Māori.

The Traditional Ecological Knowledge (TEK) model has been used extensively both overseas (Berkes, Colding, & Folke, 2000; Houde, 2007), where it originated, and in New Zealand (Moller, Charleton, Knight, & Lyver, 2009). In New Zealand the TEK model has been used to understand trends in tītī (mutton-bird) population dynamics and cultural harvesting (Moller et al., 2009). Though the results from this 14-year project has provided a wealth of knowledge, the TEK model and interpretation of data has been called into question. The major criticism of the TEK model is that cultural values and methods are co-opted into what is essentially a scientific framework (Huntington, 2000). Spiritual and metaphysical aspects of cultural knowledge are separated from ‘ecological’ knowledge, which fragments and compartmentalises what is a holistic worldview (Wehi, Whaanga, & Roa, 2009). I also believe the TEK model has a tendency to fix cultural knowledge in time, as it fails to encompass the adaptive and fluid nature of mātauranga Māori and incorporation of new tools to enhance historical cultural knowledge. The TEK model may fail to successfully translate oral histories and traditions due to lack of te reo Māori by many researchers, resulting in the undervaluing or misinterpretation of oral information (Wehi et al., 2009). Though the TEK model may work well in some situations, the people of Mōtakotako marae decided not to employ this methodology for this research project as they felt the TEK model emphasised biophysical aspects of environments and co-opted this information into Eurocentric based frameworks.

Harmsworth et al. (2011) recently reviewed current Māori cultural monitoring tools, providing a summary of approaches used nationwide. Māori environmental performance indicators (MEPI's) were an aspect of the nationwide EPI programme in the 1990s, as a method to include culturally based concepts. MEPIs are defined as "a tohu (sign) created and configured by Māori to gauge, measure and indicate change in an environmental locality. A Māori EPI leads a Māori community towards and sustains a vision and a set of environmental goals defined by that community" (Ministry for the Environment, 1998). The development of these indicators began in the early 1990s in response to state of the environment reporting, which to date had very little opportunity for Māori engagement beyond the consultation phase. The ongoing progression of these tools continues today to include aspects of physical and metaphysical health of both the environment and tangata whenua (Willis & Koroheke, 2005). Though there are multiple frameworks for carrying out Māori value based environmental planning, the two main tools that can be used to monitor environmental state and change. These tools are the cultural health indicator (CHI) and Te Mauri Model.

The Mauri Model is a decision making tool based on the concept of mauri, or the internal life force that binds the physical and metaphysical worlds. "The Mauri Model is a framework and assessment method developed to integrate across the dimensions of economic, social, cultural, which are successive subsets of the environment. These are redefined from an indigenous perspective to measure the impacts of the mauri within four key indigenous aspects: ecosystems (environmental), hapū (cultural), whānau (economic), and communities (social)" (G. Harmsworth et al., 2011). In summary, Te Mauri Model looks at human impacts (i.e. impacts of development) on key aspects of mauri, assigning a score or rating (Morgan, 2011). This tool works best when looking at the effects of urban or residential development (G. Harmsworth et al., 2011) and may be useful in the RMA framework. This method does come with its own set of challenges as many Māori do not like the concept of reducing a fundamental Māori concept, mauri, into a numerical value (Muru-Lanning, 2012). Due to the emphasis on scoring mauri, and the methodology for doing this, Mōtakotako chose not to use this approach for monitoring the Toreparu wetland.

The cultural health indicator (CHI) toolkit was the first formal method developed as a way for Māori to express values and priorities in the environmental monitoring space for freshwater habitats (G. Harmsworth, 2002; Tipa & Teirney, 2003). It was the first attempt to provide Māori with a platform for communicating cultural values that were formally recognised in what was a science dominated space. The CHI provided an opportunity to express physical and metaphysical concepts in a quantitative measure, that could be assessed by Māori over time (G. Harmsworth, 2002; Tipa & Teirney, 2003). This method was originally trialled in Otago (Tipa, 1999) and in the Motueka river catchment (Young, Harmsworth, Walker, & James, 2008) and is currently being used in the Hawkes Bay by Ngāti Kahungungu (G. Harmsworth et al., 2011). There are also multiple Māori groups using this method on a smaller scale (G. Harmsworth et al., 2011), much like this research project at the Toreparu. For the CHI to be effective and useful, this method does require some training and for participants/ assessors to have some knowledge of the habitat in question (i.e. river, stream or wetland). This may be a barrier for some groups, but is a hurdle that must be overcome for all Māori monitoring tools available today. The CHI is popular as it is straightforward to use, does not generally require expensive and specialised equipment, and is adaptable in terms of the indicators chosen and the habitat types that can be assessed. The CHI can be used for rivers and streams (Tipa & Teirney, 2003; Townsend et al., 2004), wetlands (G. Harmsworth, 2002) and estuaries (D. Walker, Nelson City Council, & Tiakina te Taiao, 2009), with potential for use in lakes (currently underway by Ngāi Tahu; (G. Harmsworth et al., 2011), marine (currently underway by Tiakina te Taiao) (D. Walker et al., 2009) and terrestrial habitats (Shortland, 2011). The wetland CHI (WCHI) was chosen by Mōtakotako as the most practical and effective way to monitor the Toreparu. The WCHI was seen to be adaptable and flexible in the indicators that could be used, creating a unique and site specific assessment sheet to be used by Mōtakotako marae now and in the future.

4. Research Rationale

With recent efforts in New Zealand, to develop successful co-management plans and collaborative processes between environmental governing bodies and Māori with regard to our freshwaters, I saw this project as an opportunity to investigate how successful environmental monitoring projects can be when they consider mātauranga Māori (Māori knowledge) for assessing the health of wetland environments. Harmsworth *et al.* (2011) examined the linkages between science and cultural indicators for river and stream health. It was this publication that helped formulate my topic, as it examined how mātauranga Māori and science may work together to assess the health of wetlands. There is currently no literature on comparative analysis for these methodologies in wetland environments.

4.1. Research Aims

The current literature, the availability of mātauranga Māori-based monitoring tools, and my experience as a Māori freshwater ecologist, has shaped my belief that scientific-derived methods, based on biophysical and chemical parameters are alone, insufficient for successful management and monitoring of wetlands in New Zealand.

The aim of my research is to look at how mātauranga Māori based wetland assessment methods enhance our understanding of wetland health when used with biophysical, scientific methods, using the Toreparu wetland as the case study. Are there similarities or differences in trends for wetland health indicators? And what do any differences communicate to us about overall wetland health?

By understanding how these two methods work together, and differ, we can increase the knowledge of, and communication about, the use of Māori value-based assessment tools and how they can complement and enhance scientific research. This will benefit both Māori and non-Māori by encouraging successful and sustainable collaborative research around wetland management and monitoring.

5. Working in Collaboration: Mātauranga Māori and Scientific Research Methodologies at the Toreparu Wetland

5.1. Toreparu Wetland

Field sampling commenced in May 2013 at the Toreparu wetland, Te Mata, in the Waikato region. Toreparu wetland is located along the Waikato west coast, between the Raglan and Aotea harbours. The wetland covers approximately 223 ha with most under private and Māori title. Approximately 52 ha of the wetland is within the Te Mata Wildlife Management Reserve and is administered by the Department of Conservation.

The Toreparu wetland is classified as a swamp, which is considered to be a fertile wetland that occupies basins, valley floors, deltas and plains. Groundwater and surface runoff are the main contributors of water (Watts et al., 2012), so these habitats tend to receive a regular supply of nutrients and sediments from adjacent land. For swamp wetlands that are permanently wet, vegetation is generally diverse and typically dominated by sedges, rushes, reeds and flax. Swamp wetlands which have seasonal periods of dry habitat, often provide habitat for forest trees such as kahikatea, pukatea, swamp maire (*Maire tawake*), and cabbage trees as well as tall herbs and mānuka (Watts et al., 2012). The Toreparu contains both permanently wet and seasonally dry habitat types.

Before 1820 the entire area from Whaingaroa (Raglan) to Kāwhia, including the Toreparu wetland, was held by Ngāti Toa and Ngāti Koata iwi (tribes), and their hapū (sub tribe). When these tribes migrated south to Kāpiti, Te Whanganui-a-Tara (Wellington) and Whakatū, tribes from inland Waikato moved out to settle the fertile coastal area. After 1820 the land surrounding the Toreparu wetland was occupied continuously by tribes whose principle lineages were Ngāti Haua, Ngāti Whakamarurangi, Ngāti Whare and Ngāti Hourua and Ngāti Naho. Their principal settlements were at Te Mākaka and Mōtakotako. The people at Mōtakotako marae are their descendants, and tangata whenua (indigenous people of the land) within this area (Volunteer A, 2013).

Settlers first arrived in Whaingaroa and the surrounding areas, including Ruapuke, Te Mata, Aotea and Kāwhia around 1855 (Vernon, 1981). When the settlers arrived in Te Mata, it was mostly bush clad and “it needed only axes, saws and hard work to convert this bush into scantling, boards and eventually homes” (Vernon, 1981). By the early 1900s, the area was mostly cleared for farming (Figure 1) (Vernon, 1981; Vernon & Buckeridge, 1973). The large hardwoods, mostly rimu and tōtara, were used for housing and battens, with large puriri used for railway sleepers (Vernon, 1981). Much of the smaller trees and scrub was burnt, including large stands of bush adjacent to the Brown’s property at Te Papatapu Rd. According to one of the adjacent landowners, this happened right up until the 1950s (Brown, 2013).

Flax milling was one of the main industries along the Waikato west coast, with mills located in Raglan, north of the Raglan harbour, Ōkete Falls, around Ruapuke and Aotea (Vernon, 1981). Some mills were operational until the 1980s. Flax harvesting was also common in and around the Toreparu wetland. Large bundles of flax and muka (fibre) were transported by barge or punt, or by horse and cart over land (Vernon, 1981). During this time, large kahikatea and other podocarps were selectively removed from the Toreparu for milling. There is still evidence of stumps at the Toreparu today (Kessels et al., 2005). Today, much of the surrounding landscape is farmed pasture so nutrient inputs and direct effects from stock accessing the wetland all threaten the health of the Toreparu.

5.2. Site Selection

Six main sites were chosen along with six sub-sampling sites (Figure 1). Full surveys were carried out at the main sites to include flora, fauna and water quality measures using scientific methods as well as a cultural health indicator assessment. The six sub-sampling sites had additional water quality information gathered using both science and cultural health assessment methods.

Surrounding catchment intactness (SCI), which can be described as the observed land-use and vegetation cover surrounding the sampling site, was used to select the main sites. Three of the main sites, labelled SCI High, SCI Mid and SCI Low, were chosen based on the degree of intactness of the surrounding catchment via satellite imagery. SCI High was surrounded by regenerating native vegetation and was dominated by native vegetation within the wetland itself. SCI Mid was partially surrounded by regenerating native vegetation with grazed pasture along the eastern edge. This site was mostly native vegetation within the wetland but had some weed species, particularly at the downstream end of the site. SCI Low was surrounded by grazed pasture and dominated by a grey willow (*Salix cinerea*) canopy.

The remaining three main sites were chosen because they were identified as being of cultural importance to the people from Mōtakotako marae. These sites are used for food gathering, or for other resources such as water, weaving or dye material (Figure 1). The Horokawau Falls site was located just downstream of the 5 m high Horokawau Falls (Figure 1) and is a key area used regularly for mahinga kai (food harvesting), particularly for eels. It is also used as an area for swimming and has been identified in the Waikato minute books (New Zealand Maori Land Court, 2009) as a very significant site for Ngāti Whakamarurangi. Hērangi Pā site was located within one of the southern arms of the wetland (Figure 1) and is an important area for water and watercress collection and is a source of weaving and dying material. This site is fed by an underground spring, which is also used as a source of drinking water. The Toreparu Stream site is the most western site, located at the most downstream end of the wetland at the upper reaches of the Toreparu Stream (Figure 1). This site is used seasonally for harvesting whitebait, mostly by tangata whenua and members of surrounding landowners' families. Unlike the SCI sites which were labelled due to the quality of the surrounding catchment, the cultural sites are all considered to be of significance. This significance is linked to a variety of uses, with no one activity valued over the other. As a result, the cultural sites were labelled to reflect the names given to the surrounding area by tangata whenua.

For each of the six main sites, a sub-sampling regime was chosen. Sub-sampling sites were either 100 m upstream or downstream depending on the availability of water for sampling.

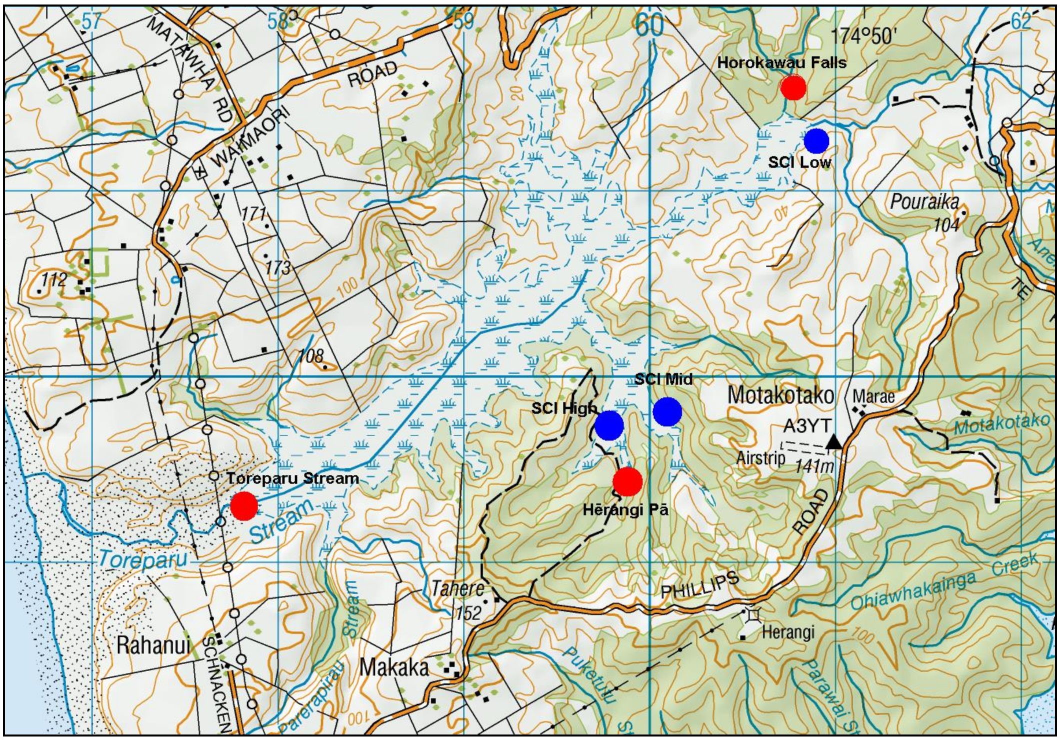

Figure 1 Location of the six main sampling sites within the Toreparu wetland. Wetland boundary delineated with light blue broken line. Blue points represent sites chosen using site catchment intactness; red points represent culturally important sites for Mōtakotako marae.

5.3. Cultural Health Indicator Assessment

5.3.1. Kaupapa Māori Research

Due to a large component of my research being based on tangata whenua values, as well as identifying myself as a Māori researcher, a Kaupapa Māori research methodology (Smith, 2012) was used to guide the process around wetland cultural health indicator development, analysis, and discussion of results.

This methodological approach assumes that the research project involves Māori people and sets out to make a positive difference to those individuals or communities being researched (Smith, 2012). In my research project, one of the main aims was to help Mōtakotako marae develop a set of cultural health indicators that reflected their values and priorities. This toolkit could be used to monitor the success of their vision for the Toreparu, which is to restore the health, enhance the cultural resources within the wetland and create a living, learning environment for the tangata whenua of Mōtakotako marae.

The research approach used must also address the cultural ground rules of respect, of working with communities and of sharing processes and knowledge and be guided by the tikanga (correct procedure/ customs) of those being researched (G. Harmsworth, 2001; Smith, 2012). For this, I had a very close working relationship with the Environment Chair of the marae, asking for and receiving advice on tikanga and correct procedure for conducting this research. Hui (meetings) were conducted, providing a space for a two-way knowledge exchange (G. Harmsworth, 2001) and open communication between myself and the tangata whenua at Mōtakotako marae. I maintained on-going communication with the Environment Chair and volunteer participants throughout the process and provided my contact details to marae members should they have any queries about the research. On completion of my thesis, I will present my findings to the marae at one of their monthly meetings.

After being educated in science and learning how to conduct scientific research, I made sure that I had a support network to guide me throughout the Māori aspect of my research. I had support from my whānau (family) and Shaun Awatere, to ensure that I was working in a culturally sensitive and appropriate manner. This research project followed the Kaupapa Māori methodology as it was formulated and refined with the help of the Chair of the Environment Committee at Mōtakotako marae. This research was developed in a way that provided benefits for tangata whenua both during the project timeframe, but also built capacity within local hapū and whānau groups to maintain these benefits into the future. A relationship with Mōtakotako marae members and the regional council was also created and a common long-term goal, to restore the Toreparu wetland, was discussed and planned. There was ongoing communication and engagement with tangata whenua throughout the data collection and writing stages of this research.

5.3.2. *Collaborative Research*

My project relies on mātauranga Māori, or more specifically *mātauranga a hapū* (hapū knowledge). As a researcher and 'outsider' who does not have whakapapa (genealogical links) to the area (Smith, 2012), I do not have the knowledge or connection with the Toreparu to carry out an assessment based on cultural values. My presentation provided an overview of the project aims, proposed methods and the role that tangata whenua would play in the research. Without input from tangata whenua, and ongoing support, the project would not have been viable (G. Harmsworth, 2001). I made this explicitly clear in my initial presentation, highlighting the need for volunteer participants. My project was received with enthusiasm and I was given official endorsement and a letter of support from members of Mōtakotako marae.

Initially, four people expressed interest in volunteering for the project; all have grown up in the area and have spent time both in and around the Toreparu wetland. Once the data collection phase started, only three participants were willing and able to take part. Participants were sent a copy of my Participant Information Sheet, Example CHI Assessment Sheet and Participation Consent Form (Appendix I). Participants were met informally in March 2013; the project was discussed and questions that arose since my presentation were addressed. A key starting point was to understand what 'cultural indicators' were and what this concept meant to the volunteers. We also discussed future aspirations and goals for the Toreparu wetland, from a tangata whenua perspective, which gave me information to start working on specific CHIs.

5.3.3. *Cultural Health Indicator Development*

Prior to any work being carried out, my project proposal was presented to tangata whenua at a Mōtakotako marae meeting in February 2013. The chair of the environment committee, Heather Thomson, requested approval for my attendance at the meeting, and a brief description of my project was added to the meeting agenda and sent to marae members. This was an essential part of the process, as formal approval and endorsement was required by kaumātua (elders) if the project was to go ahead. As a Māori researcher, working with Māori, this adherence to tikanga is part of the kaupapa Māori methodology (Smith, 2012) and the basis of a successful collaborative relationship (W. Allen et al., 2011; Fenemor et al., 2011; G. Harmsworth, 2001; Young et al., 2008) during and after the timeframe of this research project.

Wetland Cultural Health Indicators were developed using methods set out in '*Coordinated Monitoring of New Zealand Wetlands, Phase 2, Goal 2: Māori Environmental Performance Indicators for Wetland Condition and Trend*' (G. Harmsworth, 2002) and '*A Cultural Health Index for Streams and Waterways: Indicators for Recognising and Expressing Māori Values*' (Tipa & Teirney, 2003). Prior to any research being conducted, it was essential that a process that is both conceptually and culturally appropriate was developed. This involved consultation and wānanga (discussion/seminar) to identify priorities, values and potential sites for the study (G. Harmsworth, 2002). From these wānanga, indicators were identified, discussed, refined and field sheets were produced (G. Harmsworth, 2002). Essentially, the kaupapa (topic/ agenda) was determined by tangata whenua and the methodology was flexible enough to accommodate for challenges and change throughout the process. My research project used a similar approach, a kaupapa Māori methodology (Smith, 2012) to guide the indicator development process and followed similar steps to the one conducted by Harmsworth (2001, 2002).

A meeting with volunteer participants was held on 13 April 2013. This meeting was an opportunity for tangata whenua to discuss goals and the future vision for the Toreparu wetland. The key vision for Mōtakotako whanau with regard to the Toreparu wetland is to "restore and protect the Toreparu for future generations". Some key goals towards achieving this vision include:

- Maintaining and enhancing knowledge of the Toreparu for Mōtakotako whanau through a "living, learning environment".

- Providing sustainable employment opportunities for tangata whenua though tours and/or aquaculture ventures.
- Maintain the health of the Toreparu to support cultural activities such as mahinga kai and recreational use.

Using this overall vision and the key goals within this, identified above, cultural health indicators were developed. The volunteers identified the need to "develop indicators that we understand" and were specific to the Toreparu wetland.

Taonga (treasured) species; both plants and animals were considered very important indicators for health of the Toreparu. Freshwater fish species such as eels and whitebait are an important fishery for tangata whenua. The presence of taonga birds was also an important indicator, as birds were once used as a food source and a flourishing bird population was indicative of a health environment. All of the scores for the fish and bird indicators (see Appendix II) were averaged, providing a Mahinga Kai Index score as per Harmsworth (2002).

Water quality and temperature were also identified as key health indicators, as this was linked to water clarity, odour, and algal growth, use of areas for swimming, karakia (ritual chant) and success of fishing. Wāhi tapu (sacred sites) and wāhi taonga (location of taonga) were also considered to be important indicators as they provided a wealth of historical information. Wāhi taonga included the location of dye resources, weaving resources and drinking water collection. The health of the surrounding catchment, particularly the presence of native flora, bank stability, sediment inputs, any physical modification of the wetland as well as stock access were measured. The presence of invasive species such as grey willow (*Salix cinerea*), gorse (*Ulex europaeus*), yellow flag iris (*Iris pseudacorus*) and reed sweet grass (*Glyceria maxima*) were also identified as key indicators of wetland health. These indicators were refined further to produce the WCHI sheet attached (Appendix II).

Mauri, which can be described as a combination of tangible and intangible measures of life force (H.M Mead & Mead, 2003), was also used as one of the WCHI indicators for the Toreparu. Within the context of this research, mauri was a holistic measure of overall wetland health at each sampling site. Mauri of freshwaters can be put at risk by declines in water quality and impacts on cultural uses of an area (Tipa & Teirney, 2003). At the Toreparu, it encompasses the physical and metaphysical health of a wetland site, according to each volunteer at the time of sampling.

Once all the indicators had been defined, the WCHI assessment sheet was sent to all volunteer participants for review. Once the volunteers had approved the indicators and scale system, the field sheets were finalised (Appendix II).

5.3.4. Wetland Cultural Health Assessment

All three volunteer participants were self-selected members of Mōtakotako marae. Two of the volunteers are from the same family, and grew up not far from the Toreparu wetland and stream. They both knew the area well and continue to harvest whitebait annually, and occasionally eels. One of the siblings now manages the family farm. The last volunteer also grew up in the area and spent a lot of time swimming and collecting eels and whitebait from the wetland and stream. After many years away, this volunteer recently moved back to the area, and continues to utilise the Toreparu for mahinga kai practises. Though criteria for selection were not specifically defined, it was essential that volunteers had whakapapa to the area, and were tangata whenua. It was desirable that volunteers had at least some knowledge of the Toreparu through personal experience or knowledge passed down from other whānau/hapū members, and were able to carry out assessments either by visiting the sites or the video assessment that was introduced as an option after the November survey.

Cultural health indicator assessments were carried out at all sites by one volunteer on 17 August and another on 9 November 2013. The third volunteer carried out a WCHI assessment using video footage taken on 9 November 2013. This was due to their inability to access the site due to health issues. The assessment carried out on 17 August 2013 was conducted in fine weather with some patches of drizzle at the end of the day. There had been a prolonged period of very heavy rain 12 days prior to this assessment. Water levels appeared to be slightly elevated and there was evidence of sediment run-off, discolouring the water. The weather on the 9 November was warm and fine, following approximately two weeks of dry weather. Stream levels appeared to be slightly elevated but clarity was higher than during the August survey. There was a significant flood event on 12 October. The Waikato Regional Council river monitoring site at Waingaro (catchment area of 117km^2), approximately 25 km northeast of Toreparu, showed water levels rose from 0.9 m to 3.3 m in 12 hours (Waikato Regional Council, 2013). The Toreparu catchment is much smaller at 41.26 km^2 but the effect of this flash flood event was still considered significant and the effects were still obvious at the time of survey.

Assessments were carried out at sites starting at the most northern end of the wetland working to the centrally located sites and finishing at the lower reaches of the wetland, towards the coast. Approximately one hour was spent at each site with each volunteer participant taking between seven and eight hours in the field. All WCHI assessment sheets were filled in as completely as possible. Some indicators were not applicable at every site. For example, only three of the six sites were used for harvesting eels, and only one for white-baiting. When indicators were not applicable, they were marked with ‘N/A’.

All sites were filmed for video assessments during the field assessment on the 9 November. The video footage at the six main sites was filmed for up to 45 seconds and consisted of a slow-motion pan of the site to include surrounding vegetation, riparian/bank habitat and the aquatic environment. Areas of still and flowing water were zoomed in on to show water clarity and any aquatic flora and/or periphyton growth. This was then analysed by a single volunteer, and assessment sheets were filled out. The complete video based assessment, of all six sites and six sub-sampling sites, took approximately five hours in total.

5.3.5. Interpreting WCHI Indicator Scores

All scores gathered for the specific indicators discussed above, were then translated into three indices as per the WCHI methodology (G. Harmsworth, 2002; Tipa & Teirney, 2003):

- **Component 1:** sites are classified according to traditional association and intention to use in the future.

Is there a traditional association between tangata whenua and the site? Sites of traditional significance are assigned an 'A'. Sites that do not have a traditional association are assigned a 'B'.

Would Māori come to the site in the future? Whether tangata whenua would return to the site or not is also recorded. If they would return, the site is awarded a 1, and if not, a 0.

- **Component 2:** sites are evaluated for the following mahinga kai features. Each feature is rated 1–5 and the mahinga kai score is the average of the indicators 1–5 ratings (1 is poor and 5 is the highest mahinga kai rating).

- **Component 3:** sites are evaluated for a wetland cultural health measure (WCHM). First, the average scores for all indicators of wetland health at each site (except the mahinga kai values) recorded by all volunteers, was calculated. The average score for all included indicators provides the wetland cultural health measure (1 is poor and 5 is the highest cultural health rating).

Overall index: the overall three-part Cultural Health Index is expressed as shown in terms of the three components. For example, a wetland site may be given an index of:

A–0 / 2.1 / 4.2

where:

- A identifies the site as traditional (rather than a B for non-traditional)

- 0 indicates that Māori would not return to this site in the future (1 indicates they would return)
- 2.1 is the mahinga kai score (score of 1–5)
- 4.2 is the overall evaluation of wetland cultural health (score of 1–5).

5.3.6. Limitations

Some of the limitations identified with the cultural health indicator framework are summarised below and will be further investigated in the discussion chapter. The WCHI data is qualitative data in a quantitative form (Bryman, 2012), and site specific to the Toreparu wetland. One of the limitations associated with this is the requirement for volunteer participants to have a connection and knowledge of the Toreparu wetland, by having lived nearby and/or having spent time there. As a result, there were low numbers of participants some marae members felt they did not know enough about the Toreparu to carry out the WCHI assessment. Some of the kaumātua (elders) who had grown up near the Toreparu were physically unable to access the sites due to the steep terrain. This led to the video assessment method, which had multiple challenges that will be discussed later in this document.

The extreme modification of the surrounding catchment and wetland itself made WCHI assessments difficult for some volunteers, particularly when it came to the mauri assessment. There were also challenges getting all the volunteer participants to do the assessment at the same time, which can be attributed to the ‘volunteer’ nature of this work.

Tangata whenua from Mōtakotako marae have a relationship and knowledge of the Toreparu that cannot be measured or understood through scientific or Eurocentric-based methods. They are considered as experts in this area, using an expert methodology to describe patterns and changes in wetland health from a tangata whenua perspective. In this case, the data is useful not only for the hapū, but for non-Māori decision makers when it comes to collaborative research and measuring outcomes for Māori.

5.4. Science Sampling

5.4.1. Scientific Method

Scientific methods were chosen based on cultural health indicators identified by tangata whenua. For example, the health of the eel and whitebait fishery was identified by tangata whenua as a key CHI; therefore, a fishery survey using a scientific method was used at the same sites. This provided a meaningful comparison between the two methods of wetland assessment. Using this rationale a full scientific assessment was carried out at the same six sites, to include surveys for fish, birds, aquatic macro-invertebrates, terrestrial and aquatic flora along with water quality sampling.

5.4.1.1. Fishery Survey

Overnight trap netting methods were used for surveying fish at the six main sites guided by national protocols developed for rivers and streams outlined in 'New Zealand Freshwater Fish Sampling Protocols' (Joy, David, & Lake, 2013) . There are currently no standardised methods for sampling wetland fish. The first round of sampling was carried out between 9 and 12 July 2013.

At each site, two un-baited fine-mesh fyke nets and four fine-mesh G-Minnow traps were set overnight. A 150 m reach was measured and traps spread as evenly as possible within this, keeping to the main channel and deep pools. The fyke nets were set at the deepest points within the reach, facing downstream to prevent the opening being blocked by debris and iron bacteria. Though the standard methods recommend six fykes are set per site, the limited availability of suitable habitat at most of the sites resulted in fewer or no fykes being set. The G-Minnow traps were set at approximately 10 m intervals or in areas where there was sufficient water depth, within the reach. Debris was moved away from the trap openings to help prevent blockage, particularly from iron bacteria. Nets and traps were retrieved the next day and all fish captured were identified to the species level, measured and returned to the wetland. Notes on health of individual fish were also taken, such as obvious disease and injuries. Any fish that escaped or were unable to be measured were recorded as 'missed fish'.

GPS (Garmin GPS60™) location was taken at the upstream and downstream end of each reach. All information was recorded on a 'Fish Collection Form' (Appendix III). All equipment was cleaned, dried and disinfected with Trigene® after each sampling episode to prevent the potential spread of disease and aquatic pests around the wetland.

5.4.1.2. Aquatic Macroinvertebrates

Aquatic macroinvertebrates were sampled at each of the six main sites within the Toreparu wetland, in July 2013. A single sample was collected using methods outlined by (Suren & Sorrell, 2010). There was some variation in habitat types used for sampling (lead vs. channel) due to the diverse nature of the wetland, site location and water availability. At sites SCI High, SCI Mid and Hērangi Pā, samples were taken from the small channels within typical 'lead' habitat. These sites were characterised by shallow, less-open water with dense wetland vegetation growing in the water, such as sedges and rushes. Leads consist of either standing or very slow flowing water and, unlike ponds, have ill-defined margins (Suren & Sorrell, 2010). SCI Low, Horokawau Falls and Toreparu Stream (Figure 1) invertebrate samples were collected from 'main channel' habitat, which is characterised by wide, deep, open-water with well-defined banks (Suren & Sorrell, 2010). Much of the vegetation was restricted to the edges of these channels, or the riparian margins (Suren & Sorrell, 2010).

Sweep netting methods were chosen during this study because it is simple, cost-effective and some of the sites were too deep to sample using a corer. A sweep net (250 µm) was moved through the water column and jabbed into overhanging vegetation and the substrate for 1 minute to collect invertebrates. We attempted to sample the different habitats for a similar amount of time to gain a representative sample and prevent bias towards one type of habitat.

Samples were preserved in 70% isopropanol alcohol. Any large debris was discarded on site ensuring that any invertebrates remained in the sample container. Identification labels for each sample included site name and date, and were placed in the container and written on the outside. Samples were processed using *'Protocol P2- 200 Individual Fixed Count* *with Scan for Rare Taxa'* (Stark, Boothroyd, Harding, Maxsted, & Scarsbrook, 2001). The following parameters were calculated for each sample:

- Macroinvertebrate Community Index for soft-bottomed habitats (MCI-sb);
- Semi-quantitative Macroinvertebrate Community Index for soft-bottomed habitats (SQMCI-sb);
- Taxa Richness; and
- Dominant taxa (%)

5.4.1.3. Wetland Bird Surveys

Wetland bird surveys were carried out on 3 and 4 November 2013 using a decision tree and methods identified in the Department of Conservation guidelines 'Introduction to Bird Monitoring' (O'Donnell, 2012; O'Donnell & Williams, in press). These surveys used a combination of 5-minute bird count methods (5MBCs) from Dawson and Bull (1975) and playback surveys (Gibbs & Melvin, 1993). Due to the cryptic nature of bird species found or likely to be present at the Toreparu, all transects and associated 5MBCs were carried out using 'playback' of bird calls to elicit responses (Gibbs & Melvin, 1993) of species such as Australasian bittern (*Botaurus poiciloptilus*), marsh crake (*Porzana pusilla*), spotless crake (*Porzana tabuensis*) and North Island fernbird (*Bowdleria punctata*). A single transect survey was carried out at each site using methods from 'Bird Census Techniques' (Bibby, Burgess, Hill, & Mustoe, 2000). Notes on bird species seen and heard were also made during fish and vegetation surveys in July and October 2013. A previous survey by Kessels et al. (2005) recorded the presence of Australasian bittern, spotless crake, white-faced heron, black swan and mallard duck.

5.4.1.3.1. Line Transect Bird Survey Methods

At each study site, a 200 m transect was marked along the edge of the wetland to avoid disturbing vegetation and flushing birds. GPS locations were recorded at the beginning and end of each transect. At two points along each transect (beginning and end of each transect), a five-minute bird count was carried out. At a total of four points along the transect (approximately 50 m apart), recordings of wetland bird species likely to be at the site were played for approximately 30 seconds, with a ten second pause between each call. Each species call was played five times or for a total of two to three minutes, excluding pauses. Any responses were recorded to include species, number of calls, along with estimated distance and direction from observer. Notes on habitat along transects were also recorded.

Cryptic water birds such as bittern, crakes, banded rail and fernbird are known to be most vocal at dawn and dusk and are best surveyed during their breeding season (O'Donnell, 2012; O'Donnell & Williams, in press). These species all nest in wetland habitats in spring and early summer, generally between August and March (Heather & Robertson, 2000). All line transect surveys were carried out in the two hours after sunrise and two hours before sunset as per recommendations in Gibbs and Melvin (1993).

5.4.1.3.2. Five Minute Bird Count Methods

As part of the line transect methodology described above, four five-minute bird counts (5MBC) were carried out at each site using methodologies described by Dawson and Bull (1975). Stationary observer points were located 200 m apart, at the beginning and end of each transect. All birds, both species and numbers seen and heard within the five minute surveys were recorded (Appendix III). Notes on weather and habitat were recorded as a component of the line transects methodology, so were not necessary for each 5MBC, unless there were notable differences in these parameters during the 5MBCs. These parameters were quantified as a numerical value as per Bull and Dawson’s (1975) methodology.

5.4.2. Vegetation Survey

A vegetation survey was carried out at each of the six main sites using methods described by (B. R. Clarkson, Sorrell, et al., 2004). A single 2 m x 2 m (4 m^2) plot was selected at each site. Plots were located within ‘typical’ vegetation at the site and GPS recorded.

Within each plot, the number of vegetation layers was identified (usually canopy, sub-canopy and groundcover) and estimated % cover for plant species, within each layer was recorded. Canopy breaks, bare ground and leaf litter % cover was also recorded. Height was determined by tallest leaf, and for the canopy layer, this was estimated when too tall to measure by hand. Vegetation plot indicator scores and condition index were determined using a score (0-5) based on vegetation layer data.

No soil samples or foliage samples were collected during this survey.

5.4.3. Water Quality Sampling

Water quality parameters were measured using a combination of on-site readings and laboratory analysis to assess the current state of water at the Toreparu wetland. Prior to any measurements being taken in the field, equipment was calibrated and all containers were cleaned in an acid wash (10% HCl) and thoroughly rinsed with deionised water and dried. All Total N and P sample containers were labelled with date and site information. Measurements were taken in pool or main channels within each of the six main sites and six sub-sampling sites, with a total of 12 sites sampled on 17 and 18 August 2013 and another 12 sites on 4 November 2013.

During vegetation and fishery surveys, spot water quality measurements were taken using a YSI-pro hand-held water quality meter. Water temperature (^{o}C), specific conductivity (µS/cm@25°C), dissolved oxygen concentration (mg/L); saturation (%) and pH were recorded on field sheets. Measurements were taken at each site, in the same order during the August and November surveys to ensure that the effects of time of day were reduced between the two sampling episodes.

5.4.3.1. Total Nitrogen and Total Phosphorus

A single 50 mL sample of water was collected at each of the 12 sites and kept at <4^{o}C in the field, then frozen until analysis was carried out. Total nitrogen (TN) and phosphorus (TP) analysis was carried out using the Persulphate digestion method. Following every eight samples was a single 'blank' and a single 'quality control' sample of known nutrient concentration.

A digestion solution was made by dissolving 30.0 g of Potassium Persulphate and 4.5 g of Sodium Hydroxide in 750 mL of high purity water (18 Ω-cm). This was added to the sample which, when autoclaved, oxidises the organic forms of N and P to orthophosphate and Nitrate ions respectively. A 15 mL polycarbonate tube was filled with 7 mL of the water sample, 3 mL of digestion solution then mixed once the tube cap was on. All samples were digested in an autoclave for 30 minutes, once a pressure of 15 psi (121^{o}C) was reached. All samples were allowed to cool to room temperature and mixed thoroughly.

All samples were then processed through a Flow Injection Analysis (FIA) machine, producing Total N and Total P (mg/L) results.

5.5. Statistical Analysis

Comparative analysis was carried out between cultural and scientific data using the Pearson's correlation coefficient (*r*) to measure the strength of linear associations between variables (Payne, 2012). This was calculated in GenStat® with a 95% confidence interval used to test for statistical significance ($p < 0.05$).

The mahinga kai index was compared with results from the scientific-based surveys of fish and birds. This included the total catch for eels and whitebait/īnanga, total fish diversity and the total number of native bird species. The wetland cultural health measure (WCHM) was compared with scientific results for native plant cover and number of species, introduced plant cover and number of species, water temperature, dissolved oxygen concentration, specific conductivity, total nitrogen and phosphorus, as well as two aquatic macroinvertebrate metrics (MCI-sb and SQMCI-sb).

6. Results

This chapter summarises results from the WCHI and scientific surveys. First, the results for the cultural indicator assessments will be provided, along with the overall index results, comprised of the mahinga kai index and wetland cultural health measure (WCHM). The results from quantitative scientific surveys are summarised through a series of graphs and tables used to identify patterns and variation in wetland health between the study sites. Comparative analysis was carried out between the mahinga kai index and corresponding scientific parameters, and the WCHM and corresponding scientific parameters to determine similarities and differences between the two sets of results.

6.1. Wetland Cultural Health Indicator Results

6.1.1. Vegetation and Weeds

Results from the wetland cultural health indicator (WCHI) assessment of vegetation indicates variation between the six sampling sites for both health of taonga plants and percentage cover of periphyton or slime (Figure 2). The health of taonga plants is generally high, with three out of the six sites scoring mean WCHI values over three. The percentage cover of periphyton/slime within the sites generally scored lower WCHI values, with the maximum score of 4 out of 5 at two of the six sites (Figure 2).

SCI High scored the highest for the taonga plant health with a value of 5, indicating the presence of over 15 taonga plant species within the site (Figure 2). The periphyton/slime score at the same site was the lowest recorded of all the sites, with a value of 2.5, indicating between 25 and 75% cover at this site. Toreparu Stream scored a mean value of 4.5 for taonga plants, indicating the presence of between >10 taonga plant species. The periphyton/slime score was 3.5 at Toreparu Stream, indicating between 1 and 50% cover. SCI Mid scored a WCHI value of 4 for taonga plants, indicating that volunteer participants determined the presence of 10-14 taonga plants. The periphyton/slime cover scored a 3 at SCI Mid, indicating between 25 and 50% cover at this site. SCI Low scored a WCHI value of 3 for both taonga plants and periphyton/slime cover, representing 6-9 taonga plant species and slime cover of between 25 and 50%. Horokawau Falls and Hērangi Pā both scored the same for periphyton/slime cover, with a value of 4, the highest score of all six sites indicating low cover of between 1 and 25%. Horokawau Falls had the lowest number of taonga plant species with a score of 2, representing three to five taonga species present. Hērangi Pā scored 3 for health of taonga plants, which represented between 6 and 9 species in this site.

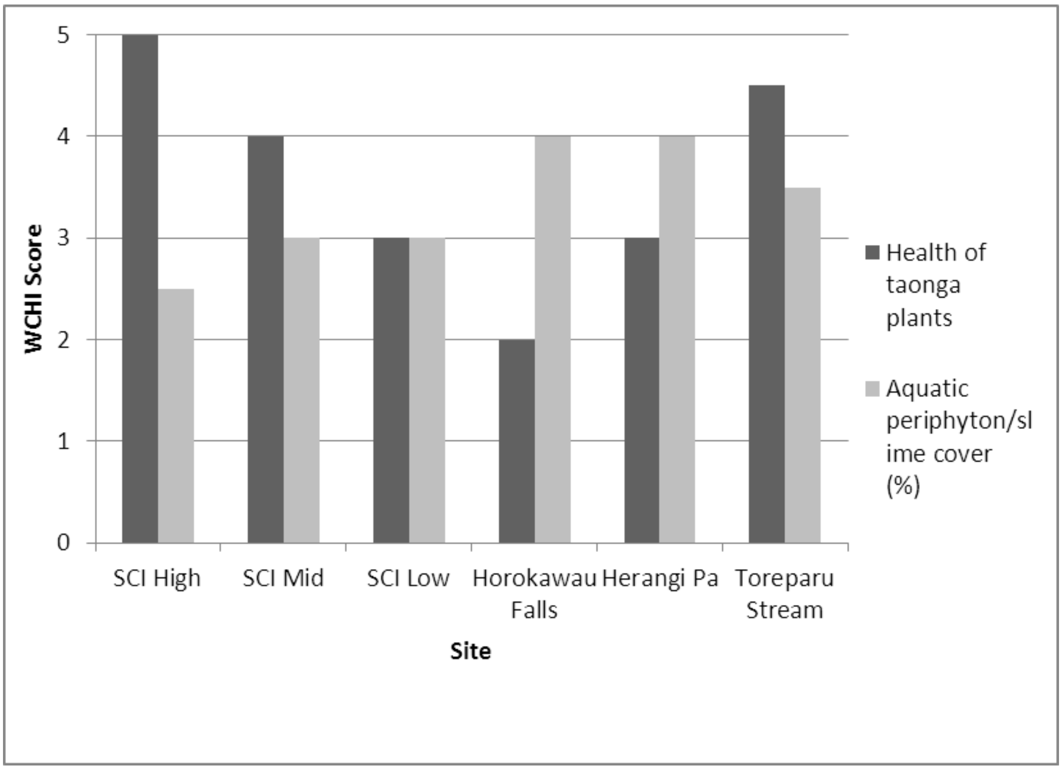

Figure 2 Mean scores for Wetland Cultural Health Indicator results (n=3) for health of taonga plants and percentage cover of aquatic periphyton/slime at six sites within the Toreparu wetland, August and November 2013.

For weed cover at all six sites, mean WCHI values for number of weed species was the same at all six sites, with some variation in the percentage of area covered in weeds (Figure 3). All six sites scored a WCHI value of 3 for the number of weed species, indicating between 3 and 5 species at each site. SCI High, SCI Mid and Hērangi Pā sites all scored a mean WCHI value of 4 for percentage weed cover, representing between 1 and 25% cover and a dominance of native species. Sites SCI Low and Toreparu Stream scored a mean value of 3, indicating a high percentage cover by weeds, between 25 and 50%. Horokawau Falls had the highest percentage cover of weed species with between 50 and 75%, represented by a mean score of 2.

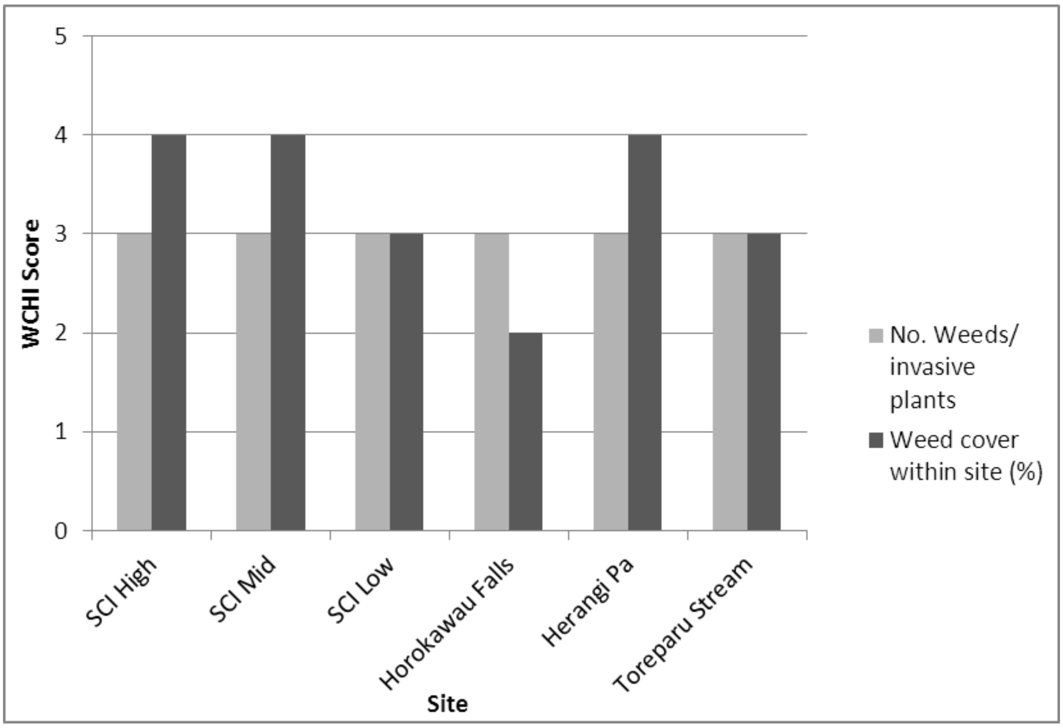

Figure 3 Mean scores for Wetland Cultural Health Indicator results (n=3) for the number of weeds/invasive plants and weed cover (%) at six sites within the Toreparu wetland, August and November 2013.

6.1.2. Mahinga Kai

6.1.2.1. Fish

The health of the tuna (eel) fishery was identified as of key importance to Mōtakotako marae, particularly the catch size and health of tuna in the Toreparu wetland. Catch size of tuna was low at three of the six sites — SCI High, SCI Mid and Hērangi Pā — with a mean score of 1 representing 1 and 2 kg catch size per annum (Figure 4). The scores of health of the tuna at these same sites ranged between 3 and 4, suggesting the individuals that are caught are considered to be of average to good health in terms of body condition and weight. Horokawau Falls and Toreparu Stream also scored relatively high on the health scale, with WCHI values of 4 at both sites representing average to high health of individuals. The catch size at Toreparu Stream scored 3, which represents an annual catch size of 5-10 kg. The annual catch size for tuna at Horokawau Falls was the largest, with 10 and 20 kg caught and a WCHI value of 4.

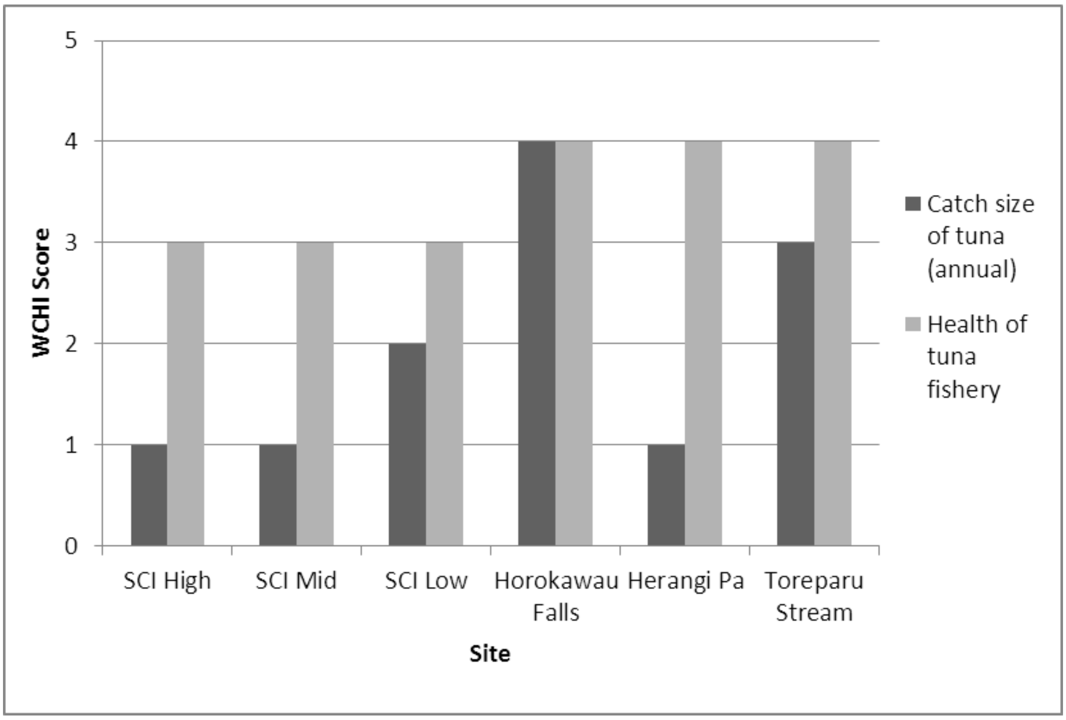

Figure 4 Mean scores for Wetland Cultural Health Indicator results (n=3) for the annual catch size and general health of the tuna (eel) fishery at six sites within the Toreparu wetland, August and November 2013.

The collection of whitebait species for food is carried out seasonally in the Toreparu wetland and stream, and the catch size and health of whitebait were both used in the WCHI assessment (Figure 5). Only two sites were scored for these indicators; the remaining four sites were marked as N/A, as they were not used for mahinga īnanga (gathering whitebait). Horokawau Falls scored a value of 5 for both indicators, which represented an annual catch of >10 kg, and individuals captured were considered to be ‘very healthy’ in terms of their body condition. Toreparu Stream scored slightly lower, with a value of 3 for both whitebait indicators. This represented an annual catch size of 3 to 5 kg, with individuals being of average or variable health in overall body condition.

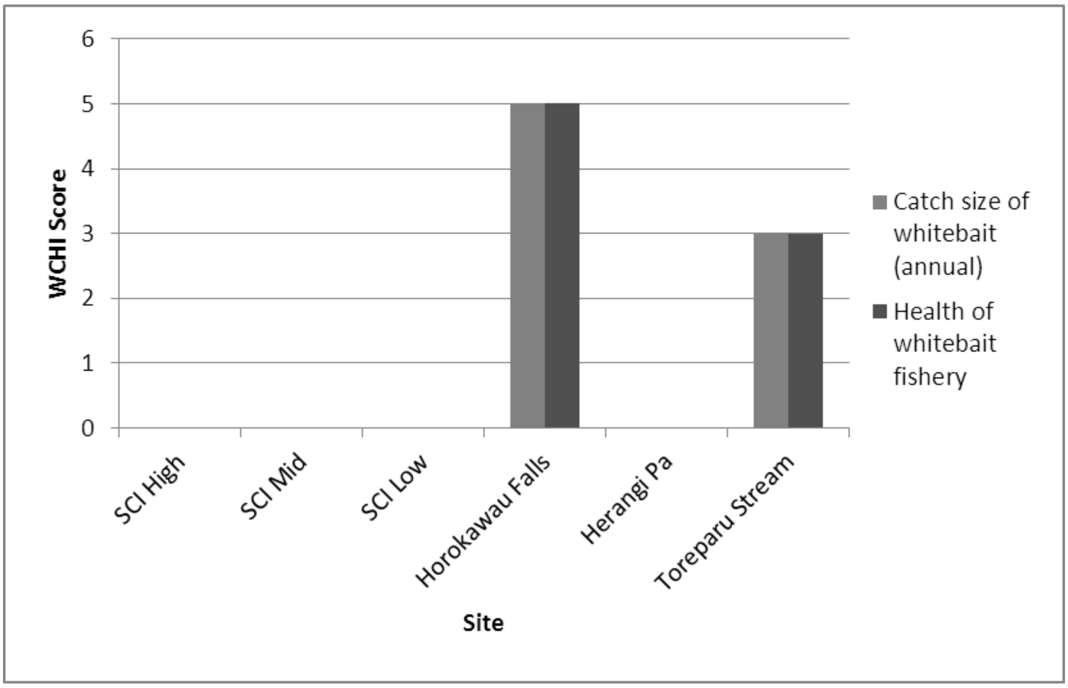

Figure 5 Mean scores for Wetland Cultural Health Indicator results (n=3) looking at the annual catch size and general health of the whitebait fishery at six sites within the Toreparu wetland, August and November 2013.

6.1.2.2. Birds

The presence of taonga bird species was also assessed at the Toreparu wetland. Five of the six sites (SCI High, SCI Mid, SCI Low, Horokawau Falls and Toreparu Stream) scored a mean WCHI value of 3, which indicates the presence of 3-5 taonga bird species seen or heard during the assessment (Figure 6). Hērangi Pā was the only site to score a slightly lower mean value of 2.5, which suggests between 2 and 5 taonga bird species were seen/heard during the time of assessment.

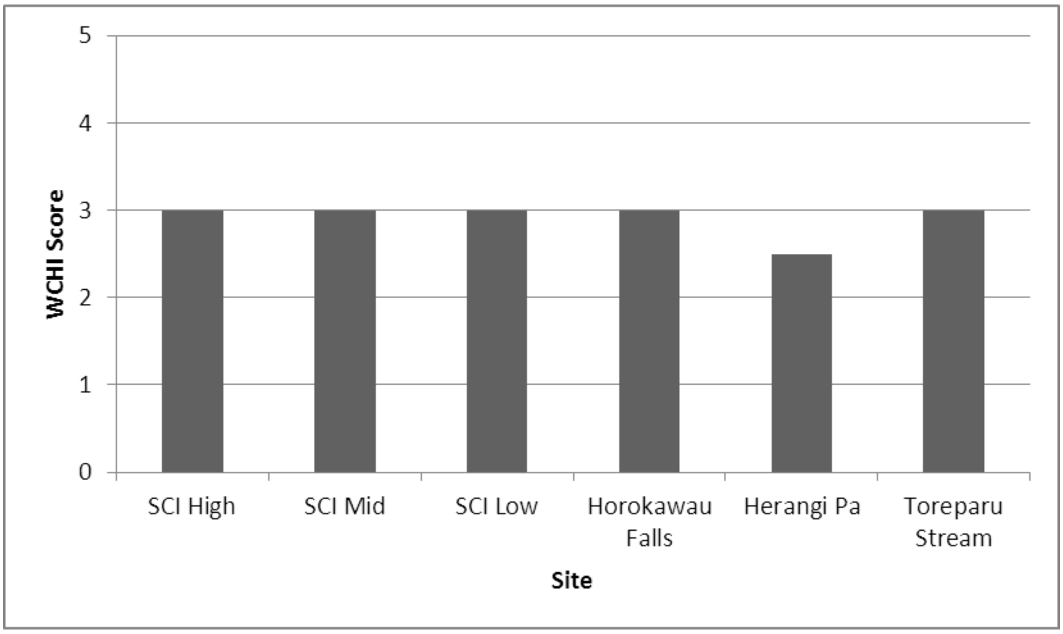

Figure 6 Mean scores for Wetland Cultural Health Indicator results (n=3) for the number of taonga bird species at six sites in the Toreparu wetland, August and November 2013.

6.1.3. Water Quality

The water quality at the Toreparu wetland was another important aspect of health to Mōtakotako marae. Water clarity, flow, temperature and sediment inputs were all identified as useful cultural health indicators. Results from the WCHI assessment show both intra- and inter-site variation in water clarity, flow and temperature (Figure 7).

Water clarity was mostly high in the Toreparu wetland, with half the sites scoring above 4. SCI Mid and Hērangi Pā scored a mean WCHI value of 5, indicating 'very clear' water at the time of survey (Figure 7). SCI High site had a mean score of 4.5, also indicating very clear to often clear water. SCI Low and Toreparu Stream sites had mean water clarity scores of 4, which illustrated that water was 'often clear'. The lowest score was observed at Horokawau Falls, with a value of 3.5, suggesting that water clarity was subject to 'seasonal change' but often clear.

Water flow, or the presence of moving water at each site, scored highly at all six sites in the Toreparu wetland (Figure 7). Sites SCI High, Horokawau Falls and Toreparu Stream all had mean WCHI scores of 5, indicating these sites were ‘always wet’ throughout the year. SCI Mid and SCI Low scored slightly lower, with a mean value of 4.5, again indicating these sites were almost always wet, but with short or intermittent periods where the water levels were low. Hērangi Pā scored the lowest, with a mean WCHI value of 4, suggesting that this site was ‘mostly wet’, and there may be times when water levels were low, particularly during drought.

Temperature was also evaluated as part of the WCHI assessment, and scores were mostly high during these surveys. SCI High, SCI Low, Hērangi Pā and Toreparu Stream all had mean scores of 5, which represented ‘consistently good temperature’ at these sites. Horokawau Falls scored a mean WCHI value of 4, which indicated that the water here was ‘mostly good temperature’. The lowest mean score was recorded at SCI Mid, with a value of 3.5. This suggested that the water temperature was mostly good but subject to seasonal variation.

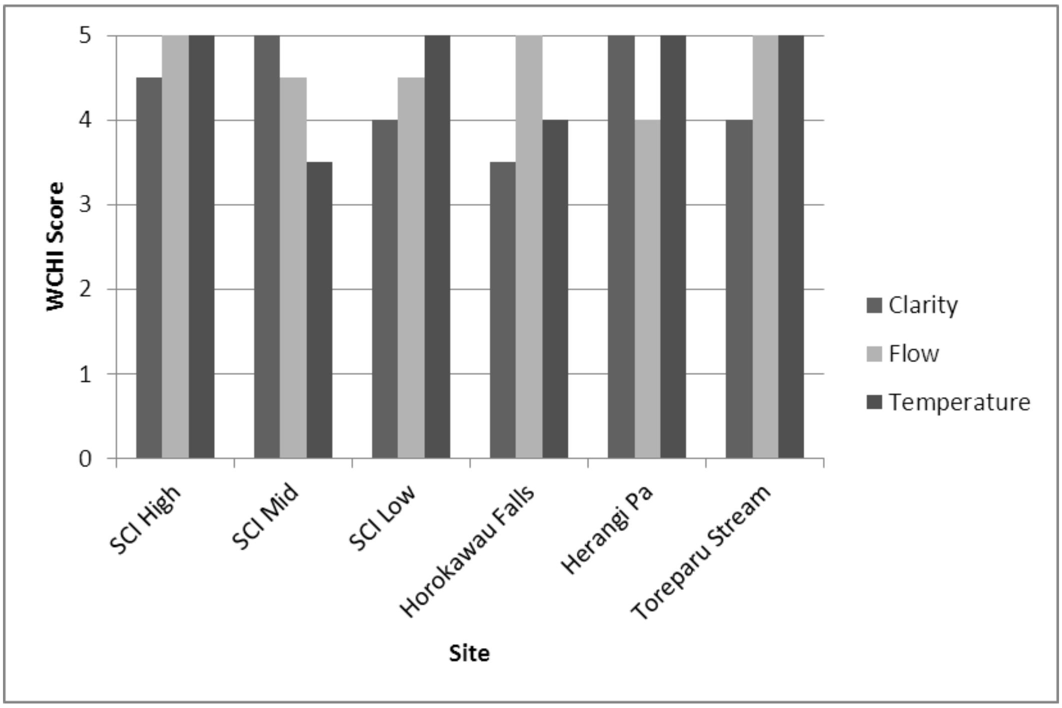

Figure 7 Mean scores for Wetland Cultural Health Indicator results (n=3) for water quality indicators (clarity, flow and temperature) at six sites within the Toreparu wetland, August and November 2013.

Sediment input (% area affected) (Figure 8) was an indicator identified by Mōtakotako marae as important to the health of waimāori in the wetland.

SCI High and SCI Mid both had a mean score of 3.5, which indicates that as much as 50% of the site was affected by new sediment inputs from the surrounding land. Hērangi Pā and Toreparu Stream appeared to be more influenced by sediment, with mean scores of 3, indicating that between 25 and 50% of the site was affected. SCI Low scored a mean WCHI value of 1.5, suggesting between 51 and 99% of the site was affected by new sediment inputs. Horokawau Falls had the lowest score of all the sites, with a value of 1, indicating between 75 and 99% of the site was affected by new sediment inputs during the cultural health assessment.

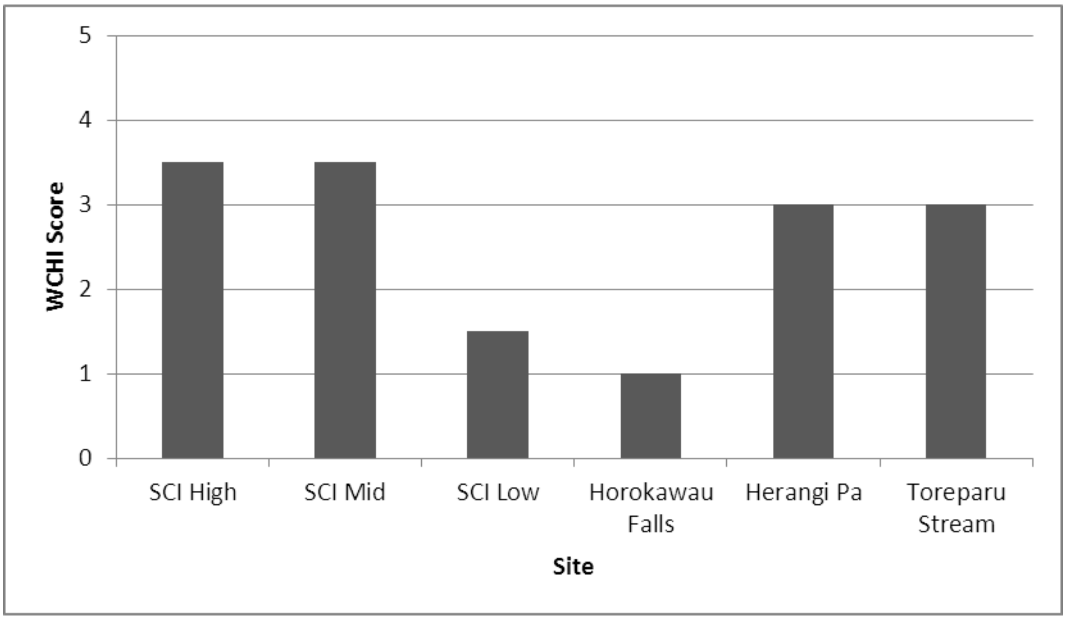

Figure 8 Mean scores for Wetland Cultural Health Indicator results (n=3) for the area (%) in each site affected by sediment input, at six sites in the Toreparu wetland, August and November 2013.

6.1.4. Wāhi Tapu/ Wāhi Taonga

Raranga (weaving) resources were also culturally significant to Mōtakotako marae and were monitored using the health of specific weaving species (harakeke and kuta) and health of dye sources such as ‘black mud’ as two indicators. The health of harakeke/kuta was high at five out of the six sites (Figure 9). SCI High, SCI Mid and SCI Low all scored 5 for health of harakeke/kuta, indicating the resource was ‘very healthy’. Hērangi Pā and Toreparu Stream scored a mean WCHI score of 4 and 4.5, respectively, indicating this resource was of average to high health at these two sites. Horokawau Falls scored the lowest for health of weaving species with a value of 1, illustrating the health of the resource was 'low'.

The health of dye sources was variable between the sites (Figure 9). SCI High scored the highest with a value of 5, indicating it was very healthy. Toreparu Stream scored a mean value of 4, suggesting the dye source was of average to high health. SCI Low and Hērangi Pā scored values of 2.5 and 2, respectively, indicating the dye source was of low-average health. Horokawau Falls, again scored the lowest value with a health of dye source being rated at 1, illustrating it was low at this site.

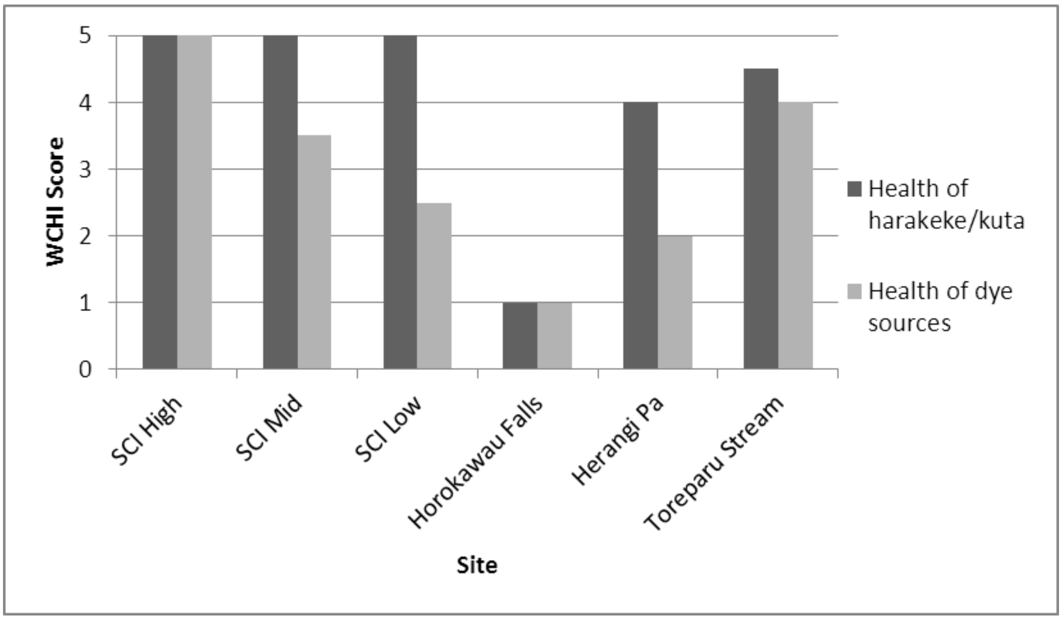

Figure 9 Mean scores for Wetland Cultural Health Indicator results (n=3) looking at the health of wāhi taonga (health of raranga species and dye sources) at six sites within the Toreparu wetland, August and November 2013.

The presence of wāhi tapu, or culturally significant areas such as pā sites (historical fortified habitation areas), middens, water sources, and pā tuna (eel weirs), were all considered during this assessment. All six survey sites were very similar in their mean wāhi tapu scores, with values of 2.5 at five of the six sites, indicating the presence of 3-9 wāhi tapu (Figure 10). Horokawau Falls scored lowest with a value of 2, indicating the presence of 3-5 wāhi tapu sites nearby (Figure 10).

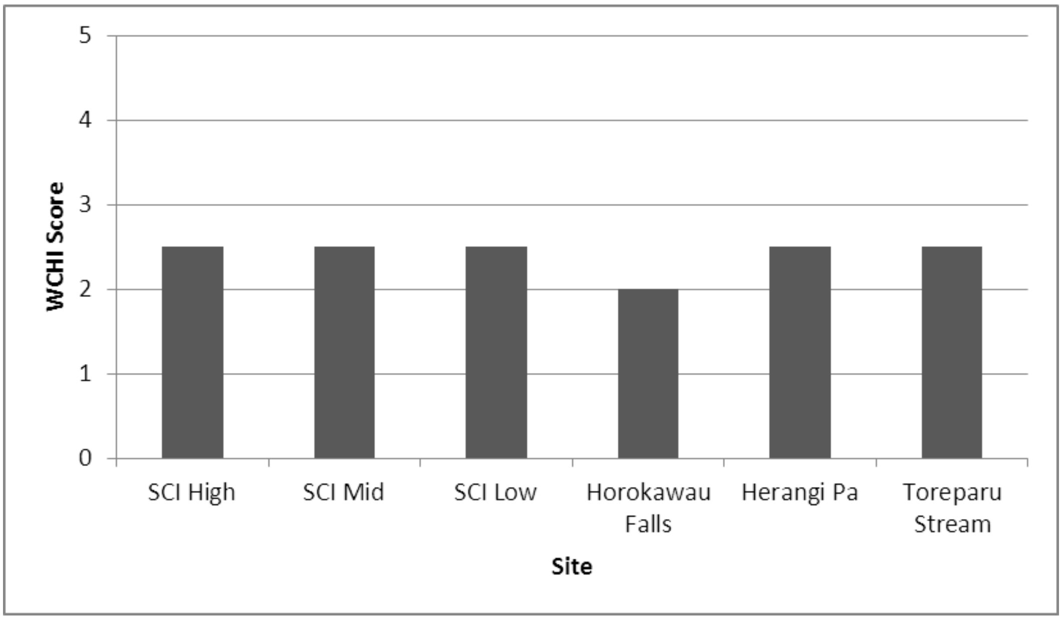

Figure 10 Mean scores for Wetland Cultural Health Indicator results (n=3) for the number of wāhi tapu in and adjacent to six sites in the Toreparu wetland, August and November 2013.

6.1.5. Perceived Issues

Another indicator of wetland health identified by Mōtakotako marae were factors negatively influencing the cultural well-being of the Toreparu, including the health of riparian margins and physical modification of the wetland (e.g., drainage, presence of culverts, changes in the water table, vegetation clearance and presence of stock). SCI High scored the highest mean values for both the land-use and modification indicators (Figure 11). The WCHI value of 4 for the land use indicator, illustrated between 1 and 20% of the surrounding land was affecting cultural values in this site, and a score of 3.5 for the degree of modification showed low to moderate modification at this site. SCI Mid and Toreparu Stream had a mean value of 2 for the land-use indicator, which suggests 40-60% of the surrounding land was affecting cultural values. Modification values at SCI Mid scored 3, indicating moderate modification at this site. Toreparu Stream and Hērangi Pā had modification values of 2, which indicated this site was highly modified. The Hērangi Pā site also had a low score (1) for land-use factors, which indicates between 60 and 80% of the surrounding land affected cultural values. SCI Low and Horokawau Falls, with mean values of 1.5, had the lowest scores for the modification indicator suggesting high to very high modification at these sites. SCI Low also had the lowest value for the land-use indicator (0.5), which illustrated that 60-100% of the surrounding land was influencing cultural values. Horokawau Falls had a score of 0 for land-use, indicating that all (100%) of the surrounding land was affecting cultural values at this site.

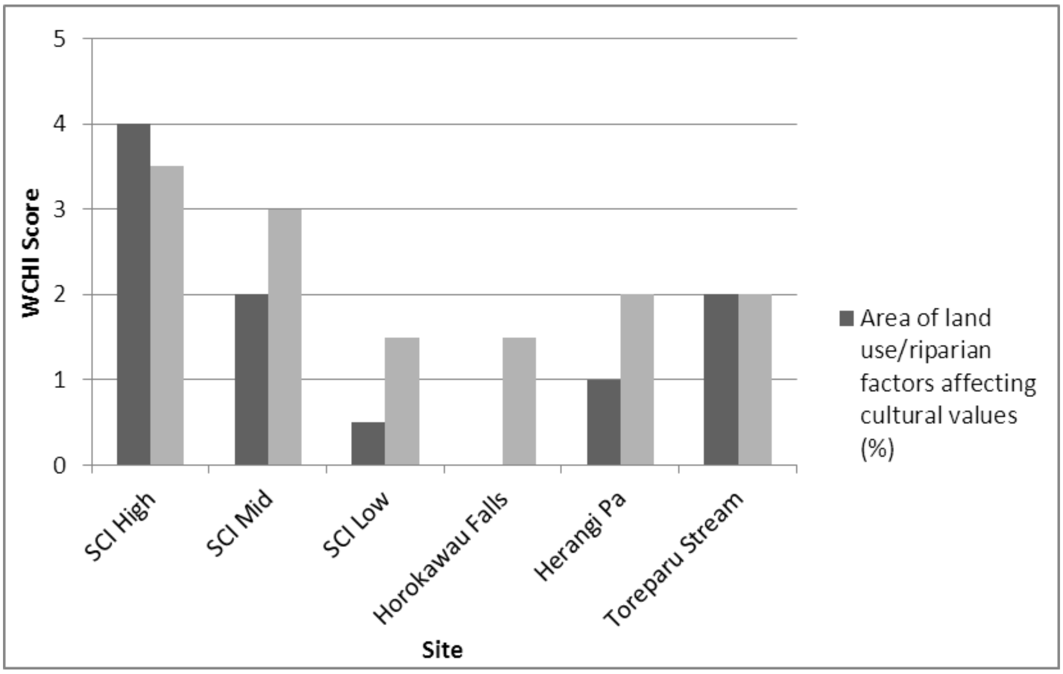

Figure 11 Mean scores for Wetland Cultural Health Indicator results (n=3) for perceived impacts on six sites within the Toreparu wetland, August and November 2013.

6.1.6. Overall Cultural Health

6.1.6.1. Mauri

The WCHI assessed the mauri of each site as a measure of metaphysical health. Mauri scores were mostly high at the six sites surveyed, with four of the sites scoring a mean value of 3. This indicates that the mauri was strong/high at these sites. The Toreparu Stream site had a mauri score of 2.5, which indicates that mauri was considered to be average-high. The lowest mauri score in the Toreparu was recorded at SCI Low, where mauri was described as average/moderate, with a mean value of 2 (Figure 12).

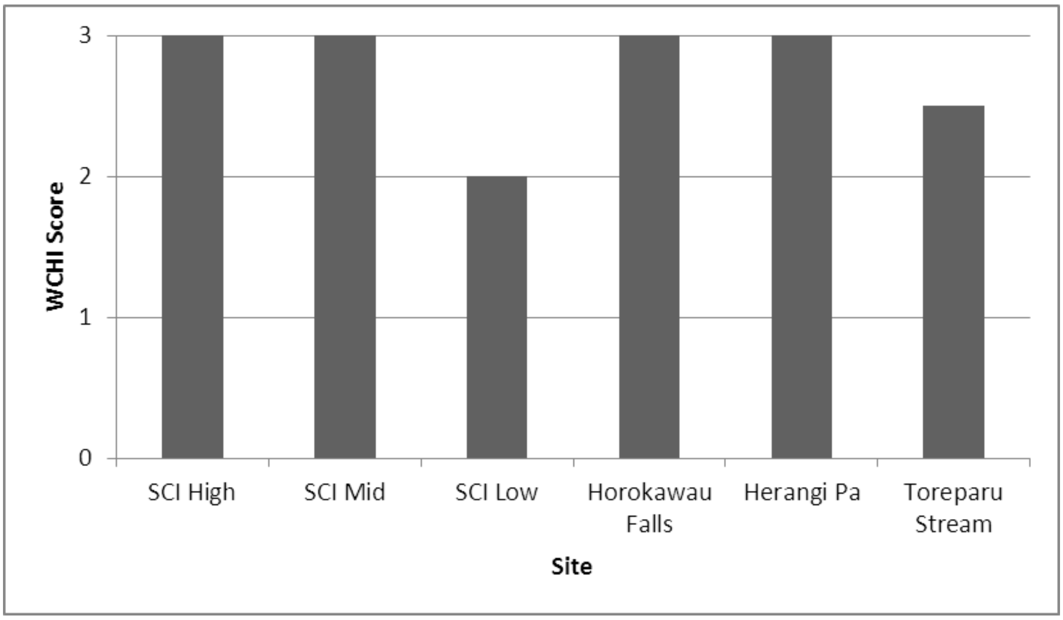

Figure 12 Mean scores for Wetland Cultural Health Indicator results (n=3) looking at the mauri of six sites within the Toreparu wetland, August and November 2013.

6.1.6.2. Mahinga Kai Index and WCHM

The Mahinga Kai Index and WCHM represent a compilation (mean value) of all the individual cultural indicators measured in this survey, and are considered the most important values when considering the cultural health of wetlands. The Mahinga Kai Index is an average score for the six fishery and bird indicators, while the WCHM is an average for thirteen indicators that measured water quality, native vegetation, weeds, health of wāhi tapu and wāhi taonga and the negative impacts from surrounding land use. Overall health of the six main sites and six sub-sampling sites show some variation in both the mean mahinga kai and mean WCHM scores in the Toreparu wetland (Figure 13, Figure14). Mahinga kai score was lowest at Hērangi Pa site, with a mean value of 2.7 (Figure 13) indicating below average health for fishery and birds. SCI High, SCI Mid and SCI Low sites all had a mahinga kai score of 2.8, representing average health for fish and bird indicators. The Toreparu Stream and Horokawau Falls sites had mahinga kai scores of 3.4 and 4.0 (Figure 13), respectively, which illustrates that health of the fishery and birds was considered to be average-high here.

Overall, mean wetland cultural health measure (WCHM) scores ranged between 2.4 and 3.9 for the six sites at the Toreparu wetland. The lowest mean WCHM value was recorded at the Horokawau falls site, with a score of 2.4 (Figure 14), indicating general wetland health here was average-poor. Hērangi Pa, Toreparu stream, SCI mid and SCI Low all had WCHM scores that ranged between 3.1 and 3.6, which indicates general wetland health was considered to be average. The highest WCHM score was at SCI High, with a value of 3.9 indicating general wetland health was average-high.

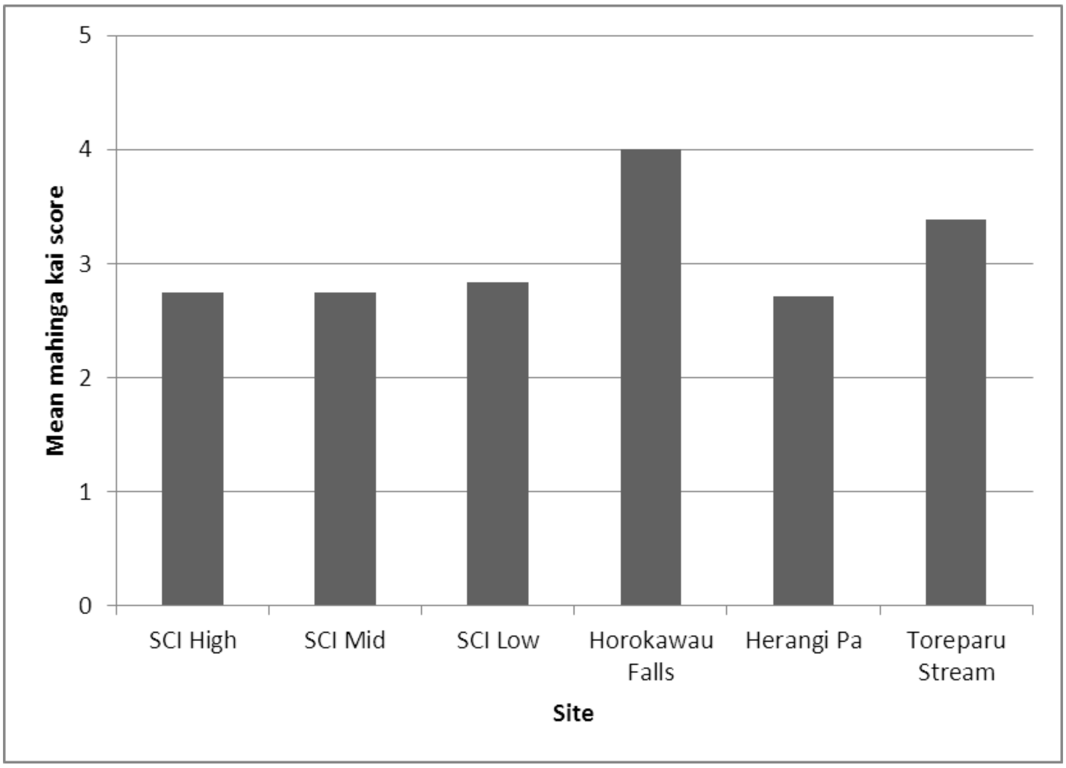

Figure 13 Mean mahinga kai scores (n=3) for six sites within the Toreparu wetland, August and November 2013.

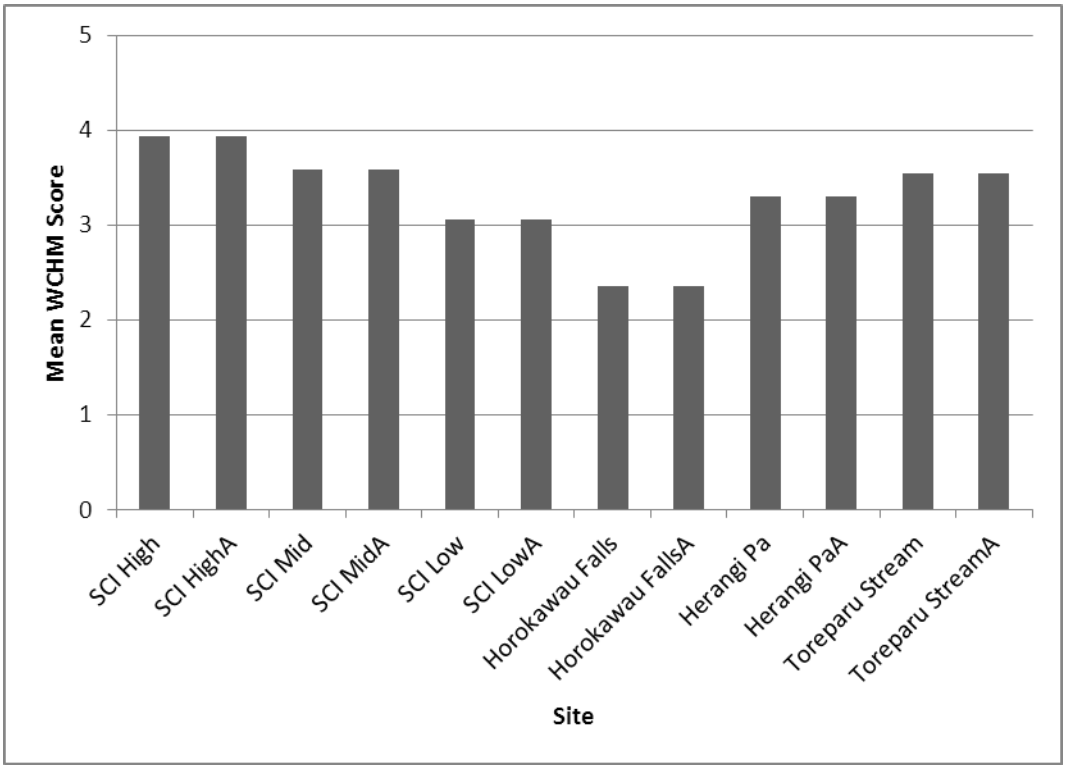

Figure 14 Mean WCHM scores (n=3) looking at the overall health of six sites within the Toreparu wetland, August and November 2013.

6.2. Scientific Results

6.2.1. Vegetation Survey

Results from the vegetation survey carried out at the Toreparu wetland in July 2013 show variation in both total species (n) and abundance of native versus introduced plants across the six sampling sites (Figure 15). Hērangi Pā and SCI High each had a total of nine species recorded within the 2x2 m sampling plot. Hērangi Pā had a higher abundance of native species, including ponga (*Cyathea dealbata*), māhoe (*Melicytus ramiflorus*), harakeke (*Phorium tenax*), Carex grasses (*Carex secta*), *Coprosma propinqua* and ferns (*Blechnum novae-zelandiae*), with only two introduced species; Himalayan honeysuckle (*Leycesteria formosa*) and water celery (*Apium nodiflorum*). SCI High had a mixed grey willow (*Salix cinerea*) and kānuka (*Kunzea ericoides*) canopy with the occasional karamu (*Coprosma lucida*). The lower storey comprised a variety of herbs, sedges and rushes including *Carex secta*, *Carex virgata*, *Carex geminata*, raupō (*Typha orientalis*), kuawa (*Schaenoplectus tabernaemontani*) and water celery. SCI Mid was dominated by native vegetation, including raupō, *Carex secta*, *Carex flaviformis*, *Juncus australis*, *Juncus sarophorus* and baumea (*Machaerina rubiginosa*). SCI Low also comprised of mostly native species, but was dominated by a grey willow canopy. Native species included harakeke, *Carex geminata*; swamp kiokio (*Blechnum minus*), gully fern (*Pneumatopteris pennigera*) and umbrella sedge (*Cyperus ustulatus*) with introduced common pasture grasses and buttercup (*Ranunculus acris*). Toreparu Stream had equal numbers of native and introduced species with grey willow along the banks, a small patch of cabbage tree (*Cordyline australis*) and patches of harakeke, Carex grasses (*C. geminata, C. secta*) and introduced herbs and grasses along the stream banks. Reed sweet grass (*Gyceria maxima*) was abundant along with water pepper (*Persicaria hydropiper*) and rank grasses. The only site where introduced species dominated the vegetation plot was at Horokawau Falls (Figure 15). The Horokawau Falls site was mostly cleared of native trees and shrubs, and was predominantly pasture with some patches of *Juncus effuses* and *Carex virgata* observed along the water's edge. The adjacent banks were covered mostly by gorse (*Ulex europaeus*), blackberry (*Rubis fruticosus*), buttercup and pasture grasses.

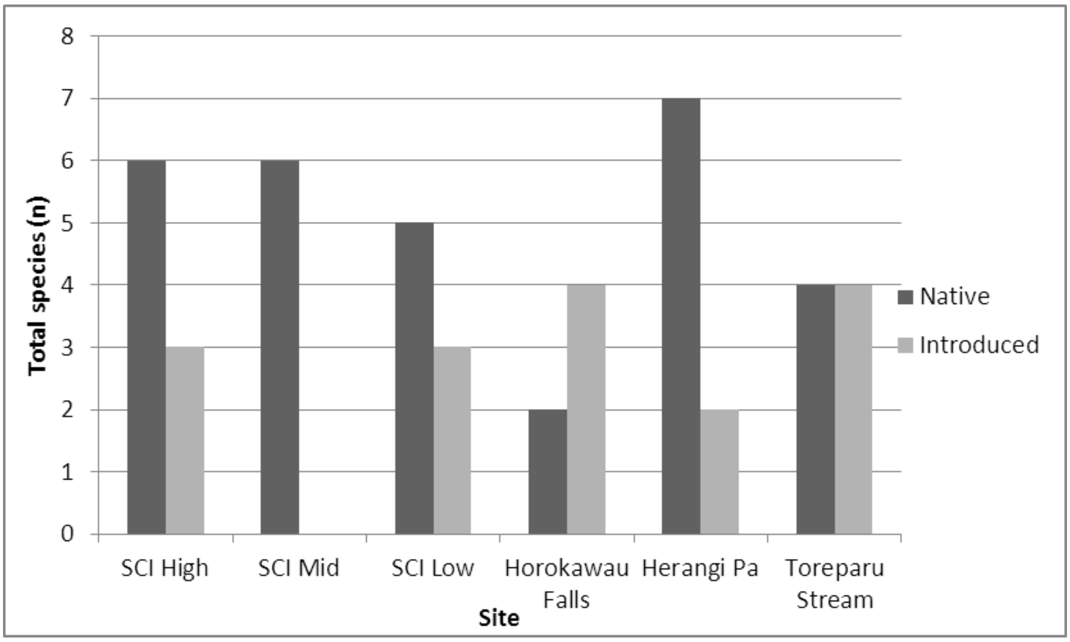

Figure 15 Total number of native and introduced species recorded in 2x2m vegetation plots in the Toreparu wetland, July 2013.

The percentage composition of native and introduced flora at the Toreparu wetland further indicates the dominance of native species within the sampling sites. Over 80% of the vegetation coverage at sites Hērangi Pā, SCI High and SCI Low was native, with the SCI Mid vegetation plot showing 100% cover of native species (Figure 16). Horokawau Falls and Toreparu Stream exhibited the opposite trend, with Horokawau Falls showing only 11% native vegetation cover and Toreparu Stream showing 33% native vegetation cover (Figure 16).

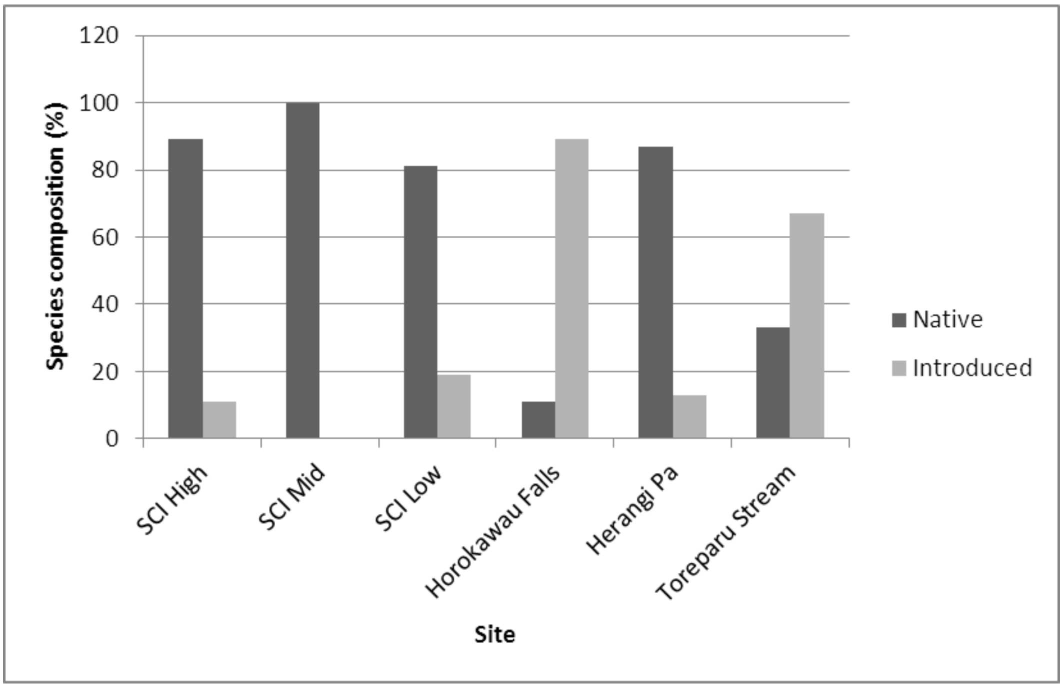

Figure 16 Species composition (%) of native and introduced flora recorded in the Toreparu wetland, July 2013.

Four out of the six sites sampled within the Toreparu were dominated by native vegetation, both in terms of number of species and percentage of cover. Grey willow appears to be spreading throughout the Toreparu and was present in three of the vegetation plots. Grey willow was also noted at SCI Mid and Hērangi Pā, but was outside of the plot location. Aside from introduced pasture grasses and herbs, the most notable weeds were Himalayan honeysuckle, gorse, blackberry and reed sweet grass, all of which have spread throughout much of the Toreparu steam, which runs the length of the wetland.

6.2.2. Fauna Surveys

6.2.2.1. Fishery Survey

Overnight trap netting surveys of all six main sites within the Toreparu wetland were carried out between 9 and 12 July 2013. Results indicate a dominance of indigenous species and an absence of non-native fish within the Toreparu (Table 1). Longfin eel (*Anguilla dieffenbachii*) were the most common species found, and were present at three of the sites: SCI Low, Horokawau Falls, and Toreparu Stream. Shortfin eel (*Anguilla australis*) on the other hand was only observed at the SCI High site, where only one individual was captured. Three galaxiid species were found during this survey, banded kōkopu (*Galaxias fasciatus*), kōaro (*Galaxias brevipinnis*) and īnanga (*Galaxias maculatus*). Banded kōkopu were captured at SCI High and SCI Low sites, with a single kōaro also found at the SCI High site. Common smelt (*Retropinna retropinna*) were also noted at Horokawau Falls. Redfin bullies (*Gobiomorphus huttoni*) were captured lower down the catchment, at the Toreparu Stream site, located within the Toreparu stream (Table 1).

Table 1 Total number freshwater fish captured during an overnight trap netting survey at six sites within the Toreparu wetland, July 2013.

Site	SCI High	SCI Mid	SCI Low	Horokawau Falls	Hērangi Pā	Toreparu Stream	Species Total
Longfin eel			1	4		1	6
Shortfin eel	2						2
Banded kōkopu	7		1				8
Kōaro	2						2
Īnanga			4			13	17
Redfin bully			1			1	2
Common smelt				1			1
Catch Total	11	0	7	5	0	15	

Total catch size at each of the six sampling sites was generally low. The largest catch of 15 individuals was at the Toreparu Stream site, within the Toreparu Stream, with a majority of the catch consisting of juvenile īnanga. The SCI High had the next largest catch with 11 individuals made up of three species (Table 1). Banded kōkopu, kōaro and shortfin eel were all present at the SCI High site with banded kōkopu the most abundant of the three species. SCI Low and Horokawau Falls sites were similar in total catch. The SCI Low site had twice the number of species with longfin eel, banded kōkopu, īnanga and redfin bullies all found during the survey (Table 1 and Figure 17). The Horokawau Falls site had the lowest abundance and diversity of freshwater fish with a total of five fish captured, four longfin eels and a single common smelt (Table 1 and Figure 17).

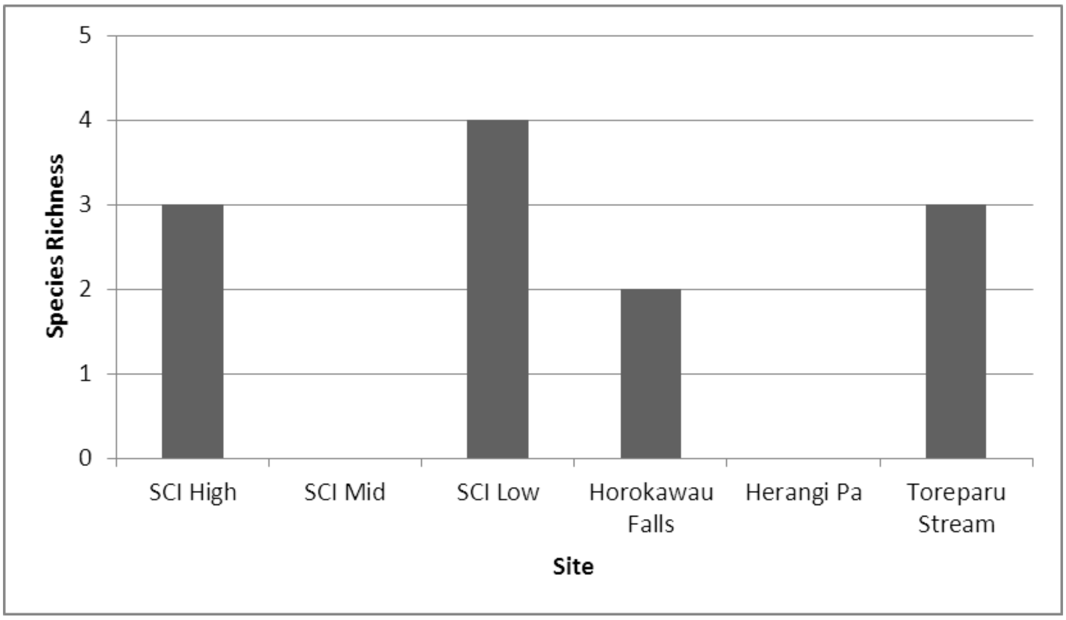

Figure 17 Species richness of freshwater fish captured during an overnight trap netting survey at six sites within the Toreparu wetland, July 2013.

6.2.2.2. Bird Survey

Wetland bird surveys carried out on 3 and 4 November 2013 revealed a number of indigenous and introduced taxa, including two threatened wetland bird species; the spotless crake (*Porzana tabuensis*) and North Island fernbird (*Bowdleria punctata*) (Hitchmough et al., 2007). The majority of species found in and around the wetland were common forest and pasture birds (Table 2).

Spotless crake were heard at three of the six main sites (SCI High, SCI Mid, and Toreparu Stream) during playback surveys and 5MBC surveys

(Table 2). At SCI Mid and Toreparu Stream, there were two or more birds calling, with only one bird at SCI High. North Island fernbird, were both seen and heard at SCI High and SCI Mid (Table 2). At SCI Mid, one pair of fernbird was observed emerging from a thicket of low-growing mānuka scrub to the edge of the wetland, calling continuously. Black shags (*Phalacrocorax carbo*) were seen at Horokawau Falls and Toreparu Stream, and are currently classified as 'Naturally uncommon' in the current '*Conservation Status of New Zealand Birds'* report (Miskelly et al., 2008).

Other 'Not threatened' native species (Miskelly et al., 2008) recorded during the Toreparu wetland surveys included fantails (*Rhipidura fuliginosa*) and grey warbler (*Gerygone igata*) which were commonly observed throughout the wetland and recorded at all sites during these surveys (Table 2). Kingfisher (*Todiramphus sanctus*), tui (*Prosthemadera novaeseelandiae*), shining cuckoo (*Chrysococcyx lucidus*), silvereye (*Zosterops lateralis*), paradise shellduck (*Tadorna variegata*), Australasian harrier (*Circus approximans*), pūkeko (*Porphyrio melanotus*), spur-winged plover (*Vanellus miles*), and pied shag (*Phalacrocorax varius*) were also seen and heard during these surveys but were more variable in their distribution (Table 2, Figure 18).

A variety of introduced passerines and common pasture and forest birds were also noted during the November playback and 5MBC surveys (Figure 18). Common pheasant (*Phasianus colchicus*), Australian magpie (*Gymnorhina tibicen*), European goldfinch (*Carduelis carduelis*), chaffinch (*Fringilla coelebs*), yellowhammer (*Emberiza citrinella*), Eurasian blackbird (*Turdus merula*), welcome swallow (*Hirundo neoxena*), common starling (*Sturnus vulgaris*) and eastern rosella (*Platycercus eximius*) were noted within the wetland itself as well as the surrounding bush remnants and pasture habitat (Table 2).

Table 2 Species presence at six sites within the Toreparu wetland based on 5MBC and playback surveys, November 2013.

Species	SCI High	SCI Mid	SCI Low	Horokawau Falls	Hērangi Pā	Toreparu Stream
Spotless Crake	×	×				×
N.I Fernbird	×	×				
Fantail	×	×	×	×	×	×
Grey warbler	×	×	×	×	×	×
Kingfisher	×	×		×	×	
Shining cuckoo	×					×
Pūkeko				×		
Tui	×	×	×	×	×	
Silvereye	×				×	×
Paradise Duck					×	×
Harrier				×		×
Black shag				×		×
Pied shag						×
SW Plover				×		
Total Native	8	6	3	8	6	9
Eastern rosella	×	×			×	
Pheasant	×				×	
Goldfinch	×	×	×	×	×	×
Blackbird	×	×			×	×
Magpie	×	×	×	×	×	×
Chaffinch	×	×			×	×
Yellowhammer		×	×	×	×	×
Welcome swallow			×	×		
Starling			×			
Total Introduced	6	6	5	6	7	5
Total Species	**14**	**12**	**8**	**12**	**13**	**14**

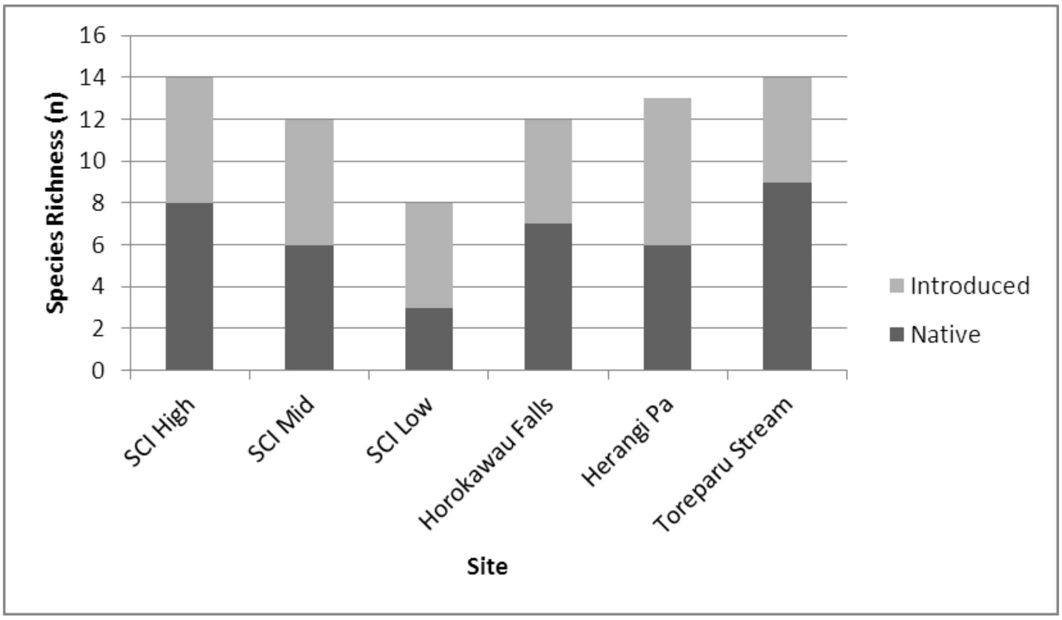

Figure 18 Total number (n) of bird species seen/heard during playback and 5MBC surveys at the Toreparu wetland, November 2013.

6.2.2.3. Aquatic Macro-invertebrate Survey

Both abundance and species richness of aquatic macro-invertebrates was generally low at the Toreparu wetland. The number of taxa found at all sites ranged between six and ten species (Table 3). Abundance of individuals was as low as 45, at the SCI Mid site, with 193 individuals sampled at Horokawau Falls. Sites SCI High, SCI Mid and Hērangi Pā all had low abundances, with around 50 invertebrates per sample (Table 3). Sites SCI Low, Hērangi Pā and Toreparu Stream invertebrate samples all contained fewer than 200 individuals (Table 3)

Table 3 Aquatic macroinvertebrate metrics from Toreparu wetland samples, July 2013.

	SCI High	**SCI Mid**	**SCI Low**	**Horokawau Falls**	**Herangi Pa**	**Toreparu Stream**
Number of Taxa	9	11	10	10	6	7
Number of Individuals	49	45	169	193	56	190
MCI-sb Value	98	81	86	83	56	74
SQMCI-sb Value	4.1	3.7	3.5	2.5	3.5	4.5
% Dominant Taxa	37	60	49	84	70	69
Dominant Taxa	Crustacea	True Fly	True Fly	Mollusca	Crustacea	Crustacea

The dominant taxa in the SCI High, Hērangi Pā and Toreparu Stream samples were crustaceans, which made up 37%, 70% and 60% of sample abundance, respectively (Table 3, Figure 19). The amphipod *Paracalliope* was most abundant in these samples, with *Phraetogammus* also found in a majority of the samples. True fly taxa dominated the SCI Mid and SCI Low sites, making up 60% of the SCI Mid abundance and 49% of the SCI Low sample abundance (Table 3, Figure 19). *Austrosimulium* (black fly larvae) and Chironomidae were the most abundant taxa within the Order Diptera. Horokawau Falls was made up mostly (84%) of mollusc species (Figure 19), with *Potamopyrgus* snails dominating this sample. *Potamopyrgus* and *Physella* were the most common mollusc taxa within the wetland, with the occasional *Gyraulus* snail at sites where there was an abundance of overhanging vegetation.

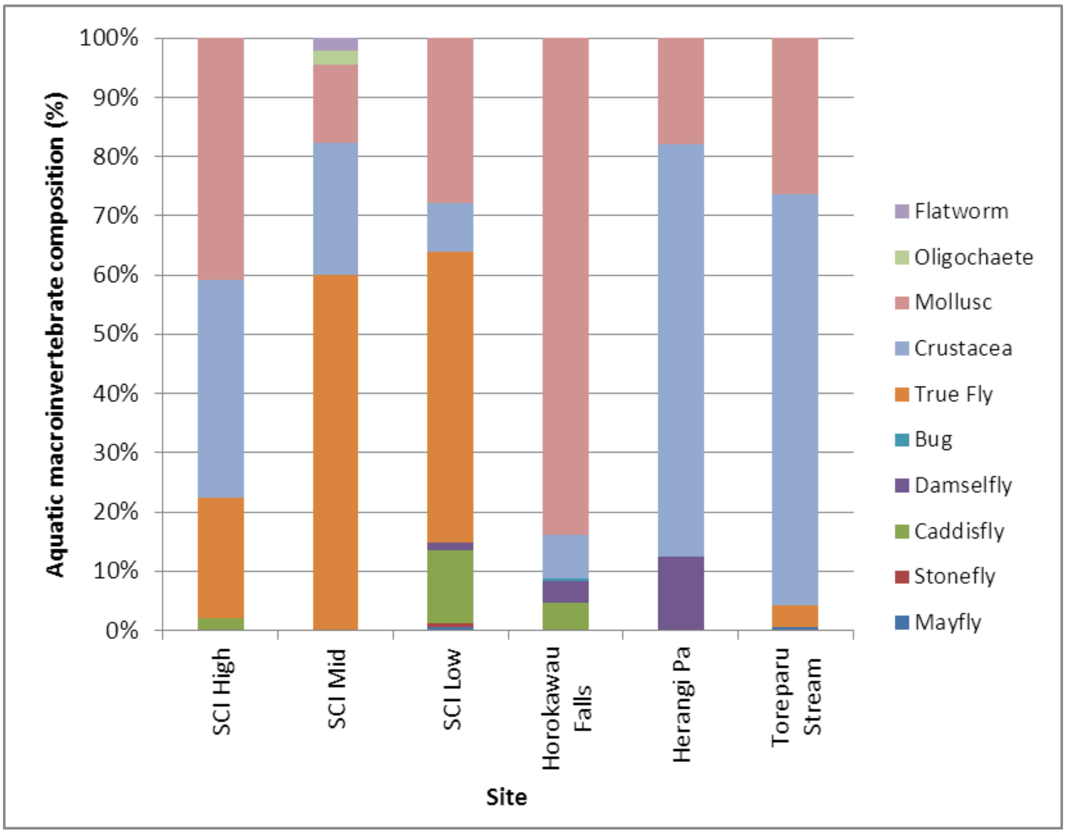

Figure 19 Percentage composition of aquatic macroinvertebrates sampled at the Toreparu wetland, July 2013.

An MCI-sb score of below 90 indicates habitat of poor quality (Stark & Maxted, 2007) or ‘probable severe pollution’ (Stark, 1998). MCI-sb scores here ranged between 56 and 98. The lowest MCI-sb value was observed at the Hērangi Pā site (56), with the next highest score of 74 at Toreparu Stream. A MCI-sb score of 81 was found at SCI Mid, 83 at Horokawau Falls, 86 at SCI Low, and the highest score of 98 was observed at SCI High. MCI-sb and SQMCI-sb scores between 80 and 99 are indicative of 'Fair' quality habitat (Stark & Maxted, 2007) or 'probable moderate pollution' (Stark, 1998). Overall, the MCI-sb and SQMCI-sb scores indicate that all six sites in the wetland are not considered to be of high quality habitat or may be affected by pollution.

Overall, the aquatic macroinvertebrate metrics and species composition indicate variation in the following metrics; total number of taxa found, the presence of EPT taxa, and overall species composition across the six sampling sites.

6.2.3. Water Quality

6.2.3.1. Spot Sampling

Water temperature in August was between 10.9 and 14.1^{0}C, increasing to between 12.9 and 18.7^{0}C in November (Figure 20). The August survey results show the lowest temperatures were recorded at SCI Mid and SCI MidA, and the highest temperatures recorded at Hērangi Pā and Hērangi PāA. Both the SCI Mid and Hērangi Pā sites and their associated sub-sampling sites are located in the southern reach of the wetland and both are fed by groundwater springs. The highest annual temperatures were recorded at Horokawau Falls and SCI Low in November 2013. These two sites also had the greatest difference between the August and November results, with an increase of approximately 7^{0}C at Horokawau Falls and 6^{0}C at SCI Low (Figure 20). While these sites are in close proximity to each other, in the north-eastern extent of the wetland, they receive water from different stream catchments.

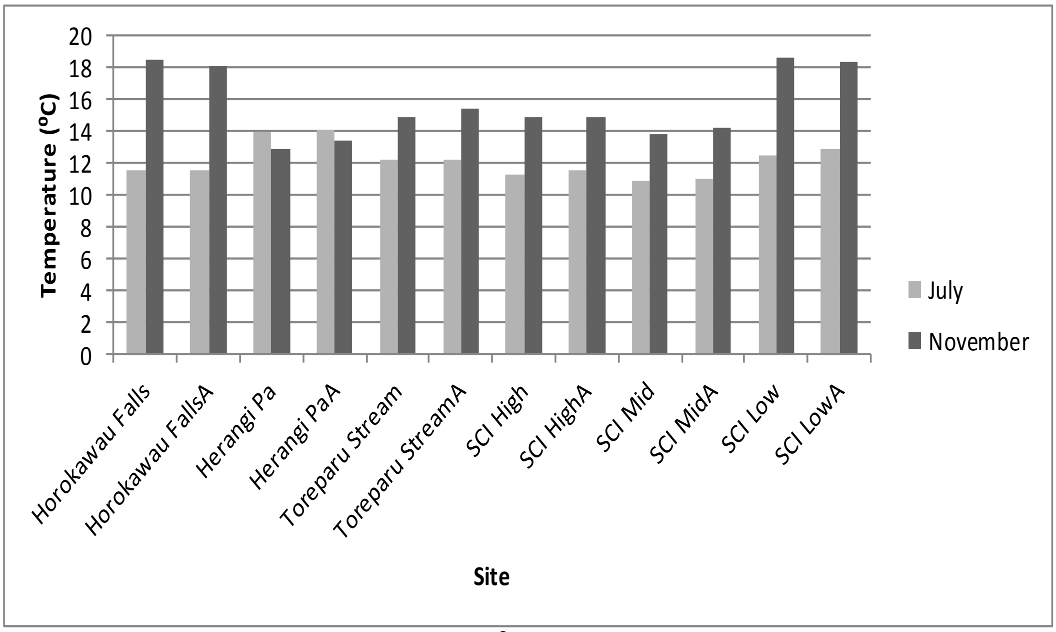

Figure 20 Water temperature (^{0}C) recorded at twelve sampling sites within the Toreparu wetland, August and November 2013.

The August survey oxygen saturation (DO %) results ranged between 72 and 97% (Figure 21). SCI Low had very low DO in August, with only 34%; SCI High was slightly higher at 51%. The November dissolved oxygen results illustrated reduced levels at most of the sites, except Hērangi Pā, which had an increase of 11% and SCI Low which had a much larger increase of 49% (Figure 21). SCI High demonstrated a reduction in DO level of 28%, SCI Mid of 43%, SCI MidA of 54%, and the greatest difference was observed at SCI HighA, where levels dropped by 77% between August and November. This is likely due to the reduced water availability at the sampling site, which, for the November survey, had to be moved deeper into the wetland, where pools of water were dominated by wetland vegetation.

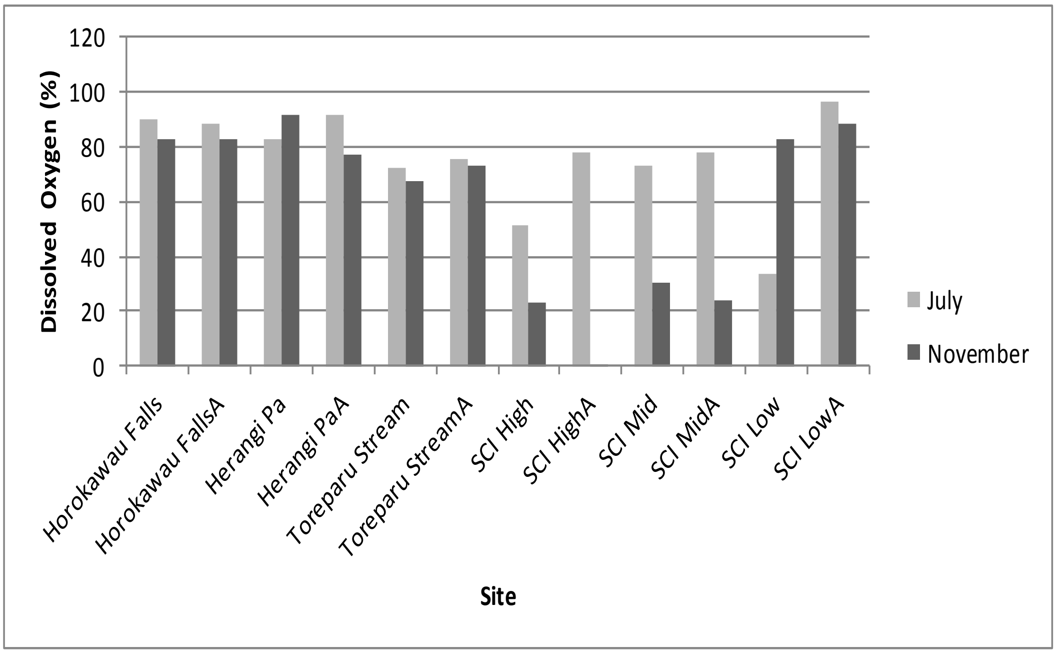

Figure 21 Dissolved oxygen saturation (%) recorded at twelve sites within the Toreparu wetland, August and November 2013.

Specific conductivity (µS/cm) was the most variable of the spot sample measurements taken in August and November at the wetland. In August, specific conductivity (SPC) within the twelve sampling sites ranged from 109 to 327 µS/cm (Figure 22). In November this variance was larger, with a range from 110 to 481 µS/cm. Horokawau Falls and Horokawau FallsA sites had the lowest conductivity during the August and November sampling periods. In August, specific conductivity was measured at 91 µS/cm at Horokawau Falls and 92 µS/cm at Horokawau FallsA.

This increased slightly in November with 110 µS/cm at Horokawau Falls, and 114 µS/cm at Horokawau FallsA (Figure 22). Horokawau Falls, Toreparu Stream, SCI Low and their corresponding sub-sampling sites resulted in similar specific conductivity values, with a range of 91–169 µS/cm. Hērangi Pā, SCI High, SCI Mid, and their corresponding sub-sampling sites also had similar specific conductivity values and were generally much higher than the other six sites. These six sites had conductivity values between 263 and 481 µS/cm, with one lower value of 180 µS/cm (Figure 22).

SPC was generally low at SCI Low and the SCI LowA sites, with no obvious patterns of increase or decrease in values between sampling events. Specific conductivity was more stable at these sites, which may be attributed to the similar physical and hydrological properties between them (Figure 22).

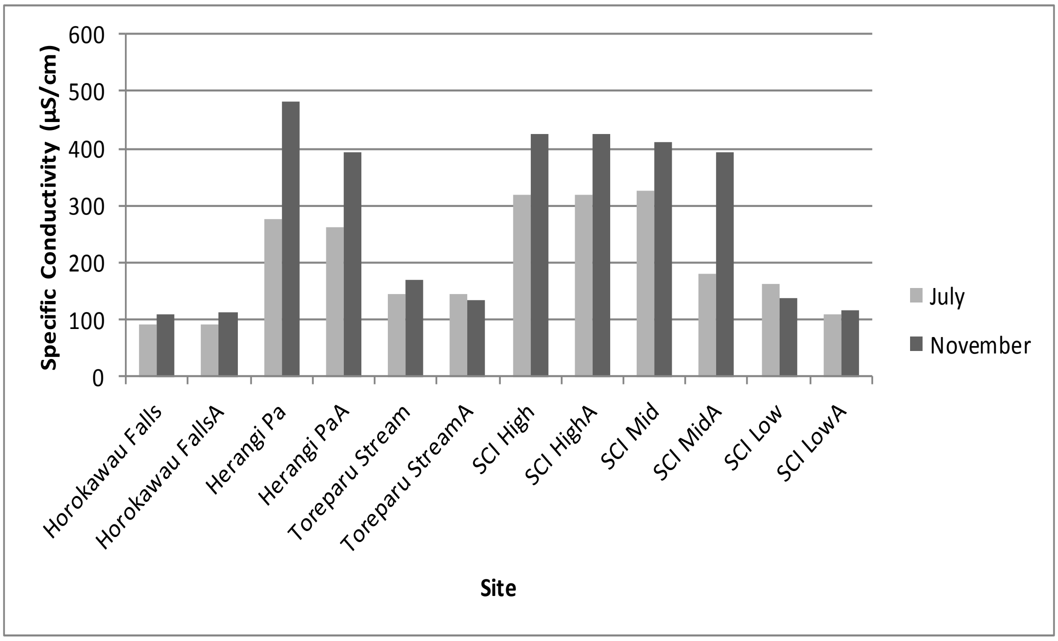

Figure 22 Specific conductivity (µS/cm) levels recorded at twelve sites within the Toreparu wetland, August and November 2013.

6.2.3.2. Total Nitrogen and Total Phosphorus

Total N (TN) levels exhibited variation in concentration between sites and sampling periods (Figure 23). The SCI Mid November sample was lost in the field. By the time this loss was noted in December, it was not possible to compare the sample with other samples collected in November, given the change in the hydrological state of the wetland. In August, TN ranged from 0.07 mg/L at SCI Mid to 1.06 mg/L at the adjacent SCI MidA site (Figure 23). The November results were less variable, with values ranging between 0.05 mg/L at SCI HighA and 0.72 mg/L at Horokawau Falls (Figure 23). Eight out of twelve sites registered a decrease in TN between the August and November samples, with Toreparu Stream, SCI High and SCI LowA all showing increased TN in November (Figure 23).

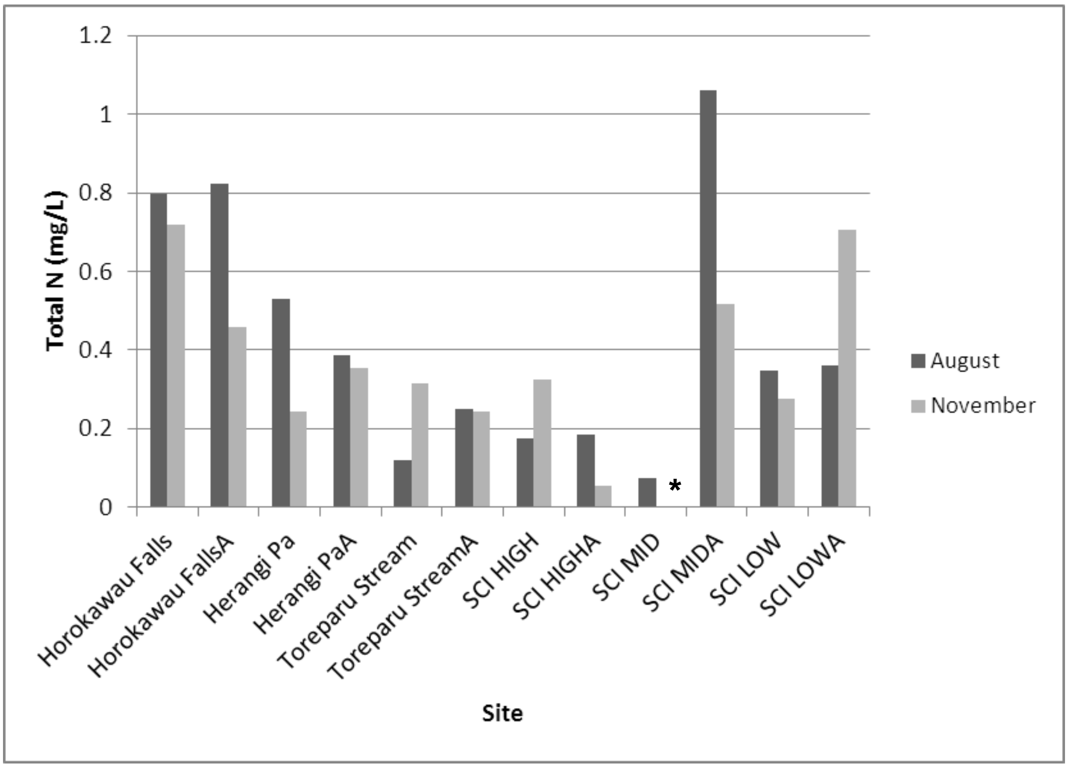

Figure 23 Total nitrogen (mg/L) levels at 12 sites in the Toreparu wetland, August and November 2013. *Sample was lost

Eleven of the twelve August samples had a Total P (TP) concentration below 0.10 mg/L, with the SCI MidA sample having a much higher concentration of 0.27 mg/L (Figure 24). The August results ranged from 0.01 mg/L at Toreparu Stream and 0.27 mg/L at SCI MidA. The November results demonstrated a general decline in TP at nine of the twelve sampling sites (Figure 24). Toreparu Stream and SCI LowA were the only sites with an increase of TP between the August and November surveys.

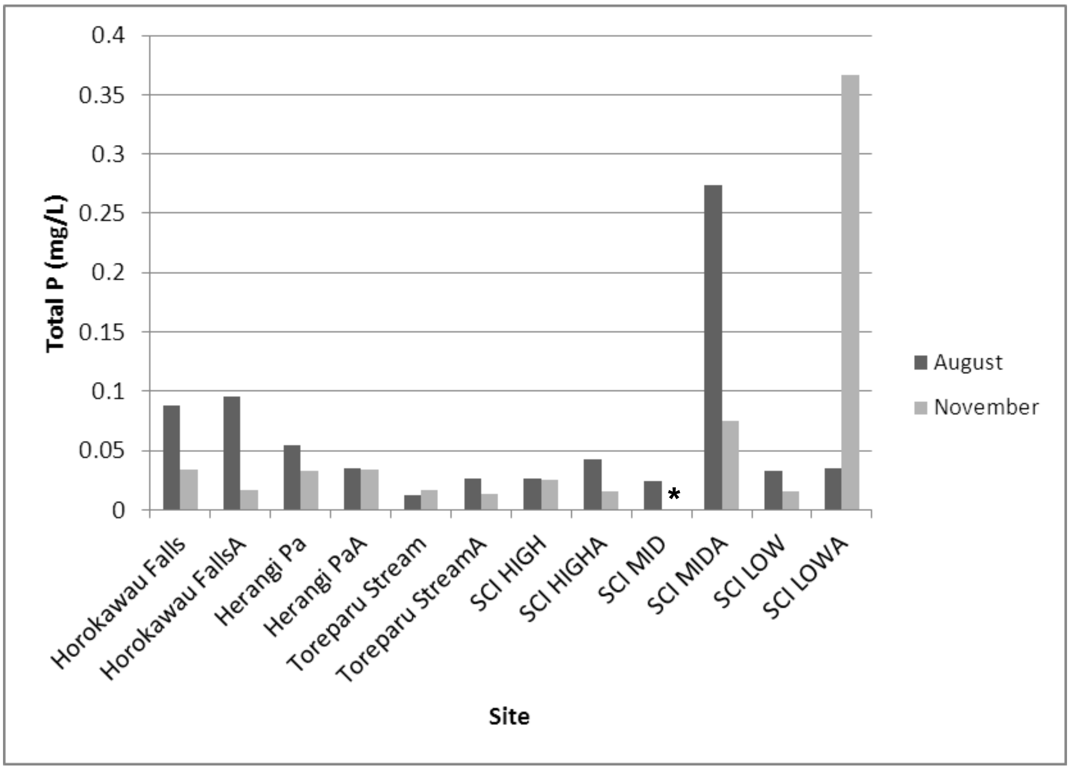

Figure 24 Total phosphorus (P) (mg/L) levels at 12 sites in the Toreparu wetland, August and November 2013. *Sample was lost

7. Comparative Analysis

7.1. Significant Correlations

Comparative analysis was carried out between results for the WCHI assessment, made up of the mahinga kai and WCHM scores, and key variables measured during the scientific surveys within the Toreparu wetland in July and November 2013. Only three of the fourteen correlations were significant; WCHM had positive correlations with dissolved oxygen (%), TN (mg/L) and the SQMCI-sb value (Table 4).

Table 4 Relationships between the mahinga kai index, the wetland cultural health measure (WCHM) index and scientific surveys results from July and November 2013, using Pearson's correlation (r) value. Significant results are given in bold.

Mahinga Kai	Pearson's *r* value	p-value
Mahinga Kai Index vs Abundance native bird	0.36	0.48
Mahinga Kai Index vs. Tuna abundance	0.27	0.61
Mahinga Kai Index vs. Inanga abundance	0.23	0.66
Wetland Cultural Health Measure		
WCHM vs. Native plant spp. (n)	0.72	0.11
WCHM vs. Native spp. cover (%)	0.65	0.16
WCHM vs. Introduced plant spp. (n)	-0.38	0.46
WCHM vs. Introduced spp. cover (%)	-0.65	0.16
WCHM vs. Temperature (°C)	0.55	0.06
WCHM vs. Dissolved oxygen (%)	**0.80**	**0.002**
WCHM vs. SPC (µS/cm)	-0.53	0.07
WCHM vs. Total N (mg/L)	**0.64**	**0.03**
WCHM vs. Total P (mg/L)	0.27	0.41
WCHM vs. MCI-sb value	0.15	0.77
WCHM vs. SQMCI-sb value	**0.88**	**0.021**

7.1.1. CHM and Dissolved Oxygen

Water quality was assessed in both July and November surveys at the six main sites, and six subsampling sites in the Toreparu wetland. There was a very strong positive correlation between WCHM and dissolved oxygen with an increase in WCHM associated with an increase in DO (%) (Figure 25). This was shown with a statistically significant r-value of 0.80 (p=0.002) (Table 4).

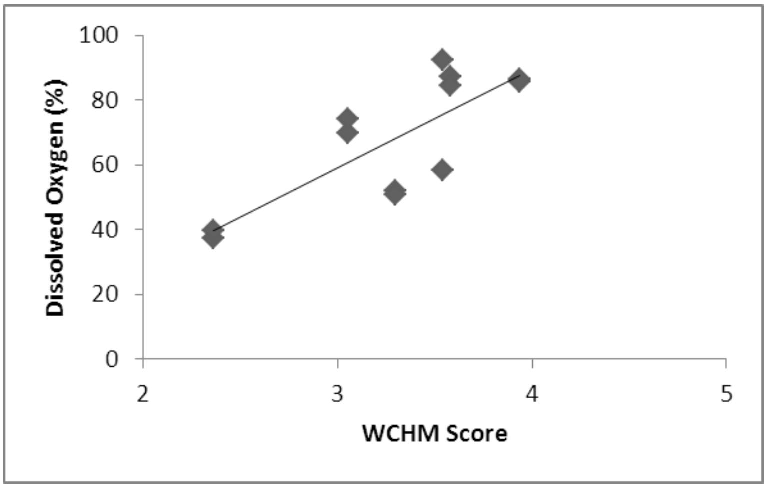

Figure 25 Relationship between mean WCHM score and mean dissolved oxygen level (%) at twelve sites within the Toreparu wetland, July and November 2013.

7.1.2. WCHM and TN

TN and TP were also measured at the six main sites and six sub-sampling sites in the Toreparu wetland. Mean results from the July and November surveys exhibited a positive correlation for both TN (Figure 26). The increase in WCHM score was linked to a statistically significant increase in TN, with an r-value of 0.61 (p=0.02) (Table 4).

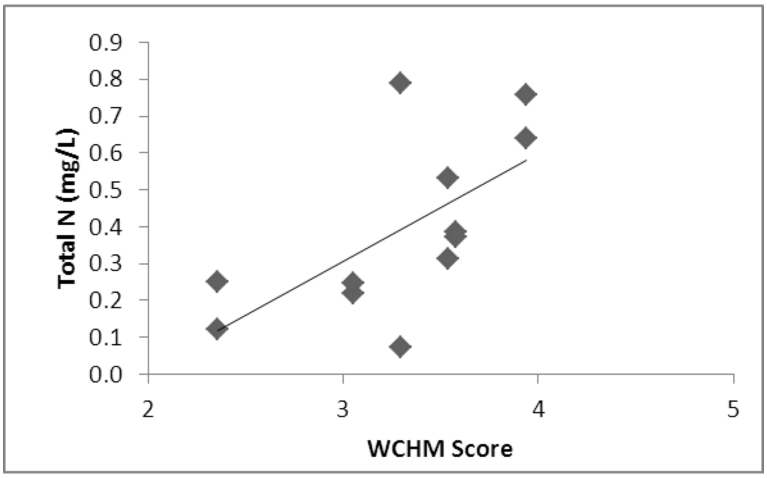

Figure 26 Relationship between mean WCHM score and mean total Nitrogen (mg/L) measured at twelve sites within the Toreparu wetland, July and November 2013.

7.1.3. WCHM and SQMCI-sb

Aquatic macroinvertebrates were also surveyed at six sites within the Toreparu wetland. Results for the semi-quantitative macroinvertebrate community index for soft-bottomed habitats (SQMCI-sb) resulted in a positive relationship with the WCHM score (Figure 27). The r-value of 0.88 was the strongest correlation observed for all variables summarised in Table 4, and was statistically significant (p=0.021).

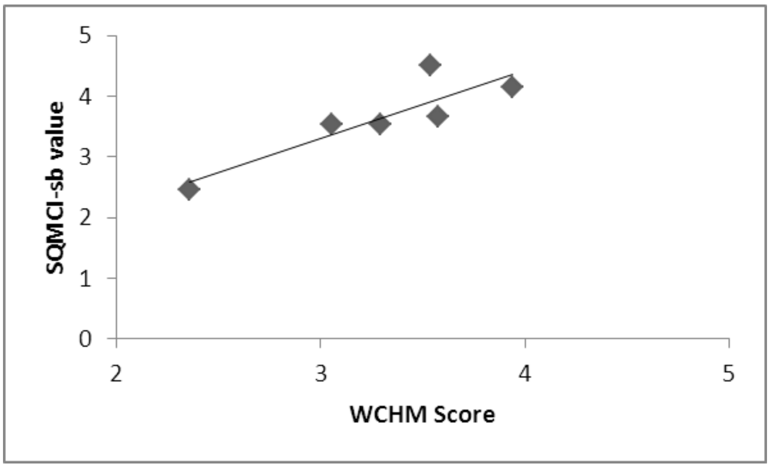

Figure 27 Relationship between WCHM scores and SQMCI-sb value from aquatic macroinvertebrate surveys carried out at six sites within the Toreparu wetland, July 2013.

7.2. Non-significant Results

Results from vegetation surveys at the six main sites exhibited positive correlation for native plant species, and negative correlation for introduced or weed species (Table 4). Comparative analysis between the WCHM, the percentage cover of native plant species (Figure 15), and the number of native plant species present (Figure 15) within vegetation plots showed that increases in cultural values corresponded with increases in both native species and cover (Table 4). The Pearson's r values of 0.72 (p=0.11) for number of native species and 0.65 (p=0.16) for native cover indicates a strong correlation between the variables (Table 4), although both these correlations were non-significant. When looking at relationships between WCHM and weed abundance and cover, there was a negative correlation for both variables measured (Table 4), although these were also not statistically significant. The number of introduced species decreased as the WCHM value increased, though the relationship was weak with an r-value of -0.38 (p=0.46) (Table 4). A similar trend was also observed for introduced/weed cover which decreased as WCHM value increased, depicted by an r-value of -0.65 (p= 0.16) (Table 4).

8. Discussion

The aim of this research was to look at how well scientific and mātauranga Māori based wetland assessment methods complement each other, using the Toreparu wetland as the case study. The aim of this chapter is not to validate one method over the other, but look at relationships between the Wetland Cultural Health Index (WCHI) and scientific method. First, I discuss why cultural indicators, such as the WCHI, is an essential aspect to monitoring wetlands and how science and mātauranga Māori methods can complement each other in collaborative research. This is illustrated through the similarities and differences in statistically significant results found at the Toreparu wetland. More detailed discussion will further investigate the comparative analyses that resulted in statistically positive ($0.5 < r < 1$) or negative ($-0.5 < r < -1$) correlations, and what may be driving these patterns. This chapter will briefly discuss trends inferred in the rest of the data, along with potential limitations with the results and methodology. This chapter includes a variety of successes and challenges that were overcome, particularly around how the cultural assessment was carried out, but also factors that influenced the scientific-based sampling.

8.1. WCHI as an Essential Aspect to Environmental Monitoring and Management

We can see from the results gathered from this case study, that WCHI's provide unique and essential information when assessing health of the Toreparu. Scientific and WCHI data complement each other, creating a holistic picture of the current state and future restoration priorities for the Toreparu wetland. Cultural Health Indicator assessment was an essential aspect to understanding the health of the Toreparu wetland. It brought new knowledge that would not have been captured using scientific methodology alone. This included information on wāhi tapu, taonga species, desired condition of the wetland from a tangata whenua perspective as well as historical knowledge of the area particularly around the health of mahinga kai and species that were once present at the Toreparu.

The complementary nature of science and WCHI's was illustrated between WCHM and dissolved oxygen and SQMCI-sb, but there were indicators that did not show similar trends in health such as the relationship between WCHM and TN. As chemical or nutrient inputs become more of an issue in our freshwaters and wetlands, this could be included as part of the cultural assessment. In summer, the effects of high nutrient loading may be evident through excessive periphyton growths, but water quality testing may need to be used in the cooler months. When resources and training are available, scientific methods can be used as a tool to complement cultural assessments.

8.2. Similarities Between WCHI and Scientific Survey Results

8.2.1. WCHM and SQMCI-sb

The strongest correlation between WCHM and scientific parameters was the positive relationship with the semi-quantitative macroinvertebrate community index for soft-bottomed habitats (SQMCI-sb). A Pearson's correlation resulted in a statistically significant ($p=0.021$) *r*-value of 0.88. This suggests that an increase in WCHM has an associated increase in SQMCI-sb, and vica-versa.

The sites that scored highest for SQMCI-sb and WCHM were the Toreparu Stream and SCI High sites. The scores for SQMCI-sb were indicative of 'fair' quality habitat (Stark & Maxted, 2007), or 'probable moderate pollution' (Stark, 1998). This suggests that these sites are likely to be influenced by excessive nutrient and/or sedimentation from the surrounding catchment (Stark & Maxted, 2007). WCHM scores for the Toreparu stream are driven by high scores for vegetation indictors, water quality and wāhi tapu and wāhi taonga indicators. The effects of surrounding land use and sedimentation were highlighted as having a negative impact on cultural value. This illustrates that both scientific and cultural indices were showing similar patterns of wetland health, but nutrient and sedimentation were seen as negative impacts on these sites.

The other four sites all had SQMCI-sb scores below 4.00, which is indicative of 'poor' quality habitat (Stark & Maxted, 2007) or 'probable severe pollution' (Stark, 1998). According to Stark & Maxted (2007), these sites may be significantly affected by nutrient inputs and/or sedimentation. When looking at the scores for the cultural indicators, the adjacent land use, wetland modification, sediment inputs and weed cover all scored within the average-low categories. The key issues at these sites, noted by volunteers on the assessment sheets, included the presence of willow and gorse, unfenced wetland habitat, presence of stock, loss of vegetation and erosion of surrounding land. At Horokawau Falls, Hērangi Pa, SCI mid and SCI Low, the impacts of grazing, erosion, the dominance of weeds and loss of native vegetation are all contributing to the low habitat quality scores for both the scientific and cultural assessments.

By comparing a scientific and cultural index, we are in essence compiling and comparing multiple environmental and biological parameters, which may explain the strong relationship between SQMCI-sb and WCHM. The MCI-sb and SQMCI-sb scores, like the WCHM, are driven by a number of mechanisms compiled into a single index or value. The MCI-sb and SQMCI-sb were developed for assessing condition of soft-bottomed streams (Stark & Maxted, 2007), as a response to nutrient enrichment and sedimentation effects. The SQMCI-sb value responds to changes in taxonomic and numerical composition of aquatic macroinvertebrates, or the relative abundance of aquatic macroinvertebrates (Stark & Maxted, 2007). As discussed previously, the WCHM is the compilation of multiple wetland indicators that includes health of vegetation, cultural sites and water quality.

The use of the MCI-sb and SQMCI-sb does come with limitations, as these indices have not been evaluated for use in wetlands or to assess other types of disturbance, such as flow variation. The use of the wetland MCI (Suren & Sorrell, 2010) was considered for this project, however, due to the physical and hydrological characteristics of the sampling sites, the MCI-sb and SQMCI-sb indices were chosen as the most appropriate method of invertebrate analysis. Four of the six sites sampled were classified as channel habitat and more like a soft-bottomed stream than typical 'lead' wetland habitat. The two sites that were considered to be ‘lead’ habitat also had a small channel with flowing water from which macroinvertebrate samples were collected.

8.2.2. WCHM and Dissolved Oxygen

Another significant relationship observed between the cultural indicators and scientific parameters was between the Wetland Cultural Health Measure (WCHM) and dissolved oxygen (%) concentration (*r*-value = 0.80; p= 0.002) (Table 4). Dissolved oxygen is considered to be an important parameter for testing the health of freshwaters (ANZECC, 2000), as it is often linked to the presence of aquatic macrophytes (K. J. Collier, Kelly, & Champion, 2007), periphyton and the survival of freshwater fish (Frimmel, 2010). Dissolved oxygen is currently measured in New Zealand as part of national and local water quality monitoring schemes carried out by the Ministry for the Environment (B. D. Clarkson & McQueen, 2004) and local councils as part of nationwide State of the Environment reporting (McDowall & Richardson, 1983) e.g., Waikato Regional Council (2011), Greater Wellington Regional Council (1999), and Otago Regional Council (1992). DO concentrations below 80% saturation influences ecosystem health and the presence and breeding success of fish (Ministry for the Environment, 1991). Waikato Regional Council guidelines for recommended dissolved oxygen concentration in freshwater habitats specify DO% should be >80% of saturation concentration (Waikato District Council, 2011). The August and November results show just under half of the sites (5/12) met this guideline with DO concentrations of 92% at SCI LowA, 87% at Hērangi Pa, 86% at Horokawau Falls and Horokawau FallsA, and 85% DO measured at Hērangi PāA (Figure 21). How does this ecologically important parameter relate to cultural values in the Toreparu?

Firstly, what are the likely drivers for the DO concentration observed? The sites that scored highly for both cultural values and dissolved oxygen concentration were Horokawau Falls, Hērangi Pa and their associated sub-sampling sites, along with the SCI LowA site. When investigating what may be driving the high oxygen concentrations at these sites, both the hydrological conditions observed and the presence of aquatic flora is likely to increase the oxygen saturation at these sites (Joy & Death, 2004).

Horokawau Falls and SCI LowA sites were open channel habitat, with swiftly flowing water and presence of aquatic macrophytes and periphyton in some areas. The Hērangi Pa site was very different, with a narrow channel fed by an underground spring, dense vegetation and thick watercress beds at the upstream extent of the sampling reach. The presence of aquatic plants such as watercress is likely to have increased dissolved oxygen, particularly during the day when aquatic plants photosynthesise (Joy & Death, 2004).

Secondly, what are the key indicators influencing the WCHM scores at the same sites? It appears that water quality indicators and cultural values are highest at these sites. Conversely, vegetation values and wetland modification scored low. The Horokawau Falls, Hērangi Pa and SCI LowA sites were both highly modified. Even though the overall WCHM index resulted in a high score, weeds and introduced species were present at these three sites, along with significant stock access which was seen to degrade site health. The water quality indicators that scored highly appear to have counteracted the low vegetation values. There were also historical values associated with the Horokawau Falls site, which was set aside as a Native Reserve in 1856 (Vernon & Buckeridge, 1973). It was an important area for food cultivation and flax collection. In the 19th century harakeke was removed and sent off to the Pakoka flax mill at Aotea, so this site was economically very significant for both local Māori and the settlers who lived here (Landcare Trust, 2014), which resulted in the high scores for wāhi tapu and overall significance. Negative impacts on wetland health included the lack of fencing at both sites, loss of vegetation and stock access which were all highlighted by the volunteers as ongoing issues. Another concern that was acknowledged by volunteers was the lack of knowledge that tangata whenua had around wetland function and the effects of landscape modification on this. This research project was seen as an opportunity to build capacity and encourage knowledge transfer between marae members.

Due to the findings from the cultural health assessment at the Toreparu wetland and our understanding of the biological and physical drivers for dissolved oxygen concentration, it may be expected in some wetlands, increases in dissolved oxygen correlate with increases in the WCHM score. The WCHM index is made up of scores for a total of 13 indicators. This includes indicators for native plants, weed cover, aquatic plants, water clarity, flow and temperature, health of weaving and dye resources, number of cultural sites as well as negative impacts such as sediment, land-use and wetland modification. Cultural indicators such as aquatic plant cover, water temperature and flow are linked to dissolved oxygen concentrations and a positive correlation between values may be explained by this. This was not always the case as some sites that had low DO had high WCHM. These sites may have high cultural value in terms of vegetation, wāhi tapu and wāhi taonga indicators, which counteracted low scores for the other indicators.

The sites that scored high for WCHM and low for DO (%) were sites SCI High and SCI Mid. Both these sites were similar in physical and biological characteristics, and were heavily vegetated and classified as 'lead' environments, which typically have slow flowing, shallow water and ill-defined margins (Suren & Sorrell, 2010). The aquatic habitats in both these sites were also covered in a thick layer of iron flock, and no aquatic macrophytes were observed. These hydrological and biotic conditions are likely drivers for the low DO levels observed. The high WCHM scores observed at SCI High and SCI Mid sites was due to the dominance of native vegetation, low weed cover, high water clarity, low water temperature and proximity of the sites to wāhi tapu and wāhi taonga. Volunteer participants commented on the CHI assessment sheets that these sites had optimal flow and temperature and were considered to be culturally significant as they were once navigable by waka and kōpapa (canoes) that brought kai moana (seafood) from the coast to the large settlement areas. The presence of multiple shell middens was also considered to be significant, all increasing the cultural values of these sites.

The time of sampling was likely to have affected the overall WCHM scores. Water temperatures were generally low in both July and

November, with large flooding events two weeks prior to each sampling episode. Post-November flood, one local landowner claimed it was the largest flood he had seen in the c.60 years they had farmed alongside the Toreparu (Brown, 2013). A wooden bridge along the Matahahaia stream (catchment area c. 4 km^2) was washed away and material from the bridge was located up to 200 m downstream. At the lower reaches of the Toreparu Stream, a large steel and wood bridge was also washed away. In the most northern reaches of the Toreparu, around Horokawau Falls, there were large deposits of sediment and coarse substrate along the stream banks and flood plain areas. Flood events of this magnitude are known to scour off periphyton and remove macrophytes beds from aquatic habitats (B. J. F. Biggs, 2000; K. J. Collier et al., 2007). Two volunteers, who were well acquainted with the Horokawau Falls site, described the presence of slimes and algae during the summer months when waters are warmer and flow is reduced. Summer conditions would have likely produced higher WCHI scores for aquatic plant and periphyton cover as flows reduced and water temperatures increased, as described by the volunteers.

8.3. Differences Between WCHI and Scientific Survey Results

8.3.1. WCHM and Total Nitrogen

Total Nitrogen (TN) (mg/L) and the wetland cultural health measure (WCHM) showed a statistically significant (p=0.03) positive correlation (*r*=0.61). Waikato Regional Council guidelines recommend that TN levels do not exceed 0.50 mg/L (Tulagi, 2011; Waikato District Council, 2011). This recommendation is based on data from NIWA's National Water Quality Network (Maasdam & Smith, 1994). These levels were exceeded in August at Horokawau Falls and Horokawau FallsA by 0.30 mg/L. SCI MidA exceeded the guideline by 0.6 mg/L which meant that total nitrogen was over double the recommended levels here (Figure 23). In November, the WRC guidelines were exceeded at Horokawau Falls by 0.20 mg/L, SCI MidA by 0.01mg/L and SCI LowA by 0.20 mg/L (Figure 23). ANZECC (The Australian and New Zealand Environment Conservation Council) guidelines allows a slightly elevated trigger value for Total N, of 0.60 mg/L

(ANZECC, 2000). SCI MidA had the highest concentration of TN during the August surveys with 1.02 mg/L, which reduced to 0.51 mg/L in November. Interestingly, the SCI Mid site had a much lower TN concentration, with 0.07 mg/L in August. What are the environmental factors that may be increasing TN concentrations at sites which are scoring highly for WCHM?

The answer to this is most likely attributed to the land-use practises happening in the upper catchments of the Toreparu and adjacent to the sampling sites. The sites that scored the highest WCHM value and had the highest TN concentrations were Horokawau Falls, Horokawau FallsA, SCI MidA and SCI LowA. The current condition of these sites and surrounding land-use were likely to contribute to the elevated TN concentrations, as has been observed when comparing native forested and pastoral streams in the Waikato (Wall & Clarkson, 2006). The Horokawau Falls sites were surrounded by grazed pasture, were unfenced and had obvious signs of stock intrusion. The SCI MidA samples were collected for an area where the water appeared to be moving slowly but also had evidence of recent stock pugging. A combination of stock intrusion and effluent effects, potential inputs from the grazed pasture along the true right bank, combined with the hydrological regime may have influenced elevated nitrogen at SCI MidA. The upper reaches of the Toreparu Stream makes up the northern extent of the Toreparu wetland catchment (Figure 1). These reaches are surrounded mostly in grazed pasture with approximately 1 km^2 in native forest at the foothills of Mt. Karioi (Figure 1). Aside from this, there are only small fragments of native vegetation in the upper catchment area. The SCI LowA site, located south east of Horokawau Falls, was also likely to have been influenced by cumulative effects of a pastoral, grazed upper catchment. The Matahahaia Stream which flows through SCI Low has a catchment that is dominated by steep, grazed pasture with very little native vegetation. The lack of riparian vegetation along the banks of these sites their upper catchments, combined with land-based nutrient sources (e.g., livestock waste and fertiliser) enable the transportation of nitrogen to the water column particularly in poorly drained soils (Alexander, Elliott, Shankar, & McBride, 2002). In New Zealand, studies on the effectiveness of riparian buffers on nutrient retention showed decreases in TN and TP in areas with a native forest catchment but had variable results where younger, planted margins occurred (Parkyn, Davies-Colley, Halliday, Costley, & Croker, 2003). It appears that land-use and loss of native vegetation is having a negative effect on TN concentrations at the Toreparu wetland. Without riparian buffers, nitrogen from farm fertiliser and stock effluent are leached through the soil or washed directly into the water during periods of rain (Buck, Niyogi, & Townsend, 2004; Quinn, Cooper, Davies-Colley, Rutherford, & Williamson, 1997; Vant, 1999). Direct inputs from stock further add to this problem, as was seen at SCI MidA.

Our results from the Toreparu wetland revealed disparities between trends with the WCHM and TN concentration measures. Total nitrogen is not able to be assessed visually, but elevated levels may be indicated by excessive periphyton growth, particularly in the summer months. Due to sampling being carried out in the cooler months combined with the effects of recent flood events, any potential nuisance periphyton growth was not evident at the time of survey (B. J. F. Biggs, 2000; K. J. Collier et al., 2007). Volunteer participants did note that at some sites, excessive periphyton growths were present during the summer month.

The WHCM measured health on a site specific basis, in this study, so did not necessarily capture catchment wide effects. The WCHM did identify indicators that influence TN concentrations, such as stock access, riparian and vegetation clearance and erosion as negatively impacting cultural health but this appears to be obscured by CHI's that scored highly, such as hydrology, physical water parameters and presence of wāhi tapu and wāhi taonga. It is important to consider not only the mahinga kai index and WCHM index, but look at the individual CHI's to determine which aspects of the site are in poor health and which indicators are scoring highly.

8.4. Non-significant Correlations

The sample size was attributed to the number of significant results found during comparative analysis. Statistical power is compromised when sample sizes are low. There were however, three comparisons that were within the 90% confidence interval range; WCHM vs native species number, water temperature and specific conductivity. Some inference may be drawn from these comparisons, but these results are preliminary and will only be briefly discussed.

8.4.1. WCHM and Native Vegetation

The WCHM showed a positive correlation with number of native plant species which suggests that as cultural health of a site increased, so did the presence of native vegetation. The composition of native plants was easily measured at each site for both the scientific and cultural assessments, due to the obvious physical qualities of vegetation, as opposed to parameters such as nitrogen in the water column. This suggests that both methods provide good indicators of wetland health from the scientific, ecological and cultural perspectives.

8.4.2. WCHM and Water Temperature

A positive correlation was also observed between WCHM and water temperature. Again, this was easily measured for both the scientific and cultural assessments. The relationship illustrates that sites with higher water temperatures, also had higher cultural values. Waikato Regional Council guidelines recommend water temperatures of <20^{0}C (October-April) and <12^{0}C (May-September) be maintained for fish spawning in rivers and streams (Waikato District Council, 2011). The November temperatures fall within these parameters. However, the August results exceed the council guidelines of 12^{0}C for six out of the twelve samples (Figure 20). There are currently no guidelines on water temperature specifically for wetlands, but the current guidelines described above are relevant for lowland streams. These guidelines can be applied to the Toreparu wetland and stream as both habitats are regarded as important for fish spawning.

The scale on which the indicator for water temperature was scored, was not based on set temperatures like the scientific survey, but on whether water temperatures were consistently ideal for cultural practises or not. Volunteer participants discussed on site the optimal water temperatures for the Toreparu and described cold water temperatures as not being ideal for mahinga kai practises. They described the reduced mobility, and therefore reduced catches of eels when water temperatures were low (approximately <12°C). It was acknowledged, however, that these periods of reduced fishing success were also considered important for the growth and recruitment of eels in the wetland.

8.4.3. WCHM and Specific Conductivity

Specific conductivity is often used as a measure Total Ionic Concentration of a solution (ANZECC, 2000; Maasdam & Smith, 1994; United Nations Environment Programme, 2004) which can be linked to sediment and nutrient input into freshwater environments (Quinn & Stroud, 2002). Hērangi Pa, SCI High and SCI Mid sites and their corresponding sub-sampling sites tended to have higher SPC values which may be linked to habitat type. These sites were located in slow flowing habitats typical of swamp wetlands. All of these sites were fed by underground springs which flow through a series of limestone caves typical of the southern reaches of the Toreparu wetland, which may influence the ion content of the water. There was also a high abundance of iron bacteria at SCI High and SCI Mid sites which is likely to have increased the conductivity of the water at these sites. The obvious increase in SPC values at these sites in November, after the large flooding event, indicates there has been an increase in ions which may be from sediment and/or mobilisation of iron bacteria.

There are suggested guidelines for specific conductivity in New Zealand rivers and streams (Larned, Scarsbrook, Snelder, Norton, & Biggs, 2004). The guideline of 175 µS/cm is the level corresponding with periphyton guidelines for protecting trout habitat, from data at 103 sites across the country (B. J. F. Biggs, 2000). Eleven of the 24 samples exceeded this guideline (Figure 22). As trout were not present, nor considered as a priority species for the wetland, this guideline was not appropriate for the Toreparu. SPC did not appear to negatively impact native fish species that were considered to be taonga, as SCI High site which had the highest SPC readings also had the highest abundance of banded kōkopu and kōaro present. At the Toreparu, these taonga fish species appear to be tolerant of waters with high conductivity.

The negative correlation between WCHM and SPC suggests that sites with high cultural health have lower specific conductivity. This was illustrated at Horokawau Falls, Toreparu Stream and SCI Low. These sites and their corresponding sub-sampling sites scored highly for native vegetation, water quality parameters and wāhi tapu and wāhi taonga indicators. The sites were located along open channels of flowing water, or more stream-like habitat which meant that sediment was more easily flushed. Conversely, the surrounding pasture and lack of riparian vegetation may also influence the likelihood of increased inputs from eroded banks, stock and farm run-off.

8.5. WCHI Methodology

8.5.1. Assessing Mauri

The assessment and application of 'mauri' as a wetland indicator was challenged in this study, with the appropriateness of using mauri in this context being called into question by some volunteer participants. Similar issues around assigning mauri with a numerical value have been raised by social scientists, challenging biophysical scientists to explore power relationships and politics (Muru-Lanning, 2012). According to Harmsworth (2002), in the context of the WCHI, the mauri scale is a qualitative assessment of the health and wellbeing of an ecosystem, in a quantitative form. The mauri scale used in the WCHI assessment can include elements of biophysical and metaphysical health as perceived by participants at a particular point in time. In other studies (G. Harmsworth, 2002; G. R. Harmsworth et al., 2011; Morgan, 2011; Tipa & Teirney, 2003; Townsend et al., 2004; Young et al., 2008), the mauri scale has been used to assess the health and wellbeing of a site from a cultural perspective. For this research project, volunteer participants attempted to assign a mauri value to each site. This encompassed various components of wellbeing and site significance for individual participants, but did come with challenges (Figure 12).

This issue surfaced during the WCHI assessment at the Toreparu and there was a reluctance to quantify mauri into a single numerical value. A criticism which has been raised by other Māori when presented with the concept of measuring mauri (Muru-Lanning, 2012). Mauri encompasses a combination of physical and metaphysical concepts and some volunteers felt that reducing this to a numerical value diminished the significance of this and were not comfortable with using mauri as an indicator (Volunteer B, 2013). Volunteer participants also felt there may be a risk with sites that scored low for the mauri indicator, being overlooked for restoration projects (Volunteer A, 2013; Volunteer C, 2013). For the people of Mōtakotako marae, mauri encompassed the whole wetland and its catchment, so was difficult to quantify at the smaller, site scale (Volunteer A, 2013; Volunteer B, 2013; Volunteer C, 2013). Again, this is a criticism that has been raised in other situations where tangata whenua have been presented with concepts or models that compartmentalise mauri for assessing environmental health. "*Mauri is the whole bloody lot- you can't break it up. It is just like the river- you've got to look at the whole catchment and not just bits of a river (Interviewee 3, Catchment 2)"* (Selby et al., 2010, p. 165). For the Toreparu case study, mauri was deemed appropriate only for a whole wetland assessment, but not individual sites.

Volunteers from the marae also had difficulty in assigning a mauri score due to difficulty in defining what mauri actually is, in the context of wetland health (Volunteer B, 2013). Mauri assessment was particularly challenging at some sites due to dissimilarity in wetland health values i.e. the extreme modification attributed to farming practises, combined with the positive aspects associated with the ongoing cultural uses. Some volunteers felt uncomfortable assigning a low mauri score, when the site was still used regularly and viewed as highly significant for Mōtakotako marae (Volunteer A, 2013; Volunteer B, 2013). This resulted in sites that were degraded or highly modified, being given a mauri score that was comparatively high.

At other sites, which were not used regularly for mahinga kai and other cultural uses, mauri was scored on the current state of physical, biotic and metaphysical characteristics. In sites that were not used regularly or at all by marae members, there was no historical context and no reference state to determine whether mauri was degraded or not (Volunteer B, 2013). The disconnection with some areas of the Toreparu was due to a combination of inability to access the wetland and many of the existing families moving away from the area. This was partly a result of much of the land surrounding the Toreparu being sold to Pākehā settlers, as a way to bring expertise and economic benefits to the area during the 1850s (Volunteer A, 2013). As farms changed hands, access became variable and knowledge around mahinga kai and other cultural practises decreased, or were retained by a minority.

While the use of mauri may be considered to be an important indicator for some Māori, as illustrated in case studies elsewhere (G. Harmsworth, 2002; Tipa & Teirney, 2003; Young et al., 2008), it may not be suitable for all situations. This is not to say that mauri assessment carried out at the Toreparu was ‘wrong’ in any way, but highlights the importance of understanding how mauri is assessed and what it means to tangata whenua. Mauri was been assessed on a combination of traditional knowledge and direct observation using indicators, such as those identified in the WCHI, which are manifestations of a robust life force (Selby et al., 2010). Reduction of mauri, through misuse or degradation (Tipa & Teirney, 2003; Young et al., 2008), was quantifiable with confidence when it was put into context and only at the Toreparu wetland/ catchment scale. Participants from Mōtakotako marae used the mauri scale to assess the significance of the site in terms of its historical importance for providing a consistent food, fibre and dye supply for the hapū. As a result, this may have inflated the mauri value chosen by participants (Figure 12), as sites with these culturally important attributes had a high mauri score, even if they were degraded or scored poorly for other indicators.

8.5.2. Participation, Training and Timing

Another challenge that was faced with the WCHI assessment was around participation (n=3), training and timing of this research project. This research relied on the self-selection of volunteer participants which may have limited the numbers and experience of those involved. Many of the marae members, particularly the kaumātua (elders) did not feel confident in their knowledge to be part of the cultural health assessment. Some of the kaumātua grew up alongside the Toreparu and had a wealth of knowledge of the area, and had spent many years using the Toreparu for mahinga kai practises, but felt that the WCHI assessment should be carried out by the younger people. Those who did volunteer attempted to encourage these kaumātua to be involved in other ways, such as interviews and/or providing information (Volunteer A, 2013). My role was not to force participation but receive information that was transmitted from kaumātua to the volunteers, which was what eventuated.

The consultation process started in February 2013, but due to timing and resourcing the WCHI assessments were not carried out until August and November. I had originally attempted to get all volunteers together to carry out the assessment but a combination of other commitments that volunteers had in the weekends, adverse weather conditions and one volunteer being injured meant that field assessments were delayed. All training around the WCHI method was carried out on site, and I accompanied each volunteer. I was present to assist in the process of the WCHI assessment but not to influence the assessment, bias or skew data. The assessments were carried out solely by each volunteer. In the end, two volunteers carried out their assessments separately, and the last one trialled a new assessment method, using filmed footage. This method and the implications involved are discussed in more detail below.

8.5.3. Video Assessment

A new method, the use of video footage for carrying out the WCHI assessment, was trialled during this research and results were found to align with the results from the Volunteer A and B's WCHI assessment. In response to the inability of one volunteer to physically access the wetland due to a back injury, video footage of each site and sub-sampling site was taken during the November 2013 survey. The volunteer filled out a WCHI sheet for each site and water quality sheet for each sub-sampling site as per the WCHI methodology. When cross-examining the indicator scores from the video vs. site assessment there were similarities between a majority of the indicators.

The indicators that aligned most closely were for native and introduced vegetation, aspects of water quality that relied on visual assessment (i.e. flow and clarity) as well as the perceived negative impacts at the sites. The indicators that were much more difficult to assess through video were the mahinga kai values (i.e. fish and bird indicators), water temperature and mauri. In this situation, the volunteer had a very good understanding of fishery values at the Toreparu and could provide data at the sites that were used regularly (Toreparu Stream and Horokawau Falls) (Volunteer C, 2013). The water temperature relied on physical touching of the water, and the mauri assessment was impossible as the volunteer was unable to get a ‘feeling’ of site health (Volunteer C, 2013).

Though this may be a viable method in some situations, there are challenges and aspects of the assessment that must be taken into account. Volunteer C knew the Toreparu wetland well and felt confident in some aspects of the assessment. This volunteer did highlight some discomfort associated with assessing the sites without “actually being there” (Volunteer C, 2013) or discussing values with the volunteers who had previously undertaken the survey. The unique knowledge of raranga or weaving resources, on the other hand, was very apparent and this volunteer provided specialised knowledge on an aspect of the wetland that the other volunteers did not know so much about.

In terms of future use of video assessment for WCHI, it is a useful tool for tangata whenua who already have knowledge of the site but cannot access the site due to physical disability or land access issues. This method worked well for indicators that are visually assessed or were from historical knowledge but not so well for indicators that rely on sound, touch or physical presence. In today’s society, where disconnection with tribal lands is common, it may provide an opportunity for engagement or sharing knowledge between iwi, hapū or whānau members but should be used with caution.

8.6. Scientific Methodology

The scientific methods used to measure both biotic and abiotic parameters in the Toreparu wetland, were chosen based on a combination of current literature and standard methods used both nationally and in the Waikato region. Though many of these methods have been regularly tested and implemented by both scientists and environmental governing bodies, they do come with limitations and biases, and are discussed below.

8.6.1. Fishery Surveys

Results from the fishery survey showed low abundance of native fish species within the Toreparu wetland. This may be partly attributed to the sampling methodology used, and the fact that only one overnight survey was conducted. Standardised methods for surveying fish populations have been recently developed and tested by the Waikato Regional Council for wadeable streams (David & Hamer, 2010), but there are currently no standardised methods for surveying wetland fish species. Trap netting methods identified in David et al. (2010) were chosen as the habitats that were surveyed in the Toreparu wetland resembled a soft-bottomed stream habitat most closely. Trap netting methods have been used for fishery surveys at other wetlands (Kessels et al., 2005; Ling et al., 2009; Robertson & Suggate, 2011). Many of our native fish species that reside in wetlands, such as mudfish, Galaxiids and eels prefer vegetated habitat as it provides cover during the day and assists in maintaining desirable water quality parameters such as low water temperatures (Hanchet, 1990; Ling et al., 2009). Limitations of the sampling method used were attributed to the distribution of fish found within the Toreparu wetland; however habitat preferences and physical barriers may also influence survey results.

Banded kōkopu were captured at SCI High and SCI Low sites, with a single kōaro also found at the SCI High site. The SCI High and SCI Low sites had an abundance of overhanging vegetation, pool habitat and flowing water which is the type of habitat preferred by these species (Allibone et al., 2010). Natural barriers to fish passage such as the Horokawau Falls, and man-made barriers such as perched culverts and dams can impede the upstream and in some cases, downstream movement of non-migratory fish and the migration of diadromous fish such as banded kōkopu, kōaro, inanga, shortfin and longfin eels (B. R. Clarkson, Sorrell, et al., 2004). Common smelt (*Retropinna retropinna*) were noted just downstream of Horokawau Falls. This species is unable to negotiate the Horokawau Falls, so were observed in the large pool at the bottom of the falls.

8.6.2. Bird Surveys

Bird surveys carried out at the Toreparu wetland, using 5MBC's and playback surveys, provided an overview of species present but may have missed rare species (D.G. Dawson & P.C. Bull, 1975; Department of Conservation, 2010). Species such as Australasian bittern or Kōtuku have been noted through anecdotal evidence from neighbouring landowners and tangata whenua but were not recorded as being present during the November surveys. While notes on species present were taken during each field trip to the wetland, only one formal survey was conducted at each site, during November. As a result, seasonal, highly mobile and cryptic species such as bittern and herons may have gone undetected. Other wetland bird species, such as the North Island fernbird and spotless crake which are generally quite bold birds, readily investigated the source of calls used in playback surveys, and were both seen and heard at SCI High, SCI Mid and Toreparu Stream.

In situations where time and or resources are limited to undertake multiple, complete bird surveys, cultural health data and knowledge from tangata whenua provides critical information. Due to the inter-generational history and connection with the wetland, passed on through oral history and whakatauki (proverbs), the people of Mōtakotako marea provided an insight to the Toreparu that would have been lost if only scientific survey had been carried out. This example shows the huge benefits of this knowledge as it provides missing information, as well as a reference condition or goal for restoration projects.

8.6.3. *Aquatic Macroinvertebrate Surveys*

Aquatic macroinvertebrate surveys were carried out using sweep netting methods identified in Stark (2001). The aim of the macroinvertebrate survey was not to provide detailed, quantitative data, but to look at the species present and gather some inference on habitat quality. Therefore, a single sampling episode was carried out in July 2013. This was approximately two weeks after a small flooding event, to allow for recolonisation of aquatic macroinvertebrates as per guidelines set out in Stark et al. (2001). Due to the variation in habitat type (lead vs channel), samples were collected from areas within each site that were hierologically and physically as similar as possible, to minimise the effects of habitat. As discussed previously (Section 3.4.1.2), the macroinvertebrate indices for soft-bottom habitat were chosen over the wetland MCI due to the habitat types sampled during this research.

8.6.4. *Water Quality*

Although TP results were not found to be significant in the comparative analysis, there were concentrations that were above recommended regional council guidelines. Waikato Regional Council guidelines recommend TP be below 0.04 mg/L (Waikato District Council, 2011). ANZECC guidelines are slightly lower with TP recommended to be below 0.03 mg/L (ANZECC, 2000). Following the Waikato guidelines stated above, five out of the twelve samples exceeded the 0.04 mg/L recommended concentration for TP (Figure 24). In November, there was a very high TP concentration observed at SCI LowA, with an excess of 0.3mg/L which is approximately seven-fold higher than the current recommended levels (Figure 24). Like TN concentrations, excessive TP loads are likely to contribute to undesirable habitat conditions such as excessive periphyton growth and could be included as part of the WCHI assessment, particularly at sites where intensive agriculture impacts aquatic habitats.

8.7. *Implications for Future Collaborative Projects*

8.7.1. The Importance of Relationships

The consultation process, development and application of the WCHI for the Toreparu wetland were largely a success, with some challenges which will be discussed below. Due to the existing whānau based relationship that I had with Mōtakotako marae, through my mother's partner, I was welcomed and supported as a trusted Māori researcher. I maintained this trust throughout the consultation process, and duration of my research, mostly through the Chair of the Environment Committee who readily transmitted findings and progress reports on to the other marae members at the monthly marae meetings.

Relationships with marae members was maintained through the two-way transfer of information during the development and undertaking of WCHI assessments, the regular transfer of information to the Mōtakotako Environment Committee, informal conversations with marae members, and a summary presentation that will be shown on completion of this research. The relationship will not end there, as this project is seen as part of the long-term goal to restore the Toreparu wetland.

The relationships that are being built between Mōtakotako marae, the Waikato Regional Council and the Department of Conservation are all key aspects to a sustainable and successful project. My role, which was not apparent at the beginning of this research, has been to raise public awareness of the Toreparu and facilitate discussion and communication between Mōtakotako marae, local governing bodies and potential funders. As trust is being built between these parties, there is more direct communication, and my role of facilitator and a 'third party' is becoming less significant. One of the key outcomes driving this project; to see the Toreparu restored for the benefit of tangata whenua as described in my kaupapa Māori methodology (Smith, 2012), means that I plan on maintaining involvement in the long-term project and assisting where I can. My work with Mōtakotako marae and history of working with the Waikato Regional Council and Department of Conservation, as well as understanding environmental restoration process means I am able to provide advice from both sides of the coin.

So often, there are cases where relationships are built between tangata whenua and environmental governing bodies, and then the key person within the council or Department of Conservation leaves, the relationship baton is not passed on (Moehau Environment Group, 2013). The relationship breaks down or simply disappears. This can leave tangata whenua disheartened as they are often required to put in a lot of time and effort into these projects, often on a volunteer basis with no financial or resource support. This has happened to Mōtakotako marae with regards to a Toreparu wetland restoration project in the past (Kessels et al., 2005), and some cynicism around the council and their commitment to the project remains. It is important that researchers and local governing bodies build and maintain relationships with tangata whenua, not just when they need tangata whenua approval, advice or help with something. For Māori, there is nothing more offensive than being considered as a tick in a box. For successful and sustainable co-management and engagement around freshwater, there has to be a foundation built on long-term positive relationships and trust.

8.7.2. Application of the WCHI

A question that is often posed to those working with cultural health indicators is whether the indicators developed can be used in other areas. For example, can the assessment sheet developed by Mōtakotako for the Toreparu wetland be used by others at another wetland? The short answer is ‘no’. Cultural health indicators are chosen by tangata whenua as they are considered to be important for the environment being assessed. Much as you would not employ scientific methods developed for assessing a river or stream at the rocky shore. Though the wetland indicators are site specific; however, the process for developing them and conducting similar research may be employed elsewhere.

The building and maintenance of relationships between ‘researcher’ or ‘outsider’ and tangata whenua is *absolutely essential* for the success of not just this project, but for any future research at the Toreparu. I am regularly asked why I think some research projects such as this one at Toreparu wetland, are successful and others are not. And I always respond by stressing the importance of relationship building, particularly in projects where tangata whenua are working with rāwaho (outsiders). Relationships and connections are considered to be of paramount importance in Te ao Māori, as it validates membership to iwi, hapū or whānau either directly through whakapapa or in my case, indirectly through my mother's relationship. "*The importance of whakapapa cannot be over-emphasised as it provides the key to many doors*" (H.M Mead & Mead, 2003, p. 60).

9. Conclusion

The main aim of this research project was to assess how well mātauranga Māori and science methods were able to work in a collaborative process to assess health of the Toreparu wetland. This was done through the use of a kaupapa Māori methodology and the Wetland Cultural Health Index as the mechanism to communicate Mōtakotako marae goals and values for the Toreparu wetland. At the same time, scientific methods for surveying wetland flora, fauna and water quality were also undertaken and comparative analysis was carried out between the two sets of results. The ability to communicate and collaborate between world views is essential as move towards a meaningful co-management and collaborative research space with regard to our freshwaters and wetlands.

Chapter one provided some background to how this project was formulated, the rationale and aims for this research. Chapter two gave a background to our current understanding of wetland habitats from a scientific perspective, looking at how this is translated into environmental policy, particularly in the Waikato. There was a brief discussion on current wetland restoration success stories. The lack of meaningful Māori input was also highlighted. This led on to chapter three which provided a background on mātauranga Māori, kaitiakitanga and the challenges facing Māori in the environmental space. Historical context was looked at and then the situation today, and how we exercise kaitiaki rights and responsibilities today.

This set the scene for this research at the Toreparu, and detail was provided in Chapter four for both the science and WCHI methods. Results for both methods were discussed separately, and then comparative analysis was carried out to look at similarities and differences between science and the WCHI. Three parameters showed significant results and these were investigated further in Chapter seven to look at what was driving similarities and differences between the different methods. The discussion chapter also looked at challenges with the implementation and methodologies used, highlighting key points for future consideration.

The results showed that our current understanding of wetland health can be enhanced through the inclusion of cultural values. Results from the WCHI brought new knowledge that would not have been captured using scientific methodology alone. This was not limited to geographical information such as wāhi tapu and historical significance of these sites. Information on taonga species, desired condition of the wetland from a tangata whenua perspective provided aspects of wetland ‘health’ that cannot be assessed through biophysical science. The historical knowledge particularly around the health of mahinga kai and species that were once present at the wetland provided us with a reference point and future vision for the Toreparu.

Science still remains an essential tool for monitoring wetland health. As demands on our freshwater resources and surrounding terrestrial environments increase, we need to be including both methodologies when setting goals and priorities for our wetlands and when monitoring change over time. As chemical or nutrient inputs become more of an issue in our freshwaters and wetlands, parameters that measure this could be included as part of the cultural assessment. This requires capacity building and sufficient resourcing for tangata whenua to carry out such assessments.

This research is only a small case study on the use of WCHI’s and science but provides some key findings when it comes to the implementation of these methods. First, for Māori and local governing bodies to work successfully together, the need for relationship building between parties becomes of paramount importance. The success of future collaborative work with Māori relies on a solid foundation of relationships. Staff in councils, universities, crown research institutes and other government departments need to be resourced and educated to build positive, collaborative relationships for the long-term sustainability of current and future projects. On the other hand, iwi and hapū leaders also require resourcing and training to successfully carry out kaitiaki duties which was an issue highlighted in this study. As the use of cultural monitoring tools becomes more common, educating our environmental managers and kaitiaki is essential.

Secondly, the indicators chosen for the Toreparu wetland are site specific; however, the process for developing them follows a kaupapa Māori methodology and is led by tangata whenua. This framework may be adapted employed in other situations. It is important to remember that the WCHI assessment should only ever be carried out by tangata whenua, that is people with genealogical links to the area/site, and preferably participants should have some knowledge of the area.

The use of mauri as a wetland cultural health indicator raised some concerns with some volunteer participants. This is an issue reiterated by some other Māori researchers. The volunteers for this research had difficulty in assigning a numerical value to what is essentially a metaphysical concept, and questions were raised as to why mauri was relevant in this context. The volunteers felt that the mauri indicator was useful as an overall gauge of wetland health, at the catchment scale but not so useful at the smaller site scale.

There were some innovative solutions used to deal with issues around site access which may be developed in the future to enable more people, particularly the elderly or disabled to be partake in cultural assessments. The use of video footage to assess cultural health of the Toreparu was found to be useful for indicators that were visually assessed but not so useful for indicators that relied on touch, sound or feeling.

And lastly, I believe if there is to be a positive future for our freshwaters and wetlands we need to be taking a holistic and collaborative approach to wetland management and monitoring. The tool and frameworks for Māori to do this are out there and we need to be educating people around the appropriate implementation of these methods. Māori and environmental governing bodies require resources to build a solid foundation on relationships, and an even playing field so there can be successful co-management our freshwater environments for future generations.

10. References

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11. APPENDIX I – Participant Information

Participant Information Sheet

Please retain this copy for your own information

Tēnā koe and greetings,

Thank you for your interest in my Masters Research project *'Mātauranga Māori, Western Science and Wetland Health'*.

My name is Mahuru Robb and I am a member of Ngāti Awa and Ngāti Ranginui tribes on the north east coast of New Zealand. I'm a Masters student studying through the Department of Biological Sciences at the University of Waikato, Hamilton, New Zealand. This research will be conducted as partial requirement for a Masters in Science (MSc).

What is this research project about?
This research is to investigate how mātauranga Māori and western science methods can be used together to assess the health of the Toreparu wetland.

What will you have to do and how long will it take?

1. An initial group and/or individual interview (depending on preference) will be used to choose key wetland indicators which are important to you as a member of Mōtakotako marae. These indicators will be looked at as part of the Wetland Cultural Health Index (WCHI) assessment. This interview will be no longer than 3 hours and may be recorded. You will be asked to give consent prior to the interview, and maybe asked to also give consent at a later stage.

2. Three sites will be chosen by participants based on cultural importance within the Toreparu (High, Average, and Low). This will be done in a group meeting, using aerial photography and should take no longer than two to three hours.

3. Once the WCHI has been developed and sites chosen, a field assessment will be carried out using anonymous data collection forms. At each site, a form will be filled in by each participant. This will be a full day's work (up to 8hrs) and transport and food will be provided.

4. Another three sites will be assessed (chosen using biological science values) with the WCHI indicators used in step 3 (above). At each site, a form will be filled in by each participant. This will be a full day's work (up to 8hrs) and transport and food will be provided.

What will happen to the information collected?
The information collected will be used by the researcher to write an MSc thesis as part of the MSc requirements by the University of Waikato. It is possible that articles and presentations may also be the outcome of the research. Only the researcher and supervisors (on request) will be privy to the hard copy notes, documents, recordings and the paper written. The researcher will keep transcriptions of the recordings and a copy of the assessment sheets but will treat them with the strictest confidentiality. No participants will be named in the publications and every effort will be made to disguise their identity. Notes and documents will be destroyed and recordings erased after 5 years.

Disputes Resolution.
Should any disputes arise during the research then please make direct contact with the researcher to initiate resolution. Should the dispute remain unresolved then please contact the research supervisor, Ian Duggan. All contact details are listed below.

Declaration to participants
If you take part in the study, you have the right to:

- Refuse to answer any particular question, and to withdraw from the study before field work is conducted or analysis has commenced on the data.
- Any information you have provided during the research. Should you choose to withdraw, as per conditions stated above, then all raw data will be returned if possible.
- Ask any further questions about the study that occurs to you during your participation.
- Be given access to a summary of findings from the study when it is concluded.

Contact details:
If you have any questions or concerns about the project, either now or in the future, please feel free to contact either:

Researcher:
Mahuru Robb
021 1133 169
07 560 0332
mahururobb@gmail.com

Supervisor:
Ian Duggan
07 838 4703
i.duggan@waikato.ac.nz

Consent Form for Participants

Mātauranga Māori, Western Science and Wetland Health.

Consent Form for Participants

I have read the Participant Information Sheet for this study and have had the details of the study explained to me. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I am over 18 and understand that I am free to withdraw from the study before field work, or to decline to answer any particular questions in the study. I understand I can withdraw any information I have provided up until the researcher has commenced analysis on my data. I agree to provide information to the researchers under the conditions of confidentiality set out on the Participant Information Sheet.

I agree to participate in this study under the conditions set out in the Participant Information Sheet.

Signed: ____

Name: ____

Date: ____

Additional Consent as Required

☐ **I agree to my responses being tape recorded.**

☐ **I agree to images of me being used in presentations and/or publications on this project.**

Signed: ____

Name: ____

Date: ____

Researcher's Contact Information*: Mahuru Robb, 021 1133 169/ 07 560 0332/ mahururobb@gmail.com*

Supervisor's Contact Information*: Ian Duggan, 07 838 4703/ i.duggan@waikato.ac.nz*

Example CHI Sheet:

MAORI INDICATORS – WETLAND MONITORING FORM

Name of wetland:
Date:
People involved in monitoring:

WHAT'S CAUSING THE PROBLEMS?

% area of land uses/riparian factors affecting Cultural Values

0 = 0%	1 = 1–20%	2 = 21–40%	3 = 41–60%	4 = 61 – 80%	5 = 81–100%

No. of point (sites) sources of pollution degrading ***te Mauri***

0 = 0	1 = (1–2)	2 = (3–5)	3 = (6–9)	4 = (10–14)	5 = (>15)

Degree of modification (drainage, water table, burning, in-flows, out-flows) degrading ***te Mauri***

1 = low	2 = moderate	3 = high	3 = v.high	5 = extreme

No. of exotic (introduced, foreign) plants, algae, animals, fish, birds (pest types) affecting Cultural Values

0 = 0	1 = (1–2)	2 (3–5)	3 (6–9)	4 (10–14)	5 (>15)

TAONGA AND MAURI? (Maori information about the wetland, its attributes)

No. of ***taonga*** species (flora and fauna) within wetland

0 = 0	1 = (1–2)	2 (3–5)	3 (6–9)	4 (10–14)	5 (>15)

% area of ***taonga*** plants within total wetland

0 = 0%	1 = 1–20%	2 = 21–0%	3 = 41–60%	4 = 61–80 %	5 = 81–100%

% area of exotic (introduced, foreign) plants covering total wetland

0 = 0	1 = 1–20%	2 = 21–40%	3 = 41–60%	4 = 61–80%	5 = 81–100%

No. of cultural sites within or adjacent to wetland

0 = 0	1 = (1–2)	2 (3–5)	3 (6–9)	4 (10–14)	5 (>15)

Assessment of ***te Mauri*** (scale)

1 = weak or low	2 = average or moderate	3 = strong or high

12. APPENDIX II- Final Wetland Cultural Health Indicator Form

WETLAND MONITORING FORM FOR THE TOREPARU WETLAND

Name of Wetland:	**Adjacent Landuse** (circle):
Site:	Pasture Horticulture Native Exotic Forest Scrub
Date:	Commercial Industrial Recreational Residential
Time:	**Area used for cultural practises?:**
Name of Participant:	**Importance of site:** **1** (Low) **2** **3** (Med) **4** **5** (High)

Māori Wetland Indicators

Taonga Species (Plants and Animals)

Total no. of taonga species in wetland

0 = 0	1 = (1-2)	2 = (3-5)	3 = (6-9)	4 = (10-14)	5 = (>15)

Catch size of tuna fishery (annual)

0 = 0kg	1 = 1-2kg	2 = 3-5kg	3 = 5-10kg	4 = 10-20kg	5 = >20kg

Health of tuna fishery (annual)

0 = Very unhealthy/ sick	1 = Low	2= Low-Average	3 = Average/ Variable	4 = Average-High	5 = Very healthy

Catch size of whitebait fishery (annual)

0 = 0kg	1 = 0.5-1kg	2 = 1-3kg	3 = 3-5kg	4 = 5-10kg	5 = >10kg

Health of whitebait fishery (in 2012-2013 season)

0 = Very unhealthy/ sick	1 = Low	2= Low-Average	3 = Average/ Variable	4 = Average-High	5 = Very healthy

No. of taonga bird species seen/heard in wetland

0 = 0	1 = (1)	2 = (2-3)	3 = (3-5)	4 = (5-10)	5 = (>10)

Health of taonga plants within site

0 = Very unhealthy/ sick	1 = Low	2= Low-Average	3 = Average/ Variable	4 = Average-High	5 = Very healthy

No. of weeds/ invasive species found within the site

0 = 0	1 = (1)	2 = (2-3)	3 = (3-5)	4 = (5-10)	5 = (>10)

Percentage cover of weeds/invasive species within the site

0 = 100%	1 = 75-99%	2 = 50-75%	3 = 25-50%	4= 1-25%	5 = 0%

Percentage cover of aquatic periphyton/ slime

0 = 100%	1 = 75-99%	2 = 50-75%	3 = 25-50%	4= 1-25%	5 = 0%

COMMENTS on health of plants/ animals within the wetland

1

Water Quality

Clarity of water at site

0 = Always dirty	1 = Often dirty	2 = Some areas dirty	3 = Seasonal change	4 = Often clear	5 = Very clear

Water flow at site

0 = None	1 = Often dry	2 = Sometimes dry	3 = Seasonal change	4 = Mostly wet	5 = Always wet

% area of substrate affected by new sediment inputs

0 = 100%	1 = 75-99%	2 = 51- 75%	3 = 25- 50%	4 = 0- 25%	5 = 0%

Water temperature

0 = Always too hot/ cold	1 = Mostly undesirable temperature	2= Variable	3 = Seasonal	2 = Mostly good temperature	5 = Consistently good temperature

COMMENTS on health/ quality of water

Cultural Resources

Health of harakeke/ kuta

0 = Very unhealthy/ sick	1 = Low	2= Low-Average	3 = Average/ Variable	4 = Average-High	5 = Very healthy

Health of dye sources

0 = Very unhealthy/ sick	1 = Low	2= Low-Average	3 = Average/ Variable	4 = Average-High	5 = Very healthy

History and Wellbeing

No. of cultural sites in or adjacent to the site

0 = 0	1 = (1-2)	2 = (3-5)	3 = (6-9)	4 = (10-14)	5 = (>15)

Assessment of mauri (scale)

1 = low/ weak	2 = average/ moderate	3 = strong/ high

COMMENTS on historical importance or mauri of the site

WHAT IS CAUSING THE PROBLEM?

% area of land use/ riparian factors affecting cultural values

0 = 80-100%	1 = 60-80%	2 = 40-60%	3 = 20-40%	4 = 1-20%	5 = 0%

Degree of modification degrading wetland health (drainage, water table, veg clearance, stock etc)

0= Extreme	1 = V. High	2 = High	3 = Moderate	4 = Low	5 = None

COMMENTS on what is *degrading* health of the wetland

COMMENTS on what is *increasing* health of the wetland

13. APPENDIX III- Survey Forms

Five minute bird count notebook field form

See other side of sheet for information on recording conditions

Observer		Date		General loc		Specific loc	

Line number	
Station number	
Grid ref – Easting, 7 digit	
Grid ref- Northing, 7 digit	
Start time (24 hour)	
Temperature (1-6)	
Wind (0-3)	
Other noise (0-2)	
Sun (minutes)	
Precip type (N,M,R,H,S)	
Precip value (0-5)	

Species	Seen	Heard

Line number	
Station number	
Grid ref – Easting, 7 digit	
Grid ref- Northing, 7 digit	
Start time (24 hour)	
Temperature (1-6)	
Wind (0-3)	
Other noise (0-2)	
Sun (minutes)	
Precip type (N,M,R,H,S)	
Precip value (0-5)	

Species	Seen	Heard

Line number	
Station number	
Grid ref – Easting, 7 digit	
Grid ref- Northing, 7 digit	
Start time (24 hour)	
Temperature (1-6)	
Wind (0-3)	
Other noise (0-2)	
Sun (minutes)	
Precip type (N,M,R,H,S)	
Precip value (0-5)	

Species	Seen	Heard

Line number	
Station number	
Grid ref – Easting, 7 digit	
Grid ref- Northing, 7 digit	
Start time (24 hour)	
Temperature (1-6)	
Wind (0-3)	
Other noise (0-2)	
Sun (minutes)	
Precip type (N,M,R,H,S)	
Precip value (0-5)	

Species	Seen	Heard

Table 3: Wetland Plot Sheet

Wetland name: | **Date:** | **Plot no:**
Plot size (2m x 2m default): | **Altitude:** | **GPS/GR:**
Field leader: | **Structure:** | **Composition:**

Canopy (bird's eye view)			**Subcanopy**			**Groundcover**		
Species[1] (or Substrate)	**%**	**H**	**Species**	**%**	**H**	**Species**	**%**	**H**

[1] % = % cover: total canopy % cover = 100%; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type:

Comments:

Indicator (use plot data only)	**%**	**Score 0–5**[2]	**Specify & Comment**
Canopy: % cover introduced species			
Understorey: % cover introduced spp[3]			
Total species: % number introduced spp			
Total species: overall stress/dieback	NA		
Total plot condition index /20	NA		

[2] 5=0%: none, 4=1–24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; very high
[3] Add subcanopy and groundcover % cover for introduced species

Field measurements:

Water table cm		Water conductivity uS (if present)	
Water pH (if present)		von Post peat decomposition index	

Soil core laboratory analysis (2 soil core subsamples)**:**

Water content % dry weight		Total C %	
Bulk Density T/m^3		Total N %	
pH		Total P mg/kg	
Conductivity uS			

Foliage laboratory analysis (leaf/culm sample of dominant canopy species):

Species		%N		%P	

Table 2: Wetland Record Sheet

Wetland name: **Date:**
Region: **GPS/Grid Ref.:**
Altitude: **No. of plots sampled:**

Classification: I System	IA Subsystem	II Wetland Class	IIA Wetland Form

Field team:

Indicator	Indicator components	Specify and Comment	Score 0– 5[1]	Mean score
Change in hydrological integrity	Impact of manmade structures			
	Water table depth			
	Dryland plant invasion			
Change in physico-chemical parameters	Fire damage			
	Degree of sedimentation/erosion			
	Nutrient levels			
	von Post index			
Change in ecosystem intactness	Loss in area of original wetland			
	Connectivity barriers			
Change in browsing, predation and harvesting regimes	Damage by domestic or feral animals			
	Introduced predator impacts on wildlife			
	Harvesting levels			
Change in dominance of native plants	Introduced plant canopy cover			
	Introduced plant understorey cover			
Total wetland condition index /25				

[1]Assign degree of modification thus: 5=v. low/ none, 4=low, 3=medium, 2=high, 1=v. high, 0=extreme

Main vegetation types:

Native fauna:

Other comments:

Pressure	Rating[2]	Specify and Comment
Modifications to catchment hydrology		
Water quality within the catchment		
Animal access		
Key undesirable species		
% catchment in introduced vegetation		
Other pressures		
Total wetland pressure index /30		

[2]Assign pressure scores as follows: 5=very high, 4=high, 3=medium, 2=low, 1=very low, 0=none