A Review of Indicators Used for 'Cultural Health' Monitoring of Freshwater and Wetland Ecosystems in New Zealand

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RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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Executive summary

Māori, like many indigenous communities world-wide, hold distinct perspectives on freshwater that concern their identity, knowledge, attachment to place through ancestral connections (whakapapa), and custodial obligations such as kaitiakitanga and whakapapa. Many wetlands also have traditional, historical and contemporary cultural significance (e.g. wāhi tapu sites, wāhi taonga) as places of settlement and cultural resource use and activity (Taura et al. 2017b). The unique relationship of Auckland's mana whenua with our region's water resources means that collaboration with respect to monitoring and reporting on environmental health is of critical importance in realising Māori aspirations. The Auckland Plan highlights the importance of strengthening the kaitiaki role of mana whenua through hapū and iwi involvement in decision-making with respect to natural resources. The plan also identifies the key role of mana whenua in protecting and enhancing natural resources and taonga tuku iho, with a particular focus on freshwater.

This review summarises the content and scoring approach of 15 different cultural health indicator (CHI) frameworks used – or proposed for use – to monitor the changes in the cultural health of freshwater and wetland ecosystems in New Zealand. Many of the systems have been designed for use in a specific geographical area or location. However, several have been tested at a range of locations and spatial scales throughout New Zealand.

More than 90 per cent the CHI indices summarised in this review are in the initial stages of development and have only been used to provide a baseline measure. The one exception to this is the Avon-Heathcote estuary and its catchment which has been assessed twice, with two measures five years apart. There was a moderate amount of overlap in 'content' between the 15 different CHI indices that were assessed; indicators such as riparian vegetation, water quality, water quantity and presence of mahinga kai (Awatere et al. 2017a; Taura et al. 2017a) were part of almost all the CHI systems. However, there was also a high variability in the number and type of indicators within each CHI. For example, 34 per cent of the 43 different indicators we identified were included in three or less of the 15 CHIs that were assessed.

Awatere et al. (2015) have proposed a freshwater CHI for Auckland that includes measurement of a set of economic, physical, and metaphysical health indicators. This framework is very comprehensive and includes many more indicators (31) than is typical for the 14 other CHIs (average of 19). However, the complexity is partly the result of this CHI covering a much wider range of issues than many of the other CHI frameworks. The nested nature of the proposed Auckland CHI also allows indicators to be grouped in a range of different ways for reporting to different audiences.

One of the clearest messages in virtually all the literature and methodologies considered for this review is that Māori need to be in control of the process through which CHIs are proposed, tested and adopted. For Māori to be active participants in environmental monitoring they need to be convinced of their role in monitoring and the benefits that may accrue from this. This means the effectiveness of a cultural health monitoring framework will be dependent on whether it has been shaped by iwi/hapū drawing on Māori ethics and principles. Mana whenua also need to be actively involved in collection of data, analysis and reporting changes. Through this collaborative approach, a CHI framework that meets the needs of both council and mana whenua is much more likely to be achieved.

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1.0 Introduction

Cultural monitoring is an assessment method that can identify and articulate iwi/hapū values and perspectives of catchments and freshwater ecosystems spatially, and then be used to monitor environmental-cultural changes through time from an iwi/hapū perspective. A large number of cultural monitoring approaches (many begun in the late 1990s as part of national and regional projects) have been developed in different parts of New Zealand. Young et al. (2008) have identified the following reasons for Māori involvement in environmental monitoring:

1. To monitor for themselves in order to manage and protect environments with which they have a relationship, and to safeguard and manage natural resources for future generations. Driven by cultural responsibilities such as whakapapa, kaitiakitanga and tikanga, and tribal expectations. Maybe project and/or location based.
2. To monitor and/or provide meaningful information in response to an issue(s) such as toxic waste, contamination, water quality, fish stocks, customary harvest etc. Usually tied to some future action to respond to the problem and check that it has been satisfactorily resolved.
3. To monitor for others in response to external needs and influences in relation to RMA, central and local government initiatives, other legislation or requirements.

Section 6(e) of the Resource Management Act 1991 (RMA) identifies 'the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, wāhi tapu, and other taonga' as being a matter of national importance. Wetlands, freshwater, and their associated ecosystems, are important to Māori under a range of the different criteria identified in Section 6(e). Māori, like many indigenous communities world-wide, hold distinct perspectives on freshwater that concern their identity, knowledge, attachment to place, and custodial obligations as kaitiakitanga (Tipa and Nelson 2012). These waters are regarded by Māori as a taonga and tupuna, and are especially important as a source of food and traditional materials (Harmsworth 2002, Taura et al. 2017b). Many wetlands also have historical and cultural importance as places of settlement and may include wāhi tapu sites (Harmsworth 2002; Taura et al. 2017b).

The unique relationship of Auckland's mana whenua with our region's water resources means that collaboration with respect to monitoring and reporting on environmental health is of critical importance in realising Māori aspirations. Strategic Direction Two of the 2012 Auckland Plan tasked the Auckland Council with 'enabling Māori aspirations through the recognition of Te Tiriti O Waitangi and customary rights' (Auckland Council 2012). As part of this strategic direction the Auckland Council has undertaken to enable tangata whenua to participate in the co-management of natural resources and to explore partnerships with mana whenua to protect, identify and manage wāhi tapu sites (Priorities and 3 of Strategic Direction 2).

Identification of the important relationships between mana whenua and the region's whenua (land) and wai (water) was recently re-stated in the Auckland Plan 2050 (Auckland Council 2018). The new Auckland Plan highlights the importance of strengthening the kaitiaki role of mana whenua through hapū and iwi involvement in decision-making with respect to natural resources. In particular, the plan identifies the key role of mana whenua in protecting and enhancing natural resources and taonga tuku iho, with a particular focus on freshwater.

There are a number of recent, comprehensive reviews of different systems to incorporate Māori values and perspectives into freshwater management (e.g. Awatere and Harmsworth 2014, Harmsworth et al. 2016,

Robb et al. 2016). There is also extensive literature on how incorporating Māori cultural values, principles and traditional knowledge (Awatere et al. 2017b) can improve natural resource management and help meet the requirements for New Zealand local authorities to honour the Crown's Treaty of Waitangi obligations to Māori (Harmsworth and Tipa 2006, Jefferies and Kennedy 2009, Harmsworth and Awatere 2012). The purpose of this paper is not to duplicate these previous efforts. Rather, the direction that has been taken is to: (1) briefly summarise the New Zealand literature on the process of formulating a cultural health indicator framework(s), including the importance of involving mana whenua at every step, and (2) provide an inventory of New Zealand cultural health indicator systems (Harmsworth 2017) that are used, or are proposed for use, and a list of the individual indicators within each index/ system.

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2.0 Importance of mana whenua input in cultural health indicators development

One of the clearest messages in virtually all the literature and methodologies that were considered in this review is – if cultural health indicators (CHIs)[1] are to be relevant and useful to Māori – they need to be in control of the process through which CHIs are proposed, tested and adopted (Harmsworth 2002, Harmsworth and Tipa 2006, Young et al. 2008, Jefferies and Kennedy 2009, Environs 2011, Tipa and Nelson 2012, Awatere and Harmsworth 2014, Robb et al. 2015, Taura et al. 2017). Therefore, an essential first step for using Māori knowledge in formulating a CHI framework is to promote discourse that seeks to understand the Māori world view and examine and determine mana whenua aspirations with respect to their goals, objectives and expected outcomes (Awatere and Harmsworth 2014). Through this collaborative approach, a CHI framework that meets the needs of both council and mana whenua is much more likely to be achieved.

The necessity to include local iwi, hapū and whānau in the process of CHI design was strongly articulated by the Māori advisory panel that was part of the Ministry for the Environment program entitled 'Planning Under a Co-operative Mandate (PUCM)'. Amongst other goals, the PUCM program sought to improve the role of Māori in the co-governance of plans and policies prepared under the RMA (1991). The Māori advisory panel stated that:

> "Finally, it is the view of this panel that… [CHIs] need to be developed by Mäori communities themselves. Whilst guidance and views can be expressed at a national level, in order for there to be real community 'buy in', [CHIs] need to be created and managed at iwi, hapü and whänau level. The top down approach, suggested by the concept of the generic [CHI], will probably work with statutory bodies and it is possible that they are the only audience anticipated by the [CHI] programme. However, environmental monitoring is being carried out by all manner of groups and individuals, formally and informally, and this is its true context."

Through empowering Māori perspectives and values for the management of water, including reporting using a CHI framework, the risk of co-opting indigenous values for a regional (or national) agenda for freshwater management is minimised (Awatere and Harmsworth 2014) and the outcome(s) will be truly reflective of Tangata Whenua aspirations and perspectives (Jefferies and Kennedy 2009).

Resourcing is an issue that needs to be addressed as part of CHI collaboration with mana whenua (Robb et al. 2015). Sufficient resources need to be provided to achieve successful collaboration at every stage. Because collaboration is a longer-term process, meaningful relationships will have to be maintained throughout and there is often a lack of capability/capacity to engage and maintain these collaborative relationships in council and iwi/ hapū groups (Robb 2014, ibid.).

[1] A variety of different terms have been used to describe monitoring and indicator frameworks that have been formulated by Māori and other indigenous peoples for use in reporting on the natural environment; including Cultural Health Indicators (CHI), Cultural Monitoring Indicators (CMI), Māori Environmental Performance Indicators (MEPI) etc. Most frameworks include components of both 'pure' environmental monitoring and 'cultural health' which is usually an aggregate of environmental and socio-cultural parameters. In this review CHI is used as a synonym which covers all these different, but related, types of monitoring and indicators.

An additional concern of many of the papers and reports that were considered for this review is the ownership of the information/ intellectual property that would be generated from a CHI that truly expressed the Māori worldview and included indicators that draw on their cultural knowledge (Harmsworth 2017, Awatere et al. 2017b). When developing Māori indicators, cultural sensitivity and intellectual property rights, were of upmost importance (Robb et al. 2016). For example, when discussing taonga lists, many groups and individuals did not want to list all their taonga and release the information. These lists need to stay with Māori groups, such as tangata whenua and kaitiaki, within some type of Māori information system (Harmsworth 2002, Environs 2011). In order to allow effective data management there is a need for a simple rational database as a method for entering, storing, and managing information gathered. An Access database or similar will be adequate. However, given the intention that these tools be easily accessible to iwi and hapū an open source GIS database, with protected access to sensitive layers of information, would be preferable (Harmsworth 1997, Jefferies and Kennedy 2009).

3.0 Developing a cultural health indicators framework

For Māori to be active participants in environmental monitoring they need to be convinced of their role in monitoring and the benefits that may accrue from this (Harmsworth 2002). Therefore, the effectiveness of a cultural health monitoring framework is dependent on whether it has been shaped iwi/ hapū drawing on Māori ethics and principles (Awatere and Harmsworth 2014). The aspirations and goals of different iwi/ hapū for freshwater, wetland and estuarine ecosystems within their rohe are likely to differ from those of Auckland Council, given the different value systems and world-view in which they are based (Harmsworth and Tipa 2006). Therefore, we should expect mana whenua to have different needs in terms of CHIs (Lyver et al. 2017).

From an Auckland Council perspective, it is essential that the indicators presented in Tables 3 and 4 of this review should be regarded as a starting point for conversations with Auckland's nineteen mana whenua groups. They should not be seen as a list of options for council officers to select the indicators which they feel are most appropriate/ practical for reporting on cultural health, and then present these indicators to mana whenua as a fait accompli.

Table 1 outlines a sequential process though which mana whenua in Auckland Council's jurisdiction could be consulted and involved in the formulation of a framework for measuring the cultural health of the various 'waters' within the Auckland region. Note that the actual monitoring is just one step within the overall process (step 6 of 7) and comes after extensive consultation. The key to the success of a collaborative process in relation to measuring and reporting on CHIs is enduring relationships between Auckland Council and mana whenua, along with adequate resourcing for all partners contributing to the collaborative process (Harmsworth et al. 2015, 2016).

Table 1: Key steps necessary to ensure Tangata Whenua values and interests are identified in formulation of CHI and to involve iwi/ hapū in this process (modified from Harmsworth et al. 2013, Awatere and Harmsworth 2014, Robb et al. 2015 and Harmsworth et al. 2016)

Title	Description
1. Mana Whakahaere	A treaty-based framework is used for engagement and policy development
2. Whakamāramatia ngā Pou Herenga	Tangata whenua values, both metaphysical and physical, are defined and reflected in the engagement process (e.g. Whakapapa, Kaitiakitanga, Mahinga Kai and Manaakitanga)
3. Whakamāramatia ngā Huanga	Shared outcomes are defined at the beginning of the engagement process
4. Whakamāramatia ngā Uaratanga	Goals and objectives are established
5. Whakamāramatia ngā Mahi	Actions on the ground that demonstrate kaitiakitanga and progress iwi/ hapū towards their goals/ objectives/ aspirations through tangible projects
6. Whakamāramatia ngā Aroturukitanga (Implement a monitoring program ensuring that consistent and repeatable culturally derived indicators are assessed and interpreted by Māori communities using steps a-f)	a) Developing taonga lists and inventories as at 1840-1880 and at present
	b) Recording the introduced animal and pest plants
	c) Developing a consistent and repeatable methodology for assessing 'mauri' (e.g. for each kaitiaki group)
	d) Assessing all land uses and discharges
	e) Assessing how modified the [site, wetland or waterway] is
	f) Assessing whether culturally significant taonga species are present or absent
7. Whakamāramatia ngā Ritenga	Set limits[1]

1 = the seven-step framework was used in the context of setting limits for mahinga kai so this step might not be relevant with respect to a CHI monitoring framework

A range of Māori and scientifically based approaches to reporting on different aspects of the 'Cultural Health' of fresh and estuarine waters (and other ecosystems) have been developed to date, many of which are complementary (Harmsworth and Tipa 2006; Awatere et al. 2017a; Taura et al. 2017). The cultural health indicator frameworks which involved the most comprehensive and thorough approach in terms of consultation with mana whenua have all started by considering a large list of potential CHIs and then refining these through discussion and field testing.

It is important that Māori are able to use their own cultural knowledge with respect to determining the suite of indicators, and this knowledge is developed locally. Traditional knowledge can be quite marae, hapū, and/ or iwi specific (Awatere et al. 2017b; G. Harmsworth pers. comm.) and this suggests the need for a fairly devolved approach amongst the 19 mana whenua recognised by Auckland Council, which each having the opportunity to develop, implement, measure and report on 'their own' set of CHIs. Some best-practice examples of this approach include the following cultural health frameworks:

1. Harmsworth's (2002) work on Māori wetland indicators which resulted in nine indicators (of the 100+ considered) being chosen as part of a multi-year consultation phase;

2. Williamson et al.'s (2016) socio-ecological framework for measuring the health of the Waikato River which resulted in 55 indicators (of the 248 considered) being chosen over a two and a half year consultation with Waikato River Iwi;
3. Tipa and Tierney's (2006) stream cultural health index is based on 14 indicators (of the 30+ considered) which were refined over a multi-year consultation program with three Iwi and Hapū across four major catchments.
4. Pauling's (2007) 'State of the Takiwā' environmental monitoring approach developed by Te Rūnanga o Ngāi Tahu as part of their Ki Uta Ki Tai – Mountains to the Sea Natural Resource Management framework

More details of these examples, and other CHI frameworks, are summarised in Tables 3 and 4 of this review. There is substantial overlap between the different indicators systems summarised in Tables 3 and 4. For example, Orchard et al. (2012) assessed the similarity in scores for the cultural health of the Ruataniwha/ Cam River between the different modules within the 'State of the Takiwa' indicator system. They found a high level of similarity between cultural health scores undertaken using the CHI Stream Health index (Tipa and Teirney 2006), the Mahinga kai index (Ibid.) and Takiwa 2.0 overall site health scores (Pauling 2007). In contrast, overall stream health results derived using the SHMAK index (Biggs et al. 2002) at many of the same sites were consistently higher (i.e. better) than those of the three culturally based systems. This result is not unexpected as the SHMAK stream health assessments do not incorporate parameters specific to cultural health. The result reinforces the need for Māori input into the design of CHI to ensure they are culturally relevant.

The most important considerations for assessing the suitability of different indicators for use as 'best-practice' CHIs are summarised in Table 2. Based on analysis against the types of criteria listed in Table CHIs can then be discarded[2] or placed into three broad groups for further use and or development: (1) suitable and relatively easy to score as appropriate datasets and skills are available; (2) suitable but difficult or very difficult to score as further research or significant work to create the dataset(s) is required; (3) suitable but only appropriate for iwi to develop the method and gather/interpret the dataset(s) required (Tipa et al. 2017).

[2] If this is acceptable to mana whenua; development of CHIs should always be Māori focused in terms of content and reporting on cultural health.

Table 2: Criteria for assessing the suitability of CHIs (modified from Harmsworth (2002))

Appropriate	Defensible	Practical
Based on a Māori knowledge frameworks, tikanga and methodologies	Repeatable and objective – i.e. limited observer bias	Cost effective
Meaningful to Tangata Whenua	Can show environmental change	Can be used for SOE reporting
Māori knowledge still available	Provides reliable information about wetland, freshwater, and/ or estuarine condition	Generic- able to be used in a wide range of ecosystems
Can be assessed and interpreted by Māori communities		Able to show incremental change on relevant time-scales
Complements scientifically based indicators		
Able to show incremental change on relevant time-scales		

Table 3.1 (of 5): Basic information about CHI systems used to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

System	Author(s)	Title	Spatial scale?
Tuhoe – forest health (with water component) 2017	Lyver, P O B, Timoti, P Jones, C J, Richardson, S J Tahi, B L, Greenhalgh, S	An indigenous community-based monitoring system for assessing forest health in New Zealand.	Forest health (including freshwater values) across large forest blocks
Waikato River report card 2016	Williamson, Bruce; Quinn, John; Williams, Erica; van Schravendijk-Goodman, Cheri	2016 Pilot Waikato River Report Card: Methods and Technical Summary	Large catchments and sub-catchments
Waitaki River report card 2015	G. T. Tipa, E. K.Williams, C. Van Schravendijk-Goodman, K. Nelson, W. R. K. Dalton, M. Home, B. Williamson and J. Quinn	This summary based on journal article "Using environmental report cards to monitor implementation of iwi plans and strategies, including restoration plans"	Large catchments and sub-catchments
Te Uri o Hau – Kaipara Harbour 2016	Mahuru, Robb; Awatere, Shaun; Harmsworh, Garth; Makey, Leane	Bicultural tools for biodiversity measurement and monitoring: TUOH Framework and Model for monitoring biodiversity in the Kaipara	Local scale reporting of sites of specific interest to Hapū
Generic rivers and streams CHI [MfE] 2006	Tipa and Teirney 2002 and 2006	A Cultural Health Index for Streams and Waterways: A tool for nationwide use	Local scale and sites (small wetlands and estuaries, food gathering locations, short stream reaches)
Wai Ora Wai Māori assessment of three Waikato River tributaries (2017)	Taura, Yvonne; Reihana, Kiri; Awatere, Shaun; Harmsworth, Garth; Forrest, Evelyn 2017	Wai Ora Wai Māori – a kaupapa Māori assessment tool for Ngāti Tahu-Ngāti Whao	Specific locations with mahinga kai values are assessed
A pilot study devising a Mauri monitoring framework for the Papanui Stream – Hawkes Bay (2015)	Brian Gregory, Dr Benita Wakefield, Garth Harmsworth, Marge Hape, Joanne Heperi (2015)	Te Hā o Te Wai Māreparepa "The Breath of the Rippling Waters" Mauri Monitoring Framework Pilot Study on the Papanui Stream	Local marae/ single catchment scale; although it was noted that the approach could be used as a basis for CHI for use in other catchments.
Generic CHI (not just water): FRST funded Uni of Waikato + consultants, aim to improve planning monitoring and outcomes for Iwi (2009)	Jefferies and Kennedy (2009)	Māori Outcome Evaluation: A Kaupapa Mäori Outcomes and Indicators Framework and Methodology	Not noted, but this seems like much more of a regional picture, at least for the ana Whenua and Wahi Tapu kete as regulation is likely to be consistent across a region
Motueka catchment CHI (based on T+T (2006) framework)	Young Roger: Harmsworth Garth: Walker Dean: James Trevor (2008)	Linkages between cultural and scientific indicators of river and stream health	Local site, extending to catchment and sub-catchment scale with aggregation.

System	Author(s)	Title	Spatial scale?
Part of larger package of wetland condition work: 'a generic set of mautauranga Māori based indicators for wetland condition and trend' (2002)	Harmsworth (2002)	Co-ordinated monitoring of NZ wetlands, Phase 2, Goal 2: Māori environmental performance indicators for wetland condition and trend.	Individual wetlands and/ or sites of cultural significance
Cultural environmental flows (minimum water flows) in the Kakaunui River (2012)	Tipa, Gail and Nelson, Kyle (2012)	Identifying Cultural Flow Preferences: Kakaunui River Case Study	Catchment or sub-catchment scale or at individual sites of cultural significance
Maurimeter assessment framework (2006)	Te Kipa Kepa Brian Morgan (2006)	Waiora and cultural identity: Water quality assessment using the Mauri model	Variable, depending on the application. However, the Maurimeter was designed for assessments of individual projects with a relatively limited spatial scale, typically at the sub-catchment level.
State of the Takiwa assessment for the Ruataniwha/ Cam catchment (2012)	Orchard, Shane: Lang, Michael: Falwasser, Tui: Rupene, Makarini: Te Karu, Tracey: Tirikatene-Nash, Nukuroa: Williams, Cherie	State of the Taikiwa 2012: Ruataniwha/ Cam River: Cultural Health Assessment of the Ruataniwha/ Cam River and its catchment	At any scale. 'Takiwa assessments' have been carried out at the marae/ hapu scale (see Gregory et al. (2015) in this table), catchment scale (this study) and for the whole South Island (Pauling 2007)
Generic Iwi-SHMAK system (2002)	Biggs, Barry; Kilroy, Cathy; Mulcock, Claire; Scarsbrook, Mike; Ogilvie, Shaun	New Zealand Stream Health Monitoring and Assessment Kit: Stream Monitoring Manual Version 2K – A Tool for Kaitiaki	Designed for site-based reporting, but the data is easily to aggregate into larger units. The method allows for scoring streams with very different physical characteristics and making meaningful comparisons between them using the same set of indicators.

System	Author(s)	Title	Spatial scale?
Auckland Council's Wai Ora Wai Māori programme (2015)	Awatere, Shaun: Robb, Mahuru: Harmsworth, Garth (2015)	Proposed mana whenua values, attributes, and measures for Auckland Council's Wai Ora Wai Māori programme	Some of indicators within this system are generic indicators that could be used at larger spatial scale(s), the whakapapa-based attributes are specifically designed to enable mana whenua to determine attributes that are suitable to the ecology with which they have a close affinity. That is, they are intended to provide flexibility for the development of location-specific/ local-scale attributes. However, these assessments could be aggregated (e.g. through a proportion/ percentage indicator) to apply to larger catchment/ rohe/ regional scale; provided the sub-sites were a representative sample of these larger units

Table 3.2 (of 5): Indicator framework summary for CHI systems used to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

System	Indicator framework used
Tuhoe – forest health (with water component) 2017	Cultural health of forest so most of the 25 indicators were about forest health. Although four of these related to water: - Appearance of the river - The quality of water in the river (in normal flow) [sediment] - The language or sound of the river [geomorphic diversity?] - The structure and vegetation canopy cover of the riverbed
Waikato River report card 2016	Many relevant indicators including 55 water related in a range of sub-categories (taura = strand of a rope or mega-value set) 1. Experience (9 sub, 5 BPJ + 3 num.) 2. Ecological Integrity (16 sub, 3 BPJ + 13 num.) 3. Kai (9 sub, 9 BPJ) 4. Water Quality (6 sub, 6 num. 3 repeat of experience indicators) 5. Water Security (6 sub, 6 num.) 6. Effort (9 sub, 8 BPJ + 1 num. 1 repeat of Ecol. Integrity indicator) 7. Sites of Significance (Scoring sites of significance is most appropriately done by iwi but this information was not available at the scale of Report Card Unit at the time of writing) 8. Economics (n/a)
Waitaki River report card 2015	Incomplete summary of "45 indicator" framework arranged into these sub-categories: - Increase engagement of whānau in a range of management initiatives - Develop flow regimes that meets the needs and aspirations of whānau - Maintain water quality for healthy aquatic systems - Protect and enhance the abundance of taonga species (birds, plants and fish) - Ensure that mahinga kai and cultural materials are fit for cultural use [Essentially a bespoke modification of the 2006 CHI (same authors).]
Te Uri o Hau – Kaipara Harbour 2016	Range of established approaches recommended across the four Marae as they were interested in different ecosystems: River/ stream CHI (x3 sites) Marine CHI (x1) Estuarine CHI (x4 sites) Wetland CHI (x2 sites) Iwi estuarine toolkit (x2 sites) Freshwater fish (x2) WESTERN FW mussels (x1) WESTERN + other bird, forest and cultural heritage monitoring
Generic rivers and streams CHI [MfE] 2006	Three indicator groupings: Site status (2 sub indicators) – is this a traditional site and is it used by Iwi? Mahinga Kai (4 sub indicators indicators) – mahinga kai species present? Compares the species present today with past. Access to the site. Would Iwi return to site? Cultural stream health (8 sub indicators) – Water quality. Variety of habitats. Catchment land use. Riparian vegetation. Use of the riparian margin. Riverbed condition/sediment. Water clarity. Channel modification

System	Indicator framework used
Wai Ora Wai Māori assessment of three Waikato River tributaries (2017)	This indicator system is much more streamlined than many of the other CHIs listed in this table. It was specifically developed to support iwi/ hapū participation in setting freshwater standards under the NPSFW, particularly in relation to mahanga-kai sites/ values Three indicator groupings are used, each of which includes two questions: Taiao Ora – Flourishing nature - Is it safe to eat species from this site? (3 sub indicators) - Do taonga species have a suitable habitat? (1 sub indicators) Whānau Ora – Thriving families - Can whānau exercise manaakitanga? (1 sub indicators) Can whanua participate effectively in whānaungatanga (connection)?(1sub indicators) Mauri Ora – the essence of vitality Are the senses awakened at the mahinga kai? (1 sub indicators) Do tangata tiaki feel connected to the mahinga kai? (1 sub indicators)
A pilot study devising a Mauri monitoring framework for the Papanui Stream – Hawkes Bay (2015)	Composite system using the following: A: CHI (see Motueka example in this table) of 22 Indicators, all of which relate directly to stream health, water quality, physical characteristics of the stream, riparian/ catchment vegetation, or cultural use. B: Iwi-SHMAK assessment (see SHMAK example in this table) – basic level without invertebrate sampling C: Takiwa assessment (see Ruataniwha example in this table) of 7 scored in indicators and assessments of the diversity and abundance of taonga, cultural resources and pests.
Generic CHI (not just water): FRST funded Uni of Waikato + consultants, aim to improve planning monitoring and outcomes for Iwi (2009)	3 kete in the full indicator suite. 1 relates to freshwater values. The other are more concerned with planning rules and Iwi exercising control in their rohe. Mana Whenua Kete = 'Mana whenua is appropriately respected': Index 1 (5 indic.), Index (4 indic.), Index 3 (3 indic). Wahi Tapu Kete = 'Wahi Tapu are protected': Index 1 (3 indic.), Index (3 indic.), Index 3 (3 indic.), Index 4 (3 indic.) Mauri Kete = 'The Mauri of all waterways are in optimal health' (breakdown of this indicator below)
Motueka catchment CHI (based on T+T (2006) framework)	21 Indicators are grouped by Atua: Tangaroa (8 sub indicators); Tane Mahuta (5 sub indicators); Haumie tiketike and Rongomatane (2 sub indicators); Tumatauenga (4 sub indicators); Tawhiri Matea (2 sub indicators).
Part of larger package of wetland condition work: 'a generic set of mautauranga Māori based indicators for wetland condition and trend' (2002)	Nine indicators derived from an initial list of 'over 100 Māori and scientific indicators'. A separate change component is specified for five indicators which brings actual number of 'parameters scored' to 14. But it would seem sensible to assess change for all nine indicators which would then give a total of 18. Placed in three groupings: What's causing the problem (4 sub indicators) Taonga and Mauri (5 sub indicators) Change in Taonga and Mauri (5 sub indicators)
Cultural environmental flows (minimum water flows) in the Kakaunui River (2012)	Nineteen indicators grouped into Mahinga kai – 9 sub attributes Wai Mauri – 4 sub attributes Hauora (well-being) – 3 sub attributes Cultural landscapes – 3 sub attributes Aggregated scores were then compared to flow data (flow meters co-located with some assessment sites) to determine flows that were: Unsuitable (score of <3); Suitable (score >3-<5); Appropriate (score 5+)

System	Indicator framework used
Maurimeter assessment framework (2006)	The Maurimeter was initially developed by Morgan (2007) for engineering purposes but has also been used in many other situations and has wide application. It is an assessment method developed to integrate information across environmental, economic, social, and cultural dimensions. These are redefined from an indigenous perspective to measure the impacts of the mauri in four key indigenous aspects: 1. Ecosystems (environmental) values (the physical and spiritual integrity of the ecosystem), within which are embedded; 2. Hapū (cultural) values (such as sustainable practices, provision of culturally important resources, ability to exercise rangatiratanga, traditional knowledge, customary practices etc.), within which are embedded; 3. Communities (social) values (H and S of mana whenua, non-Māori and Māori from other areas. Employment and recreation) within which are embedded; 4. Whānau (economic) values (a measure of the direct personal effect on the whānau undertaking the assessment. The way this is perceived will vary from whānau to whānau. Actual measured indicators will vary from site to site, as each is a bespoke assessment related to the project/ location and hapu/ whānau undertaking the assessment
State of the Takiwa assessment for the Ruataniwha/ Cam catchment (2012)	This report uses the 'State of the Takiwa' assessment methodology, which is usually carried out in conjunction with other assessment tools; Most often the Cultural Health Index (CHI)(see above), Stream Health Monitoring and Assessment Kit (SHMAK) (next column). Electric fishing and/ or water quality testing are also often incorporated. Examples of other Takiwa assessments include Pauling (2007), Pauling et al. (2007) Lang et al. (2012), Orchard et al. (2012b). The Takiwā general site assessment consists of three forms. (1) The Site Definition Form records the site name, locality, traditional significance and traditional condition of the site amongst other details. (2) The Site Visit Form records information on aspects of the monitoring visit, including the date, time, weather conditions, heritage/archaeological details, land use and other relevant information. (3) The General Site Assessment Form includes questions addressing the health of the site in relation to the following categories: The amount of pressure from external factors; Levels of modification/change at the site; Suitability for harvesting of mahinga kai; Access issues; Willingness to return to the site; Overall state/health of the site; and Presence and abundance of culturally relevant species.
Generic Iwi-SHMAK system (2002)	Modification and update of the original SHMAK system for use as a tool for Kaitiaki support and extension of the SHMAK concept for iwi use (SHMAK Versions 1K and 2K of the manual). Four main 'indicator' groupings as follows: - 16 observational indicators relating to activity in and around the stream that could be affecting freshwater values and water quality. These are designed as aids to interpretation of the measured indicators, rather than indicators themselves. - Five 'standard' measured biophysical indicators of stream health: flow velocity; pH; water temperature; conductivity, clarity - Three indicators derived from assessments of the streambed composition, sediment deposits and bank vegetation. - 'Streambed life' indicator derived from an assessment of invertebrates and periphyton in the stream bed. Different levels of complexity are provided for this measure. The streambed life indicator is sometimes dropped from other CHI systems that incorporate parts of SHMAK (e.g. Papanui Stream and Ruataniwha examples in this table).

System	Indicator framework used
Auckland Council's Wai Ora Wai Māori programme (2015)	The focus of this report was the development of a Māori Freshwater Values Framework for input into the National Policy Statement for Freshwater Management (NPSFM). Therefore some of the indicators suggested lie outside what would traditionally be used in a 'pure' CHI framework. The summary outlined is for the whole framework as it is Iwi who should determine what indicators are included or excluded. The report does not define a 'master' set of values for iwi/ hapu within Tāmaki Makarau. However, it is a useful starting point for mana whenua to build on and add to. The system includes a basic set of quantitative/ biophysical attributes (many from the other sources in this table) that can apply to all Māori freshwater values. These indicators would sit alongside a more comprehensive set of specific qualitative indicators determined by individual iwi and hapu. In particular, the 15 mauri assessments for 15 of the 16 Māori values provide substantial scope for individual iwi/ hapu/ whānau to tailor this system to their specific needs (He Au Putea (economic growth) is the only Māori value that does not incorporate a mauri assessment). The nested framework outlines 126 individual indicators (Table 6) – some of which could be further sub-divided into other indicators. The nested nature of this framework lends itself to grouping indicators in different ways; three possible groupings are outlined below Māori values: This is the approach of the authors who describe the framework as 'a set of 16 economic, physical, and metaphysical values that can be applied to the Tāmaki Makaurau context.' [Plus one set of biophysical indicators.] 1. Waiora (pure water); 2. Waitapu (sacred waters); 3. Waitapu (sacred waters); 4. Waikino (polluted water); 5. Mahinga kai (food gathering area); 6. Waiwera (hot or geothermal water); 7. Wahi taonga (sites of significance); 8. Wai takaro (recreational areas); 9. Wahi Tupuna (historical sites); 10. Wahi Tapu (restricted sites); 11. Waipuna (spring water); 12. Hauora Taiao (healthy environment); 13. Mahi Ahu Whenua (agriculture); 14. Mahi Mara (horticulture); 15. He Ara Haere (navigational routes); 16. He Au Putea (economic growth); 17. Biophysical indicators incorporating all Māori values

Table 3.3 (of 5): Scoring system and method summary for CHI systems used to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

System	Scoring system and method
Tuhoe – forest health (with water component) 2017	4-7 point Likert scale – implies non-linear bioD./ env. response Numerical, but scoring system means these numerical values do not directly sum to provide a numerical summary. Scores are assessing using the Best professional judgement (BPJ) of regular forest users
Waikato River report card 2016	4 point scale A – D with no + or – (although + and – allowed in aggregate grades). 4 point Scale looks to be scaled as: excellent, OK, affected, badly affected. Likely to be a high variability in effects between sub-indicator (if not within them) as there are so many different indicators and groupings. Designed to be aggregated as numerical values with Overall value (for that area)/ 8 taura (=mega value set)/ sub-indicators within taura/ sub-sub indicators for some in Ecol. Integ. A mix of Best Professional Judgement (BPJ) and numerical indicators. However, numerical indicators are focussed within the 'Ecological Integrity' 'water quality' and 'water security' taura
Waitaki River report card 2015	- Although a number of biophysical indicators are used, such as water quality, they also included indicators that required conditions to be assessed through a cultural lens (includes traditional numeric indicators (e.g. water quality) - The scoring used to assess each indicator ranged from 1 (poor) to 5 (excellent). A score of three means that conditions are approximately in the middle of the range. This equates to a 'C' grade**.** **- Using a tiered approach**[1], multiple metric scores were then aggregated to an indicator level and multiple indicator scores aggregated to an 'objective' score.
Te Uri o Hau – Kaipara Harbour 2016	Based on other reporting frameworks. Therefore, this approach includes a complementary mix of western scientific monitoring (i.e. quantitative measures and BPJ semi-quantitative condition frameworks) and Iwi based cultural monitoring (i.e. BPJ semi-quantitative condition frameworks and observational data)
Generic rivers and streams CHI [MfE] 2006	Site status is descriptive. But traffic light system used for scoring[2] Mahinga kai and cultural stream health use 1-5 point system with some indicators not using all 5 gradations (e.g. Would Māori return to the site scores 1 for No and 5 for Yes) . Use a mean of subs to get final score 'Each of these eight indicators receives a score from each rūnanga member involved in the assessment. The scores for each indicator are then averaged.' BPJ (note Iwi, not professional. The idea is that this is done by Māori) With a scale to guide 1-5 scores values. However, only the 1 and 5 values are scored and language leaves considerable room for interpretation. Expect high observer bias. Cultural indicators were correlated with MCI and SQMCI scores to test their relevance in the testing process
Wai Ora Wai Māori assessment of three Waikato River tributaries (2017)	The first Taiao Ora indicator uses three Yes/ No question about specific food resources (kōura, tuna and watercress) to generate a value (0-3). The five remaining indicators use 0-4 point Likert assessment scale using BPJ. The definition of score ranges for the Likert scales is variable between the five indicators; one is well defined, but several are not, and do not have defined 'example states' for each score band. However, despite this the scores given by each assessor were very similar. This might not be the case without some 'calibration' of new observers at different sites. For the three 'test streams' reported on, four assessors (kaimahi) were used and their assessment scores were averaged. A total score is calculated for each site and score bands are provided for the overall mauri of mahinga kai at each site.

System	Scoring system and method
A pilot study devising a Mauri monitoring framework for the Papanui Stream – Hawkes Bay (2015)	- 15 of the 22 CHI indicators use a BPJ assessment where a 1-5 point scale is used. A general example of what level of the scale relates to which condition score is provided, with some examples. The 7 remaining indicators use species lists for fish, insects, birds, plants and pest animal species. - CHI Assessment sheet implies that each indicator should be scored by a minimum of three assessors and their BPJ scores averaged for each indicator - SHMAK uses 8 numerical indicators, 5 of which are measures and three are numbers derived from semi-quantitative observational data
Generic CHI (not just water): FRST funded Uni of Waikato + consultants, aim to improve planning monitoring and outcomes for Iwi (2009)	- Protection of Mauri by territorial authority (3 sub indic.) - Pro. of Mauri by Tangata Whenua (3 sub indic.) - Pro. of Mauri by other agencies (3 sub indic.) - Pro. of Mauri by wider community (3 sub indic.) - Physical evidence that Mauri protected (5 sub indic. governing physical characteristics of water and waterway, threats etc.) The focus on planning means traditional freshwater quality indicators are a very small component of the overall picture (30% of the Mauri kete and 12% of all indicators) - Scored using a 1-5 point scale (no + or -) with each measure scoring for both the ideal and actual situation [not sure how this works as wouldn't the ideal always be the best?] - BPJ using the 1-5 scale. Not all indicators seen so hard to see if there is consistency amongst them in terms of unambiguous language and 'levels' between them [?]. - Best result is a 1 which means these might not be designed for numerical summaries[?]
Motueka catchment CHI (based on T+T (2006) framework)	- Retain several binary options from Tipa and Tierney work: Site status (traditional/ not); Mahinga Kai (present/ not); Future (will return/ not) - The main list of 21 indicators is each scored 1-5 - Also had a single 'overall health' indicator (#22) "feeling in puku" which correlated well with the other indicators. - Intended to be carried out by multiple Iwi or Hapu observers. The average scores for different observers to derive a summarised value for the site. BPJ with a scale to guide 1-5 scores BUT only the 1 and 5 values are scored and language leaves considerable room for interpretation. - On some indicators (e.g. bird life, ngahere taonga and pests there is no guide for the scores). - Expect high observer bias with current system.
Part of larger package of wetland condition work: 'a generic set of mautauranga Māori based indicators for wetland condition and trend' (2002)	- Eight indicators are scored using a 1-5 point scale. One indicator uses a 3 point scale [which could easily be converted to 5, why wasn't this done?] - Scoring is numerical (species and point source counts, % cover values) for 7 indicators and BPJ for remaining 2. - Use of fixed values creates a 'step problem' e.g. is having 15 taonga species (score 5) really 20% better than having 14 (score 4)? - The values scored area: % area of land uses/ riparian factors affecting cultural values; # of point sources degrading mauri; Degree of hydro modification; # of introduced exotic organisms; # of taonga species; % area of taonga plants; % area of exotic plants; # of cultural sites; Assessment of Te Mauri
Cultural environmental flows (minimum water flows) in the Kakaunui River (2012)	-BPJ of Māori observers. -All nineteen indicators – which are not listed in this paper – [perhaps to preserve the integrity of cultural knowledge?] were given a rating of 1-7 by Māori assessors for all flow attributes at each site (1 being totally satisfactory, 7 being totally unsatisfactory). -For each attribute the individual ratings are averaged, producing a single 1-7 score. Then the flow attributes within each theme are averaged—for example the nine attributes scores for the mahinga kai component are averaged. The output is a single score for each of the four themes.

System	Scoring system and method
Maurimeter assessment framework (2006)	- In the original system five ratings of mauri are given for each aspect/ indicator, based on whether it is: Enhancing mauri +2; Maintaining mauri +1; Neutral – 0; Diminishing mauri – 1; Destroying or significantly diminishing mauri – 2 - In later application of this model a sixth category has been added to represent highly sustainable practices + 3 - A unique feature of the Maurimeter – in comparison with all the other systems summarised in this table – is the step of weighting the four aspects of mauri to address their relative importance to users and decision-makers. This weighting is applied to each aspect before scoring is completed and hierarchies developed. The weightings outlined in Morgan (2006) were 40% ecosystem, 30% hapu, 20% community and 20% whānau.
State of the Takiwa assessment for the Ruataniwha/ Cam catchment (2012)	- One question (would you return to this site?) is a Yes/ No response - Five indicators scored on 1-5 Likert scale using BPJ, with average between multiple observers. Levels of the five indicator are not well defined and open to wide interpretation (e.g. question one is 'How would you describe the pressures at this site?' with a scoring range of 1 = immense pressure and 5 = low pressure) - One indicator is a list of management actions required for the site, with multiple yes/ no possible for each listed action. - The indicator scores and data from assessments are entered into the Takiwā 2.0 database and the 'Takiwa index' score for overall site health calculated. This index reflects the average score from nine individual assessments. - Data implies this is a simple average but there may be some weighting of different scores within the database?
Generic Iwi-SHMAK system (2002)	- Observational data on recent (within 6 weeks) pressures in the surrounding are scored yes/ no. - All five biophysical indicators and river assessments comprise measured variables that are scored in a range of different ways to derive a value that is 'biological meaningful' as the score range is non-liners (e.g. pH 5 or less scores -5; pH 5.5-6.0 scores 5, pH 6.5-7.5 scores 10). - Score ranges within indicators is also variable from 10 (i.e. 1 to 10) to 40 (i.e. -20 to -40). The contributions of each indicator to the site total are set at 20 points (for 3 indicators) and 10 (5 indicators). - Streambed and periphyton assessment uses a modified (and simplified) MCI type index that is suitable for more expert community groups to make quantitative assessments of the diversity and quality of stream-life. - The variable contribution of specific indicators to the total site score is highly developed in this system, in comparison with all the other CHIs summarised in this table.
Auckland Council's Wai Ora Wai Māori programme (2015)	- As currently proposed the system is dominated by dichotomous choice – Ae/ Kao (Yes/ No) – indicators which would be qualitatively assessed by iwi/ hapu, based on their local interests; presumably using BPJ with the responses from multiple observers averaged for a final score (?). – Ae/ Kao indicators comprise 58% (72/125) of the total. However, Awatere et al. (2015) note that these indicators may be developed further by mana whenua to reflect increasing complexity in scoring approach, with the potential adaption of scale data (e.g. low, medium, and high OR 4. Pai rawa atu, ka rawe (excellent); 3. Ka pai (good); 2. Ahūa (fair); 1. Kino, pārū, pōhara, (poor)). - If measurements were to be repeatable across different observers these levels would need to be clearly defined, with examples. - 13% of indicators (16/125) use a simple numeric value, based on the number of hui, mostly, or the number of other features of interest such as # of boat ramps, # of trails connected, # of local employment opportunities. - 12% of the indicators use mauri assessments (sensu. Morgan 2006) of different 'types' of freshwater (e.g. Waitapu (spring water) vs. Waiwera (geothermal water)) or freshwater 'sites' (e.g. Wahi taonga (sites of significance) vs. Wai takaro (recreational areas)). - The remaining 17% indicators comprise numerical indicators based on established scientific measures (e.g. total nitrogen, dissolved oxygen etc.) or quantifiable properties (e.g. food standards or catch per unit of effort for mahinga kai).

Table 3.4 (of 5): Cultural knowledge summary for CHI systems used to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

System	Source of cultural knowledge
Tuhoe – forest health (with water component) 2017	Mixed-age group of 90 **Tuhoe from Ruatahuna** - Multi-step process of identification indicators, picking most relevant and sign-off from elders - Community likely to be one of the most 'integrated' with their rohe in NZ
Waikato River report card 2016	The co-design process took more than 2.5 years with representatives of the **five Waikato river iwi**, alongside the research team. - Within this process, there were a multitude of discussion and analytical steps both from cultural and scientific point-of-views - Over 248 potential indicators were assessed and rationalised - The aspirations of Māori and communities as captured under the Waikato River Indep. Scoping Study were used to underpin the indicators - Waikato River Iwi contributed to all phases of the report card development, including review of the taura level grades; taura grades were shared with iwi representatives who checked them against iwi representatives BPJ.
Waitaki River report card 2015	- Ngai Tahu – explicitly grounding the report card in the goals and objectives of Ngāi Tahu is akin to the principles of ecosystem management, in which decisions are made by society about the desired sustainability condition of each part of the landscape. - The original report on which this indicator was based could not be sourced = Tipa G, Nelson K, Williams E. 2015. The cultural health of the Waitaki catchment – an unpublished report for Environment Canterbury. This information was based on a summary Journal article.
Te Uri o Hau – Kaipara Harbour 2016	- Smaller Iwi group on thee Kaipara Harbour Te Uri o Hau (TUOH) - A kaupapa Māori approach was followed involving hui at four marae as well as workshops and fieldwork. Open to all but limited group (19 total) with age range from child to kuia. Sites and site-specific indicators were chosen - Identified "a variety" of sites around the Kaipara [assume their rohe in northern section]. Once these sites were chosen Landcare staff and Kaitiaki "identified site-specific indicators and chose monitoring methods"
Generic rivers and streams CHI [MfE] 2006	- Part of MfE program to increase capacity for cultural/ environmental monitoring - Initial work with Ngai Tahu on the Taieri - Expanded to include the '3-indicator groups' format and further work with two Ngai Tahu rununga based in Taieri and Kakaunui catchments - Tested in two further catchments; Hakatere (also Ngai Tahu) and Tukituki (Ngāti Kahungunu)i - From the data collected, a Cultural Health Index was developed that is generic in the sense that it can be used confidently by any iwi at sites in streams of any size or river type.
Wai Ora Wai Māori assessment of three Waikato River tributaries (2017)	Ngāti Tahu-Ngāti Whaoa rohe streams. Collaboration between Waikato-Tainui researchers and Manaaki Whenua Landcare Research. Initial methodology based on review of, use and involvement in many of the existing CHI systems outlined in this table, combined with interviews and wānanga held in 2016 with the Waikato-Tainui Technical Advisory Group. Between 2016 and 2017 members from the Ngaāi Tahu-Ngāti Whaoa Rununga Trust and kaitiaki oversaw and further developed the tool for application to Ngāti Tahu-Ngāti Whaoa mahinga kai sites
Generic Iwi-SHMAK system (2002)	The updated version of this system was informed after 'field-testing' and comments with several different Iwi and hapū, most notably the Kaupapa Taiao unit of Te Runanga o Ngai Tahu
Maurimeter assessment framework (2006)	None listed for this publication. Rather it represents a summary of the author's many years of professional and cultural knowledge.

System	Source of cultural knowledge
A pilot study devising a Mauri monitoring framework for the Papanui Stream – Hawkes Bay (2015)	- Extensive consultation through 15 wānanga, hui and field trips undertaken over a 14 month period. Kaumātua and other mana whenua views captured in semi-structured interviews. - While four marae are present in this catchment, and were originally consulted, due to time and resource constraints the bulk of the consultation was with a single marae: **Ngāi Te Whatuiāpiti marae, hapū is Ngāti Whatuiāpiti Tuturu o Kahungunu.** This approach was endorsed by the other three marae in the Papanui catchment. - 'Semi structured interviews held with Kaumātua, mana whenua and other participants associated with each wananga. These interviews were digitally recorded and transcripts were produced for whānau to comment, amend and make any adjustments.'
Generic CHI (not just water): FRST funded Uni of Waikato + consultants, aim to improve planning monitoring and outcomes for Iwi (2009)	-'This report presents the intent, findings, and outputs of the Mäori research objective of PUCM Phase 3, which focuses on developing and testing a kaupapa Mäori environmental outcomes and indicators framework and methodology.' - 'Two iwi that undertook trialling were **Ngāti Maru Rūnanga, based in Thames**, and **Te Rūnanga o Ngāti Awa of Whakatane**. Both iwi have long established, functional, and strong tribal authorities and both have dedicated environment units run by experienced resource management. The rohe of Ngāti Maru includes lands over a vast geographic area … includes both rural land, and intensively urban lands including some in Auckland.'
Motueka catchment CHI (based on T+T (2006) framework)	- Pan iwi/ hapu organisation called 'Tiakina Te Taiao' which is based in the Motueka and Riwaka catchments (Ngati Koata and Ngati Tama?) - Used the Tipa and Tierney system (they were involved in the workshops) but 'modified' [how is unclear?] to local structure, descriptions and recording system. Significant is the adaptation to use the Atua framework for the grouping and reporting of individual indicators.
Part of larger package of wetland condition work: 'a generic set of mautauranga Māori based indicators for wetland condition and trend' (2002)	- 'Māori researchers, and Kaitiaki communities in wetland areas' throughout NZ including Auckland, Waikato, BOP, Central N. Island, Canterbury, Otago and Southland. [Tainui, Ngāti Te Ata, Te Arawa, Ngāti Naho, Hauraki, Ngāti Rauhoto, Ngāti Te Urunga, Ngāti Tūwharetoa, Ngāti Raukawa, Ngāti Tukorehe, Ngāti Rarua, Te Ati Awa, Ngai Tama, Ngai Tahu] - 'Conceptual approaches and Māori knowledge was recorded during field visits, hui, on-on-one interviews and discussions with Māori resource managers, researchers, planners kaumātua, and interaction with other wetland specialists' - The indicators identified in stage I (above) were then field trialled to evaluate their effectiveness for national application and use in assessment and reporting frameworks
Cultural environmental flows (minimum water flows) in the Kakaunui River (2012)	- A series of interviews with members of three Iwi and Hapū of Te Rūnunga o Moeraki (Ngai Tahu) in different sub-catchments [?] of the Kakaunui River. These provided descriptions of river flows, how rivers are used, and the attributes that describe healthy flows and support cultural uses. - From these descriptions 19 flow attributes (4 four groupings) were extracted and listed on an assessment form. - This form was later used in the field to assess six sites on a weekly or monthly basis from Dec 2007 to January 2009 – a total of 18 assessments for each site. - There was a 'team' of assessors but no detail on the number contributing to each grading and/ or if these were independent assessments.
State of the Takiwa assessment for the Ruataniwha/ Cam catchment (2012)	Takiwa is an environmental monitoring system developed by Ngai Tahu (Pauling 2004) that is aimed at facilitating Tangata Whenua to gather, store, analyse and report on information in relation to the cultural health of significant sites, natural resources and the environment within their respective takiwa (tribal areas).'

System	Source of cultural knowledge
Auckland Council's Wai Ora Wai Māori programme (2015)	Consultation was outlined in a previous report (Harmsworth and Awatere 2012). The authors had undertaken an extensive review of the literature around the involvement of Māori in the freshwater management objectives, planning and the policy process – which included the use of CHI. The 'Unitary Plan Māori Values Framework Discussion Document' and iwi management plans relevant to the Auckland region were also reviewed. The authors also brought their extensive knowledge from many years of consultation on freshwater values and co-management/ governance of freshwater by mana whenua. Following this initial phase, specific input was sought from Auckland iwi/ hapu in two workshops held in March 2012.

Table 3.5 (of 5): Sample selection and design summary for CHI systems used to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

System	Delineation of sub-sites and special locations	Sample design (sites and frequency of measures)
Tuhoe – forest health (with water component) 2017	Not discussed. Designed for assessing forest health in a relatively confined rohe area (c.50km x 15km rectangle around Ruatahuna)	Not specified but assumption is 'the comparative nature of the interview-based approach relies heavily on regular and repeated forest visits and/or harvest of resources to form and update impressions during a season or over multiple years'
Waikato River report card 2016	Laudable efforts to provide separate analysis based on geography. The Waikato River is split into four parts and Waipa reported separately = five main areas) and function type (five reporting areas are split into main-stem + tributaries; also 'major' lakes have separate reporting). All up, 16 different report cards are produced.	Not specified. Assume this is part of SOE reporting frame work and would therefore require re-sampling at least every 5 years
Waitaki River report card 2015	Six report cards were developed for the Waitaki catchment, one for each of the sub-regions and one for the catchment as a whole.	Not specified. Assume this is part of SOE reporting frame work and would therefore require re-sampling at least every 5 years
Te Uri o Hau – Kaipara Harbour 2016		Dependant on the methodology used
Generic rivers and streams CHI [MfE] 2006	Simple approach that can be replicated in multiple locations for larger site(s)	Not specified. Assume this is part of SOE reporting frame work and would therefore require re-sampling at least every 5 years
Wai Ora Wai Māori assessment of three Waikato River tributaries (2017)	The simplicity of the system lends itself well to multi-site reporting to get aggregate scores for a larger river, catchment or rohe of the iwi or hapu undertaking the assessments. The field testing used three locations on three different – fairly widely separated – tributaries of the Waikato River.	Not specified as this is a pilot study. Assume this is envisaged to be on typical 'State of the rohe Environment' style reporting frequencies of 1-5 years.
Generic Iwi-SHMAK system (2002)	This is a generic method; many users will have a specific site in mind when this method is adopted. However there is substantial guidance on good site selection for larger 'catchment-wide' (or bigger) studies in other related publications.	In-depth discussion in the document with respect to appropriate sample sizes and strategy. This system is envisaged to include much more regular monitoring than the other approaches reviewed. Suggest seasonal (i.e. 4 times/ year) or monthly is best, with twice a year regarded as the minimum sampling intensity.
Maurimeter assessment framework (2006)	Designed to be applied to a wide range of projects and/ or locations. Specific sites and monitoring frequency were not identified.	Designed to be applied to a wide range of projects and/ or locations. Specific sites and monitoring frequency were not identified.

System	Delineation of sub-sites and special locations	Sample design (sites and frequency of measures)
A pilot study devising a Mauri monitoring framework for the Papanui Stream – Hawkes Bay (2015)	Assessment of the entire stream reach and catchment (c.800 ha) area under consideration – aggregated with point sampling for some indicators.	Not stated – location and marae or hapu specific
Generic CHI (not just water): FRST funded Uni of Waikato + consultants, aim to improve planning monitoring and outcomes for Iwi (2009)	Variable. Governance indicators are likely to relate to a wider area, while the physical parameters would need to be assessed on catchment or sub-regional basis.	Not stated but the fact this program is related to better planning outcomes means reporting should occur on time-frames appropriate for SOE reporting and regional/ district plan evaluation (i.e. every 5-10 years)
Motueka catchment CHI (based on T+T (2006) framework)	Designed to cover the catchment with some sites chosen to coincide with representative scientific sampling (n=14) , but a group (n=11) were chosen on cultural importance/ relevance	'Ideally each site would be monitored twice a year, with the time of monitoring based on the annual migration of the kuaka. Each of the six sites would ideally be monitored twice/ year by three different 'iwi monitors' under the management of the research programme manager.
Part of larger package of wetland condition work: 'a generic set of mautauranga Māori based indicators for wetland condition and trend' (2002)	Individual wetlands of significance to Iwi, Hapu and Whānau	Not stated – location and Iwi or Hapu specific
Cultural environmental flows (minimum water flows) in the Kakaunui River (2012)	Individual locations on the river that are of cultural significance, with data from different sites combined to create a grade for a catchment/ sub-catchment	Would include as many culturally appropriate sites as possible within the reporting area – presumably with some minimum # to ensure a representative picture. Once cultural flow levels are established then flow monitoring is able to encapsulate if cultural requirements are being met.
State of the Takiwa assessment for the Ruataniwha/ Cam catchment (2012)	The sites were 'chosen to reflect the source to sea management philosophy' and include headwaters, tributaries and main stem sites. How closely they follow a truly representative/ random sample was not investigated. Sample seems quite comprehensive as it includes 44 sites within a c.3500 ha catchment	No repeat sampling of this catchment yet but the Takiwa system has used a 5-yearly repeat measure in the Avon-Heathcote estuary and catchment (c.f. Pauling et al. (2007) and Lang et al. (2012)).
Auckland Council's Wai Ora Wai Māori programme (2015)	Specifically designed for measuring the cultural health of sub-sites and special locations.	Proposed framework, specific sites and monitoring frequency were not identified.

Table 4.1 (of 4): Comparing individual indicators used by key CHI systems to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

	Riparian vegetation	Mahinga kai –presence and/ or productivity	Fish species	Water clarity	Water flow	Cultural site[number present and/or suitable management of]	Pest plants/ animals	River bank and/ or stream bed condition	Point sources of pollution effects on Mauri	Sediment on river bed	Use of river
Number of CHIs with this indicator	13	12	11	11	11	10	10	10	9	9	9
Wetlands Harmsworth (2002)	X	X	X			X	X		X		
Iwi-SHMAK (2002)	X			X	X			X	X	X	
Maurimeter Morgan (2006)	?	?	?	?	?	?	?	?	?	?	?
Tipa & Tierney (2006)	X	X	X	X	X	X		X		X	X
Motueka Young et al. (2008)	X	X	X	X	X	X	X	X		X	X
MfE CHI Jeff. & Kenn. (2009)	X	X	X	X	X			X	X	X	
Tipa & Nelson (2012)1	X	X	X	X	X	X	X	X		X	X
Takiwa Cam River (2012)	X	X	X	X	X	X	X	X	X	X	X
Tipa et al. (2015)1	X	X	X	X	X	X	X	X	X	X	X
Gregory et al Hawkes Bay (2015)	X	X	X	X	X	X	X	X	X	X	X
Auckland	X	X	X	X	X	X	X	X	X	X	X
Williamson et al. (2016)	X	X	X	X	X	X	X		X		
Wai Ora Wai	X	X	X			X	X		X		
Urewera Lyver et al. (2017)	X	X		X	X		X	X			X

Table 4.2 (of 4): Comparing individual indicators used by key CHI systems to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

	Access to river	Catchment vegetation and/or land use	Compare mahinga kai to past	Water quality	Active work and restoration	**Rongoā** (harvest plant spp.)	Shape and form of river	Bird life	Site values are known and treasured	Statutory protection	Would you return to the site?
Number of CHIs with this indicator	8	8	8	8	7	7	7	6	6	6	6
Wetlands Harmsworth (2002)		X	X			X					
Iwi-SHMAK (2002)				X			X				
Maurimeter Morgan (2006)	?	?	?	?	?	?	?	?	?	?	?
Tipa & Tierney (2006)	X	X	X				X				X
Motueka Young et al. (2008)	X	X		X		X	X	X			X
MfE CHI Jeff. & Kenn. (2009)			X	X	X		X		X	X	
Tipa & Nelson (2012)1			X	X	X		X		X	X	X
Takiwa Cam River (2012)	X	X	X	X	X	X	X	X	X	X	X
Tipa et al. (2015)1	X		X	X	X	X		X	X	X	X
Gregory et al Hawkes Bay (2015)	X	X	X	X	X	X	X	X	X	X	X
Auckland Awatere (2015)	X	X	X	X	X	X	?	?	X	X	X
Williamson et al. (2016)	X				X			X			
Wai Ora Wai	X	X				X					
Urewera Lyver et al. (2017)		X						X			

Table 4.3 (of 4): Comparing individual indicators used by key CHI systems to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

	Insect life (MCI)	Science water quality	Feel in puku	Habitat variety	Weather	Nga-here taonga	Smell of water	Artificial structures	Navi-gation	Other economic indicators	Specific Mauri Assess-ments
Number of CHIs with this indicator	5	5	4	4	4	3	3	2	2	2	2
Wetlands Harmsworth (2002)						X					
Iwi-SHMAK (2002)	X	X		X	X						
Maurimeter Morgan (2006)	?	?	?	?	?	?	?	?	?	?	?
Tipa & Tierney (2006)						X					
Motueka Young et al. (2008)	X		X		X	X	X				
MfE CHI Jeff. & Kenn. (2009)											
Tipa & Nelson (2012)				X							
Takiwa Cam River (2012)	X	X	X		X						
Tipa et al. (2015)				X							
Gregory et al Hawkes Bay (2015)		X	X	X	X						
Auckland Awatere (2015)	X	X	?	?		?	?	X	X	X	X
Williamson et al. (2016)	X	X						X	X		
Wai Ora Wai			X				X				
Urewera Lyver et al. (2017)							X				

Table 4.4 (of 4): Comparing individual indicators used by key CHI systems to report on Māori perspectives of the environmental and cultural health, kaitiakitanga, and rangatiratanga of freshwater ecosystems in New Zealand

	Taste of water	Use of river margins	Water use	Flood and other hazards	Inter-gene-rational transfer of knowledge	Rubbish	Cultural assessments for different waters	Signage	Sustainable production and practices	Whaka -papa	Total number of topic areas in this system
Number of CHIs with this indicator	2	2	1	1	1	1	1	1	1	1	n/a
Wetlands Harmsworth (2002)											10
Iwi-SHMAK (2002)											12
Maurimeter Morgan (2006)	?	?	?	?	?	?	?	?	?	?	?
Tipa & Tierney (2006)		X									17
Motueka Young et al. (2008)		X									23
MfE CHI Jeff. & Kenn. (2009)											15
Tipa & Nelson (2012)1											17
Takiwa Cam River (2012)											27
Tipa et al. (2015)1											21
Gregory et al Hawkes Bay (2015)											26
Auckland Awatere (2015)	?	?	X	?	X	?	X	?	X	X	31
Williamson et al. (2016)			X			X		X			19
Wai Ora Wai	X										13
Urewera Lyver et al. (2017)	X		X								12

4.0 A cultural health indicators framework for Auckland?

Mana whenua are interested in measuring the cultural health of Auckland's water resources. Harmsworth and Awatere (2012) report on relatively recent consultation undertaken with Auckland Region mana whenua groups with respect to freshwater co-management/ co-governance arrangements between Auckland Council and Māori. Manaaki Whenua-Landcare Research were engaged by council to develop a suggested approach for how Māori values and interests could be integrated into regional planning objectives, policies, and rules for freshwater management in the Unitary Plan. One of the important aspirations expressed by Iwi was their desire for a CHI that could be used to report on the condition of freshwater, estuaries and harbours. Mana whenua are also interested in being actively involved in the measurement of cultural health.

Developing mātauranga Māori indicators for monitoring: Iwi and hapū wish the Auckland Council to acknowledge the validity of mātauranga Māori indicators. These indicators can be either quantitative (e.g. biophysical) or qualitative (whakatauāki – proverbs). To achieve this outcome, developing the iwi/hapu capacity to monitor is required. (Summary of mana whenua outcomes; page 6, Harmsworth and Awatere 2012)

Harmsworth and Awatere (2012) recommended that CHI indicators for Auckland should be formulated through meaningful consultation with individual iwi/ hapū groups following the approach summarised in Table 1 (above). Following on from Harmsworth and Awatere (2012), Awatere et al. (2015) have proposed a set of CHI indicators for Auckland.

> '[This report] presents a set of 16 economic, physical, and metaphysical values that can be applied to the Tāmaki Makaurau context. Although this is by no means the complete set of values for Tāmaki, it does provide a starting point for mana whenua to build on and add to. The intention in developing the framework has been to identify qualitative attributes and measures along with biophysical attributes and measures to provide a robust and holistic data set that will help elucidate the challenge of managing within limits. We have identified a basic set of quantitative/biophysical attributes that can apply to all Māori freshwater values alongside a more comprehensive set of specific qualitative attributes.' (Awatere et al. 2015)

Garth Harmsworth and Shaun Awatere, the co-authors of both of the 'Auckland focussed' reports outlined in this section, are two of the most prominent New Zealand researchers in relation to the use of mātauranga Māori for reporting on cultural health. Therefore, it would seem appropriate to follow – as closely as possible – the CHI monitoring framework that they have proposed for monitoring the cultural health of freshwater within Tāmaki Makaurau. The Awatere et al. (2015) CHI system is one of the frameworks summarised in Tables 3 and 4. The reporting framework is also summarised in Table 5.

The main problem this author perceives with the Awatere et al. (2015) approach is its apparent size and complexity in comparison with some of the other CHI frameworks; this has the potential to be quite daunting to potential assessors and users. However, this is partly the result of this CHI covering a much wider range of issues than many of the other CHI frameworks (Table 4), which is a positive. There are several additional reasons that may help in practical application and use of this framework, despite its apparent complexity:

1. Not all indicators might be applicable to all iwi/ hapū. That is, its comprehensive nature allows for easy modification by selecting only those areas of particular interest to the iwi/ hapū and/ or assessment locations;
2. When used at the local scale, not all indicators will be applicable to every site;
3. A large number of the indicators are Ae/ Kao (Yes/ No) in nature, as opposed to multi-scale assessments across a range of values (i.e. 0-5 Likert scale measures);
4. The nested nature of the framework allows indicators to be grouped in a range of different ways. For example, as aggregated domain indicators (column 1 in Table 5), Māori values (column in Table 5), or general indicator category (column 3 in Table 5).

Because this framework will comprise a relatively large number of indicators/ questions – most of which are not measured, and many of which are scored using 'Best Iwi Judgement' across a limited range of scores – it is not well suited for numerical reporting on the indicators themselves. However, indicators based on proportions could be used, with the detailed cultural assessments carried out by iwi and hapū not directly reported. For example, 1 – proportion of catchments (or freshwater management units, rohe, marae etc.) with iwi-led CHI monitoring; – proportion of catchments where Cultural Health/ Mauri is steady or improving; 3 – proportion of catchments where Cultural Health/ Mauri is improving; 4 – proportion of catchments where cultural health is improving across all four domains (meta-physical, physical, economic, biophysical, see Table 5).

Table 5: Proposed monitoring framework for Auckland Council Wai Ora Wai Māori programme (from Awatere et al. 2015)

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
Meta physical	Waiora (pure water)	Regulatory attributes	Ceremonies are performed	# of hui	MR1
			No artificial mixing of mauri	Ae/ Kao[b]	MR2
			Intergenerational transfer of knowledge	# of hui[c]	MR3
			Access to Waiora	Ae/ Kao	MR4
		The state of the mauri (life force)	CHI mauri assessment		MM5
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	MW6
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	MW7
			Presence of Tohu (indicators, features or marks)	Ae/ Kao	MW8
	Waitapu (sacred waters)	Regulatory attributes	Ceremonies are performed	# of hui[c]	MR9
			No artificial mixing of mauri	Ae/ Kao	MR10
			Intergenerational transfer of knowledge	# of hui	MR11
			Restricted access to Waitapu	Ae/ Kao	MR12
		The state of the mauri (life force)	CHI mauri assessment		MM13
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	MW14
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	MW15
			Presence of Tohu (indicators, features or marks)	Ae/ Kao	MW16
	Wai Māori (drinking water, freshwater)	Regulatory attributes	No artificial mixing of mauri	Ae/ Kao	MR17
			Intergenerational transfer of knowledge	# of hui	MR18
			Access to Wai Māori	Ae/ Kao	MR19
		The state of the mauri (life force)	CHI mauri assessment		MM20

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	MW21
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	MW22
			Presence of Tohu (indicators, features or marks)	Ae/ Kao	MW23
	Waikino (polluted water)	Regulatory attributes	No artificial mixing of mauri	Ae/ Kao	MR24
			Mauri is restored	Ae/ Kao	MR25
			Restricted access to Wai Māori	Ae/ Kao	MR26
		The state of the mauri (life force)	CHI mauri assessment		MM27
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	MW28
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	MW29
			Presence of Tohu (indicators, features or marks)	Ae/ Kao	MW30
Physical values	Mahinga kai (food gathering area)	Regulatory attributes	Access to mahinga kai	Ae/ Kao	PR1
			Intergenerational transfer of knowledge	# of hui	PR2
		Taonga species	Fish are safe to eat	Ae/ Kao	PT3
			Birds are safe to eat	Ae/ Kao	PT4
			Plants are safe to eat	Ae/ Kao	PT5
			Abundance of taonga species	# of hui	PT6
				CPUE[d]	PT7
		The state of the mauri (life force)	CHI mauri assessment		PM8
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW9
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW10

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW11
	Waiwera (hot or geothermal water)	Regulatory attributes	No artificial mixing of mauri	Ae/ Kao	PR12
			Intergenerational transfer of knowledge	# of hui	PR13
			Access to Waiwera	Ae/ Kao	PR14
		The state of the mauri (life force)	CHI mauri assessment		PM15
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW16
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW17
			Presence of Tohu (indicators, features or marks)	Ae/ Kao	PW18
	Wahi taonga (sites of significance)	Regulatory attributes	Access is restricted	Ae/ Kao	PR19
			Protection and enhancement	Ae/ Kao	PR20
		The state of the mauri (life force)	CHI mauri assessment		PM21
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW22
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW23
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW24
	Wai takaro (recreational areas)	Regulatory attributes	Safe to swim	Pai rawa – Ahua Pai[e]	PR25
			Safe for recreation	Pai rawa – Ahua Pai	PR26
			Safe for other activities	Pai rawa – Ahua Pai	PR27
		The state of the mauri (life force)	CHI mauri assessment		PM28
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW29
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW30

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW31
	Wahi Tupuna (historical sites)	Regulatory attributes	Access is restricted	Ae/ Kao	PR32
			Protection and enhancement	Ae/ Kao	PR33
		The state of the mauri (life force)	CHI mauri assessment		PM34
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW35
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW36
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW37
	Wahi Tapu (restricted sites)	Regulatory attributes	Access is restricted	Ae/ Kao	PR38
			Protection and enhancement	Ae/ Kao	PR39
		The state of the mauri (life force)	CHI mauri assessment		PM40
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW41
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW42
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW43
	Waipuna (spring water)	Regulatory attributes	No artificial mixing of mauri	Ae/ Kao	PR44
			Intergenerational transfer of knowledge	# of hui	PR45
			Access to Waipuna (spring water)	Ae/ Kao	PR46
		The state of the mauri (life force)	CHI mauri assessment		PM47
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW48
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW49
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW50

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
	Hauora Taiao (healthy environment)	The state of the mauri (life force)	CHI mauri assessment		PM51
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	PW52
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	PW53
			Other Tohu (indicators, features or marks)	Ae/ Kao	PW54
Economic	Mahi Ahu Whenua (agriculture)	Regulatory attributes	Intergenerational transfer of knowledge	# of hui	ER1
			Sustainable production	Sustainable practices	ER2
		Ahu whenua species	Safe to eat	Food standards code	EO3
		The state of the mauri (life force)	CHI mauri assessment		EM4
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	EW5
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	EW6
			Other Tohu (indicators, features or marks)	Ae/ Kao	EW7
	Mahi Mara (horticulture)	Regulatory attributes	Intergenerational transfer of knowledge	# of hui	ER8
			Sustainable production	Sustainable practices	ER9
		Mara kai species (food garden/ food from the ground)	Safe to eat	Food standards code	EO10
		The state of the mauri (life force)	CHI mauri assessment		EM11
		Whakapapa (interconnectivity)	Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	EW12
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	EW13
			Other Tohu (indicators, features or marks)	Ae/ Kao	EW14
	He Ara Haere (navigational routes)	Access	Customary use	# of boat ramps	EO15
			Recreational use	# of boat ramps	EO16

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
			Tauranga waka (port or landing area)	Ae/ Kao	EO17
				Condition	EO18
		The state of the mauri (life force)	CHI mauri assessment		EM19
		Whakapapa (interconnectivity)	Cultural/ historical heritage trails	# of trails connected	EW20
			Navigation for customary purposes	Ae/ Kao	EW21
			Presence of Tipua (metaphysical/supernatural phenomena)	Ae/ Kao	EW22
			Presence of Kaitiaki (guardian or key species of plant or animal)	Ae/ Kao	EW23
			Other Tohu (indicators, features or marks)	Ae/ Kao	EW24
	He Au Putea (economic growth)	Kaitiakitanga (sustainable resource management)	Sustainable practices	Ae/ Kao	EO25
			Environment is enhanced	Ae/ Kao	EO26
		Manaakitanga (principle of reciprocity)	Local employment opportunities	# of FTEs	EO27
			Local training opportunities	# of FTEs	EO28
		Whanaungatanga (principle of shared experiences)	Joint-ventures with local community	Pai Rawa – Ahua Pai	EO29
			Joint-ventures with other iwi	Pai Rawa – Ahua Pai	EO30
		Whakatipu rawa (growing the asset base)	Intergenerational equity	Pai Rawa – Ahua Pai	EO31
			Local investment	Pai Rawa – Ahua Pai	EO32
Biophysical attributes	All Māori attributes	All Māori attributes	Minimum flows	Mean annual low flow (m3/s) – 7DEMALF	BA1
				Water velocity (m2/s)	BA2
			Level of nutrients	Total nitrogen (g/m3)	BA3
				Total ammonia (g/m3)	BA4
				Total phosphorus (g/m3)	BA5

Domain	Māori value or freshwater feature	General indicator category	Indicator	Units/ measure	Indicator number[a]
			Water clarity levels	Turbidity (NTU)	BA6
			Habitat extent and condition	Dissolved oxygen (%)	BA7
				MCI	BA8
			Level of pathogens	E. coli (count/ 100mL)	BA9
				Cynobacteria	BA10

a: These indicator numbers were not used in Awatere et al. (2015). They have been added to emphasis the relationships between different indicators. The first letter denotes the indicator domain (M = meta physical, P = physical, E = economic, B = biophysical), the second letter denotes the general indicator category (R = regulatory, M = mauri assessment, W = whakapapa, O = other category, one of seven). Indicators are sequentially numbered within domains.

b: Ao/ Kao = Yes/ No.

c: # of Hui = number of meetings or gatherings where this issue is discussed.

d: CPUE = catch per unit effort

e: Pai Rawa – Ahua Pai = scale of the condition of the resource/ relationship/ feature, relative to the 'ideal state'.

5.0 Discussion and summary

This section discusses some of the practical problems associated with implementing the types of CHI indices outlined in Tables 3 and 4. The considerations are largely scientific ones and relate to how data from cultural health assessments could be used to inform statistically testable indicators for monitoring 'State of Cultural Health' in the same way that regional 'State of the Environment' monitoring is undertaken by Auckland Council. The discussion assumes that mana whenua have decided to undertake cultural health monitoring and that at least some of that data is numerical, or can be converted to a numerical format. Scientific rigour should be a consideration in the development of CHIs but mana whenua should always remain in control of the process, and if they do not want to place scientific considerations 'front and centre' when formulating a CHI for their rohe then this approach needs to be respected.

All the CHI indices summarised in this review are in the initial stages of development and have only been used at a local scale and/ or to provide a baseline measure. The one exception to this is the Avon-Heathcote estuary and its catchment which has been assessed twice, with two measures five years apart (Pauling et al. (2007) and Lang et al. (2012)) using the 'State of the Takiwa' system developed by Ngai Tahu (Pauling 2004). Therefore, there is very limited evidence of the link(s) between CHIs and the other environmental values which council is trying to enhance. This problem is summarised by Tipa and Teirney (2006) who comment that:

> 'Because the project is only at the stage where a 'tool' to assist assessment and data collection has been developed, the process has not progressed to the point where it is possible to provide resource management agencies with hard evidence that the use of the Cultural Health Index will result in positive environmental outcomes.'

However, while the impetus for commencing CHI reporting by local authorities is often related to environmental reporting, and all CHIs currently used in New Zealand have a significant environmental focus, they are designed to measure changes in cultural values. Therefore, whether a CHI system is able to quantify and reliably monitor changes in environmental values/ outcomes is less important than reliability monitoring changes in cultural health values/outcomes. The types of measures and measure systems outlined in Tables 3 and 4 will produce relatively 'noisy' data. This will require a long-term commitment to data collection – probably in the order of multiple measures over 20-30 years – to properly assess the effectiveness of specific cultural health indicators.

Some of the systems use indicators which convert numerical measures into categories based on the size/ value of the measure; for example, the number of taonga species present within the study area. The use of fixed values creates a 'step problem' e.g. is having 15 taonga species (score 5) really 20 per cent better than having 14 (score 4)? In systems where these 'stepped'

indicators are used it would be much more preferable to convert the results to continuous variables which are then able to be easily averaged across different observers, sites or catchments. In practice this should be relatively easy to resolve as these types of 'step indicators' are not a major component of most of the systems that were reviewed.

Almost all the assessment systems outlined in Tables 3 and 4 are likely to contain a high variability in actual biological effects between sub-indicator groupings (and possibly also within the groupings). My assumption is that there is also likely to be similar variation in 'cultural impact/ effects' between indicators and indicator groupings. For example:

1. A linear response is assumed for many indicators when this is probably not the reality. For example, the impact of vegetation clearance within a stream catchment will depend on how much vegetation is left – a five per cent loss of forest or scrub vegetation in a catchment that is 80 per cent forested has a very different impact when compared to the same loss (i.e. 5%) in a catchment that is only eight per cent forested.
2. Using an aggregated approach assumes that values for all indicators respond in a similar way along the scale of measurement (i.e. response function). For example, a 0.05 change from 0.95 to 0.90 means the same thing, in terms of its impact on the value[3] of 'water clarity' as it does for 'the presence of mahinga-kai species'. This assumption is almost certainly invalid and the actual impact of a change in indicator value is likely to vary widely both between and within (see point 1) indicators.
3. While the two points above are based on the author's knowledge of environmental and biodiversity measures, the assumption is that they would apply equally to many of the cultural indicators.

The complexity of these 'interaction effects' only increases with the more complicated systems – for example those of Awatere et al. 2015 (125 indicators) and Williamson et al. 2016 (55 indicators) – as there are so many different indicators and groupings. However, it should be noted that these problems are not unique to CHI assessments, they are inherent in any indicator system that tries to compare 'apples with oranges', which is also the case for many purely science based environmental indicator frameworks.

Two of the frameworks reviewed for this report make some attempt to resolve 'interaction effects' between multiple indicators. The maurimeter framework weights the four domains (ecosystems, Hapū (cultural), Communities (social), and Whānau (economic)) after scoring, depending on the perspective of the user. The Iwi-SHMAK system makes extensive use of weighting within the measured indicators and for the invertebrate taxa assessments. Score ranges for individual

[3] These could be environmental, biodiversity, cultural or social values.

indicators are non-linear; in order to account for non-linear nature of biodiversity/ environmental complexity they are trying to represent. However, the Iwi-SHMAK is probably the least Māori led and/ or informed indicator reviewed. Rather, it is a western science-based indicator which has been configured to allow it to be used as part of a cultural health assessment. Takiwa assessments may also involve some weighting within the Takiwa 2.0 database.

Many of the indicators in Tables 3 and 4 are based on best professional judgement (BPJ); or, as they should always be carried out by Iwi, then 'best iwi judgement' (BIJ) is probably a better term. In most cases these BIJ indicators are intended to be carried out by multiple iwi/hapū observers, with the scores for different observers averaged to derive a summarised value for the site/ stream reach/ catchment etc. BIJ with a scale to guide 1-5 scores. However, in many of the CHIs only the 1 and 5 values are scored and language leaves considerable room for interpretation. For some indicator/ CHI combinations (e.g. bird life, ngahere taonga and pests) there is no 'how to' guide (with examples) for the different scores. Therefore, high observer bias would be expected in many of the current systems; which reduce the value of these systems for monitoring 'natural' change over time and/ or the impact of policy and management interventions. However, with adequate resourcing of training and calibration between different iwi observers, and better delineation of the different levels, the impact of observer bias could be significantly reduced.

From a western science/ statistical reliability perspective, the site selection approach for almost all the CHI indicator case studies reviewed is sub-optimal. In most cases the sites are chosen through a qualitative process, as opposed to a random, stratified random or systematic approach. This raises the possibility that CHI assessments may not be representative of their study area as a whole. The omission of suitable monitoring sites that are inaccessible or where access is prohibited (e.g. in Orchard et al. 2012a) is particularly problematic as they may represent an important aspect of the 'overall picture' that is not sampled. The following approach from Orchard et al. (2012b) is representative of many CHI studies:

> 'Aspects considered… included logistical issues, site accessibility and safety, and similarity to other sites. All potential sites were retained unless there was a specific reason for excluding them from the final site selection. For example, some sites of significance to tangata whenua (e.g. some springs) were not selected as State of the Takiwā monitoring sites where a similar monitoring site had been identified nearby. In choosing amongst the potential sites established by the Rūnanga monitoring team consideration was also given to the need for a relatively even distribution of sites from source to sea in keeping with a Ki Uta Ki Tai [mountains to sea] approach'.

However, it must be remembered that these are cultural health assessments, and if the sites selected for monitoring encompass all the culturally significant components of a catchment or rohe, or are a representative sample of culturally significant locations, then the results will be

reliable. In addition, in most of the larger studies referenced in this review, effort was made to sample sites that included all parts of the catchment (i.e. headwaters and multiple locations along the main watercourse, and tributary streams). For the smaller studies – e.g. those undertaken at the marae scale – it was often possible to achieve very good coverage of the sub-catchment of interest with a handful of sample sites.

One point that comes across clearly in the discussion around cultural health indicators – as it does with biodiversity monitoring – is that in the final analysis we are trying to measure the un-measurable. ‘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’ (Robb 2014). This speaks to the importance of ensuring sensitivity and mana whenua participation not just in the design of a CHI and data collection, but also the analysis and reporting phases. Experience with ‘best professional judgement’ type environmental monitoring indexes suggest that scientifically robust detection of changes in cultural health with the CHIs summarised in Tables 3 and 4 may prove problematic in the short- to medium- term. However, the role of CHIs in strengthening the connection of mana whenua with their rohe, enhancing kaitiakitanga and rangatiratanga, and helping Auckland Council build enduring relationships with Māori means they should be actively pursued.

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