Volunteer monitoring as a focus for community engagement in water management in Aotearoa-New Zealand: review and prospects

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ABSTRACT

This article overviews community-based water monitoring (CBWM) in Aotearoa-New Zealand (NZ). CBWM was strongly boosted in NZ around 2000 by the development of the Stream Health Monitoring and Assessment Kit (SHMAK) and the Wai Care community initiative. Reform of freshwater management in NZ may be one driver for renewed interest recently in CBWM. Because professionals perceive volunteer-monitoring data as unreliable, they currently give little support to volunteer monitoring. To address their concern, we compared CBWM with measurements by regional authorities (RAs) – the main water management agencies in NZ. Agreement was encouragingly close for a comprehensive range of variables, including the important state-of-environment (SoE) indicators: visual clarity, *Escherichia coli* and macroinvertebrates. Community volunteers need and want ongoing professional support and encouragement, and, fortunately, there are important benefits for water management agencies, including engagement of citizens in water management and use of volunteer data. Professional support for CBWM in NZ could include: advice and encouragement, training, database development and quality assurance. Current research and development is focused on improving resources and systems for volunteer monitoring, notably with upgrading of the SHMAK. We are enlisting volunteers, equipped with improved tools and support systems, to assess the benefits of riparian rehabilitation and the suitability of water for swimming.

Key words | citizen science, ecological condition, volunteer monitoring, water quality

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INTRODUCTION

Water quality has been consistently rated by the public as the foremost environmental issue in Aotearoa-New Zealand (NZ) since opinion surveys began in 2000 (Hughey *et al.* 2016). This public concern has led to additional policy initiatives aimed at addressing diffuse pollution and other water issues, notably the National Policy Statement on Freshwater Management (MfE 2017), which envisages increased involvement of the community in water management. The citizen-science literature suggests that community water monitoring may be a key component among a raft of initiatives for engaging communities as 'catchment citizens and agents of change'.

Community-based water monitoring (CBWM) is commonplace internationally, and there is increasing interest worldwide (Stepenuck & Green 2015). In NZ, despite a promising start in the late 1990s, notably with development of the Stream Health Monitoring and Assessment Kit (SHMAK; Biggs *et al.* 1998) and the establishment of Wai

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Care (literally 'water-care') community stream monitoring in the Auckland Region, CBWM seemed to falter in this country for about a decade (e.g., Coates 2013). We think major reasons for this hiatus include the lack of ongoing support for volunteers by water managers and other professionals, including lack of coordination across monitoring groups plus low regard for volunteer data.

However, with rapidly increasing interest globally and in NZ (reflected in a strong upswing of SHMAK sales since about 2012 – Rod McKay, NIWA, unpublished data) it seems timely to re-invigorate professional support of CBWM in NZ. This paper overviews the history of CBWM in NZ, summarises recent NZ research and development, and outlines current initiatives.

A BRIEF HISTORY OF COMMUNITY WATER MONITORING IN NZ

Volunteer water monitoring has a much younger history in NZ than in the USA, where community water monitoring can be traced back as far as the 1920s (Jalbert 2014). However, little is known about the early development of CBWM in NZ. Freshwaters (rivers, lakes, and wetlands) represent the ecosystems most commonly targeted by community groups for restoration efforts, with nearly half of those groups conducting stream monitoring (Peters *et al.* 2015b). The mid to late 1990s saw the establishment of numerous stream care or 'Friends of' groups to raise local awareness of freshwater issues; e.g., Friends of the Waikanae River (1997), Lake Cameron Care Group (1997), Waikato River Care (1999), Tarariki Streamcare Group (1999) (Nature Space 2017).

Support for CBWM in NZ has come from a number of established programmes which resource and support community groups and schools in monitoring. These programmes were either administered by regional authorities (RAs) (e.g., Stream Sense by Environment Waikato, Wai Care by Auckland Council), universities (e.g., Waterwatch by Lincoln University), independent government bodies (e.g., National Waterways Project by the Royal Society of NZ) or trusts (e.g. Styx River Catchment Water Quality Monitoring Programme by the Styx Living Laboratory Trust, Whitebait Connection by Mountains to Sea Conservation Trust (MTSCT)).

Wai Care, a water quality monitoring and education programme delivered by Auckland Council for communities and schools in the Auckland Region, has been one of the most successful examples of regional authority-led partnerships. The programme was developed in response to the growing awareness among citizens of the serious impacts of human activities on freshwater resources and the increasing number of community 'care' groups wanting to assess such impacts. The name Wai Care – *wai* is the Māori (indigenous Polynesian) name for water – was adopted in 1999 at several *hui* (meetings) at the offices of the Auckland Regional Council (Wai Care 2003). Wai Care has been very successful in the region. For example, there were 138 community groups monitoring 142 sites in 2014, with an additional 7,700 primary and secondary school students involved in the programme (Lepla 2015).

Although water quality monitoring is a growing area for citizen science in NZ, a number of initiatives have experienced reduced funding, institutional support or scope over the last 10 years. For example, the National Waterways Project (Royal Society of NZ) and Stream Sense (Waikato Regional Council) have been discontinued. Lincoln University ended its partnership with Waterwatch in 2017, with Waterwatch forming a Trust to secure the future of the programme. The Styx Living Laboratory ceased its Freshwater Invertebrate Monitoring Programme after the Christchurch earthquake in 2011 and is still seeking enthusiastic volunteers to re-establish the programme. Wai Care has seen a decrease in the number of professional coordinators, a key component of its success (Chard *et al.* 2005).

Despite these set-backs, there has been increased effort to provide a nationally consistent CBWM programme providing coordinated support and protocols which extend beyond regional boundaries. The protocols and philosophy of the Wai Care programme were adopted and expanded for national use by the MTSCT (in Māori language, *Nga Maunga ki te Moana*). MTSCT was established in 2002 to deliver community and school-based conservation programmes. As of 2016, Whitebait Connection, MTSCT's freshwater monitoring programme, had supported over 64,000 volunteer hours in aggregate over its lifetime (MTSCT 2016). Like Wai Care, Whitebait Connection relies on coordinators to support community groups. It now operates in eight regions across the North and South Island of NZ. These programmes provide training opportunities (half a day to a day) to individuals and groups interested in CBWM. National coordination has been offered as an explanation for the greater success (in terms of sites monitored and community investment) of comparable programmes in Australia (Chard 2004).

The Stream Health Monitoring and Assessment Kit

Volunteer water monitoring in NZ was strongly boosted with the development of the SHMAK by NIWA in association with a rural advocacy organisation, Federated Farmers, in the late 1990s (Biggs *et al.* 1998, 2002). SHMAK uses biomonitoring indicators (periphyton and macroinvertebrates) to assess stream ecological condition – with supporting measurement of water quality variables and stream habitat attributes. SHMAK was originally developed for use by farming families in NZ concerned with the condition of streams traversing their land (Biggs *et al.* 1998). But the kit was soon adopted more widely, including by Māori groups and schools concerned with stream condition or active in riparian management. SHMAK was updated (SHMAK-2) with involvement of the NZ Land Care Trust and improved documentation (Biggs *et al.* 2002).

An important innovation in the SHMAK was a visual clarity method. The SHMAK tube (Figure 1(a) can be regarded as a microcosm of the standard method for measuring visual water clarity: the (horizontal) sighting range of a black disc viewed with an underwater periscope (Figure 1(b)) (Davies-Colley 1988). Zanevald & Pegau (2003) showed that this index of visual water clarity is ‘robust’ in depending only on the optical properties of the water. The black disc method has been used for professional monitoring of visual clarity in rivers in NZ for 30 years. Kilroy & Biggs (2002) showed that SHMAK tube measurements are indistinguishable from *in situ* black disc observations for visibilities less than 0.6 m. A new national standard for professional water quality monitoring in NZ (Milne *et al.* 2017) specifies *in situ* black disc measurements for waters with visual clarity >0.5 m, and the SHMAK tube for waters of lower clarity.

When considered in relation to core variables for river and stream state-of-environment (SoE) reporting in NZ (Table 1), it is obvious that SHMAK does not cover some important water attributes. SHMAK does not include any method for dissolved oxygen or nutrients (nitrogen and

Figure 1 | Measurement of visual water clarity in New Zealand. (a) The SHMAK clarity tube in use for water of relatively low clarity. The black target (20 mm diameter disc) is mounted on an aquarium magnet that is being moved to the extinction distance. (b) Visual clarity measurement *in situ* as the horizontal sighting range of a black disc. The observer is using an underwater periscope to observe the extinction distance of the black disc target fixed to a steel stake driven into the streambed (at left) (Photo credits: A. Rob Davies-Colley; B. Graham Timpany).

Table 1 | Assessment of current and future SHMAK capability for volunteer measurements versus state-of-environment (SoE) monitoring variables for rivers and streams in NZ

River SoE variables[a]	Notes on current status
Discharge	Not measured currently in SHMAK, but should be assessed at least as High, Med, Low – or read staff gauge at nearby hydrometric site?
Water quality variables	
*Temperature	Currently measured in SHMAK.
Dissolved oxygen	Could be measured with test kits.
*Visual clarity	SHMAK clarity tube currently used, clearer waters would be better measured *in situ* with black disc equipment (Figure 1).
Ammoniacal nitrogen	Difficult for professional laboratories at typical environmental concentrations.
Nitrate–nitrite–nitrogen	Amenable to volunteer measurement by colorimetry.
Total nitrogen	Difficult for volunteer measurement as requires chemical digestion.
Dissolved reactive phosphorus	Amenable to volunteer measurement by colorimetry but typical environmental concentrations are low so caution is advised.
Total phosphorus	Difficult for volunteer measurement as requires chemical digestion.
E. coli bacteria	Petrifilm method agrees well with professional measurements.
Biomonitoring attributes	
*Macroinvertebrates	Extension of current SHMAK monitoring protocols to include kick net sampling would better align professional and volunteer methods.
Macrophytes	Assessment of macrophytes (total coverage and 'clogginess') would be useful for assessing stream restoration efforts.
*Periphyton	Categories of periphyton in SHMAK should be simplified and include observations of (potentially toxic) cyanobacteria.
Physical habitat attributes	
*Habitat assessment	Inclusion of a modified version of the SEV (Clapcott 2015) protocols for measuring various stream and habitat characteristics would better align professional and volunteer methods.

Variables currently measured in SHMAK indicated with an asterisk.
[a]'Supporting' water quality variables in river SoE monitoring in NZ include: conductivity, pH, turbidity, total suspended solids (TSS), and coloured dissolved organic matter (CDOM).

phosphorus). Perhaps most significantly, SHMAK contains no method for assessing faecal contamination in fresh waters. However, at least some of these other attributes are tractable for volunteer monitoring (Table 1). For example, Stepenuck *et al.* (2011) showed that volunteer measurements of *Escherichia coli* were in reasonable agreement with professional data. And several different wet chemical methods for dissolved oxygen obviate the need to use an expensive oxygen probe and are suitable for volunteer use (Storey *et al.* 2016). Updated methods for assessing instream and riparian habitat characteristics will reflect those used by water managers – the National Rapid Habitat Assessment Protocol (Clapcott 2015).

SHMAK, as a toolkit, provides standardised protocols for volunteers to measure many of the SoE reporting variables (Table 1). This standardisation is important as it legitimises volunteer-collected data, forming a bridge between the public and the science community (e.g., Ottinger 2010). However, as SHMAK is a tool and not a part of a programme as such, embedding it within an institutional structure (such as a regional council) may improve its accessibility (Peters 2016). The fact that some stream restoration groups do not use SHMAK (Peters *et al.* 2016) may reflect the lack of support outside the Auckland area. This sentiment was echoed by Māori users of the kit in a series of workshops held in 2006 (Adams & Penny 2006). SHMAK resources have been used in the delivery of the Whitebait Connection programmes, however, the kit has required some modifications to serve the needs of diverse users beyond the original 'target market' (see below). A key factor for the success of SHMAK and the use of CBWM data in the future is the further strengthening of the partnerships with those 'on the ground' to promote the uptake and continued use of SHMAK.

RECENT RESEARCH AND DEVELOPMENT INITIATIVES IN NZ

Research on CBWM has been conducted recently by NIWA in response to several major policy documents and other initiatives in NZ. Firstly, the freshwater reforms in NZ, culminating in the National Policy Statement on Freshwater Management (NPS-FM) in 2014 (MfE 2017), envisage increased community engagement in water management. Secondly, the report 'a Nation of Curious Minds' (MBIE 2014) encourages increased citizen involvement in science in NZ. More recently, the Regional Council Research Science & Technology Strategy (2016) of the regional government sector (who do most environmental management in NZ) signalled the need to expand citizen involvement in environmental science for resource management. The NPS-FM does not mention volunteer monitoring, although it gives considerable attention to the need to expand monitoring coverage across NZ to meet data need. However, as recognised by the regional sector, one powerful way to engage citizens in water management is to involve them in volunteer water monitoring (Storey *et al.* 2016). Such involvement could also help RAs improve the spatial and temporal coverage of their monitoring.

A paired monitoring study to test reliability of volunteer data

A major issue for community monitoring of water, in common with volunteer measurements generally, is the perception by professionals of data unreliability. We sought to test the reliability of volunteer measurements by comparing with near-simultaneous professional measurements at the same stream sites (Storey *et al.* 2016; Storey & Wright-Stow 2017). Over an 18-month period, volunteers used an upgraded SHMAK with horizontal visual clarity (black disc method), a dissolved oxygen kit (LaMotte's Winkler titration method www.lamotte.com), and *E. coli* measurement (3M™ Petrifilm™ media with a simple 35 °C incubator and disposable membrane filtration cups). Volunteers received half a day of training in the methods and ongoing support in the form of answering questions and feedback on results throughout the duration of the study.

Community volunteer and regional council measurements agreed closely for (the key reporting variables) visual water clarity and *E. coli* (Figure 2) as well as (as expected) for temperature and electrical conductivity. Agreement was weaker for dissolved oxygen (albeit over a restricted range) and rather poor for nitrate (colorimetric

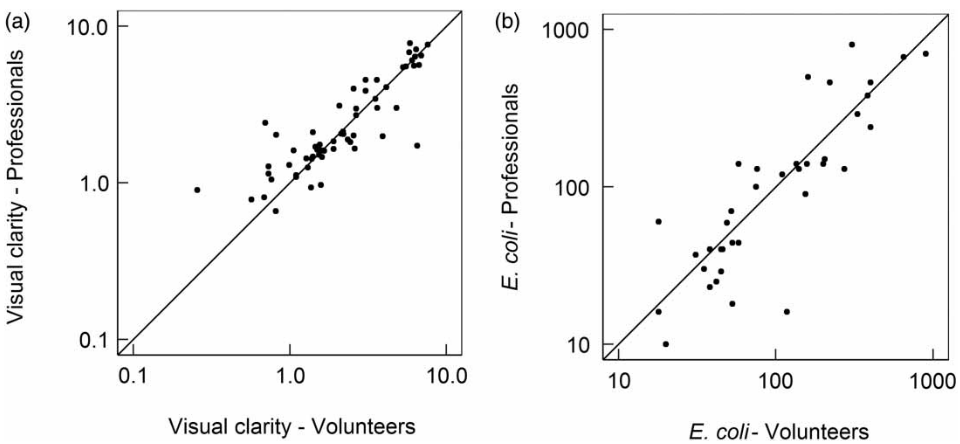

Figure 2 | Visual clarity and *E. coli* measured by community volunteers in NZ compared with paired measurements by regional council technicians. Replotted from the data of Storey *et al.* (2016). (a) Visual clarity (in metres) by the black disc method (or SHMAK tube for visibility <0.5 m). (b) *E. coli* – measured in CFU/100 mL by the 3M™ Petrifilm™ method by volunteers versus standard laboratory methods by professional agencies.

test method) and pH. Volunteer visual assessments of periphyton (% streambed cover) agreed with council assessments when 'thick mats' and 'filamentous' categories were grouped together (Storey *et al.* 2016).

Furthermore, Storey & Wright-Stow (2017) reported fair to good agreement, at the same nine stream sites, between twice-yearly volunteer and professional assessments of stream ecological condition based on (different) macroinvertebrate biotic indices. They concluded that, given suitable training and support, volunteers can make reliable assessments of stream water ecological condition. This is consistent with other studies in NZ (Moffett & Neale 2015) and elsewhere.

Perceptions of volunteers

An understanding of volunteer motivations, how motivations vary across demographics, and how water monitoring programmes progress or are discontinued is necessary for ensuring volunteers remain supported. Currently, there is no national inventory of CBWM groups in NZ which could provide an overall assessment of CBWM, although more general reviews of community restoration groups (Handford 2011; Peters *et al.* 2015a, 2015b) and citizen science initiatives (Peters 2016) can be drawn upon. In addition, there are focused interviews with selected participants of programmes such as Wai Care (Chard 2004), users of SHMAK (Adams & Penny 2006; Kin *et al.* 2016), and volunteers in a range of care groups (WRC 2011). Case studies of specific monitoring groups (Blackett *et al.* 2011; Coates 2013) have also provided insights into the perceptions of volunteers.

In follow-up research on the underlying values for engaging in water monitoring, Kin *et al.* (2016) interviewed volunteers ($N = 34$) from the nine participating CBWM groups. They used questionnaires and focus-group interviews to elicit volunteers' motivations for undertaking monitoring and clarify what would encourage them to continue long-term monitoring. Environmental concern was a key motivation for volunteers to engage in stream monitoring, while less-mentioned factors included the opportunity to enjoy nature and a way to give something back to the community. For groups engaged in stream rehabilitation, monitoring was a valuable means to assess the result of their efforts and to sustain motivation. Good technical tools were considered important, and volunteers preferred quantitative measurement to subjective assessments. Social networks played a crucial role, with groups that had strong connections with their community being more likely to continue long-term monitoring. Support from councils and scientists were much valued for giving CBWM groups a sense of being part of a 'bigger picture'. Monitoring activity increased awareness and understanding of water science and management issues, and some volunteers felt empowered to engage in freshwater planning including advocating for protection or restoration of their local stream.

Challenges identified by community groups in maintaining volunteer water monitoring include those related to recruitment and retention of volunteers (Blackett *et al.* 2011; WRC 2011; Coates 2013). Volunteers are typically older adults (>50 years old; Chard 2004; Peters *et al.* 2015b), and a 'lack of interest from younger people' (WRC 2011) may influence the longevity of care groups. In addition, a lack of knowledge-flow between community members and researchers was suggested by volunteers as contributing to volunteer fatigue and drop-out rates (Blackett *et al.* 2011). Members of the Waitao-Kaiate Environment Group (Blackett *et al.* 2011) noted that the group's activities have raised awareness of good environmental practices, leading to many local landholders carrying out pro-environmental activities. However, there was no feedback from relevant professionals as to whether or not this awareness and action had made a difference in improving environmental outcomes. Similar criticisms have been echoed by participants in the Wai Care programme, who have requested that their monitoring results be included in council reports and strategies and disseminated to the wider community (Chard *et al.* 2005).

Perceptions of water managers

The perceptions of CBWM by regional authority (RA) staff were examined by van Hunen *et al.* (2017). Focus-group discussion sessions were conducted, supported by written questionnaires, with small groups (4–12) of self-selected participants from the five collaborating RAs in the Storey *et al.* (2016) study. The discussion participants recognised significant benefits of CBWM to both RAs and CBWM groups, notably: filling gaps in state-of-environment (SoE) information; increasing knowledge and awareness of water issues within communities; and engaging citizens on water management. Most participants also acknowledged and identified significant barriers to CBWM: limited RA staff time and resources for supporting CBWM; data reliability concerns (which constrains council use of community data); health and safety concerns over volunteers working in river channels; and a lack of strategic planning by RAs on support for CBWM. Numerous strategies to overcome these barriers were identified by the participants, and none of the barriers seemed insurmountable. According to the participants, RAs could more actively foster and support CBWM. Indeed, van Hunen *et al.* (2017) concluded that the potential of CBWM in NZ may only be realised if partnerships are formed between CBWM groups and RAs.

The lack of use of volunteer data has been noted by RAs and volunteers alike and differs vastly from successful CBWM programmes overseas (e.g., Latimore & Steen 2014). In a review of citizen science data use across a range of environmental restoration groups (Peters *et al.* 2015a), agency staff lamented a lack of systems in place within NZ agencies for integrating community data into environmental reporting. Yet they noted a strong role for community data to add value to existing monitoring. This was particularly evident for stream-monitoring data, which agency staff commented were 'never used for anything and never fed back to the groups' (Peters *et al.* 2015a). However, it is obvious that professional agencies *can* use citizen science data in NZ. For example, Manaaki Whenua – Landcare Research has used volunteer bird observations in the NZ Garden Bird Survey to demonstrate changes in abundance of some bird species across NZ (MacLeod *et al.* 2017). For water managers who work with citizen science data, these limitations are considered minor compared with the benefits from supporting freshwater management initiatives (Canfield *et al.* 2002; Latimore & Steen 2014). CBWM can assist managers to overcome resource limitations (funding and personnel), while increasing long-term and regional coverage, site access, and public support for management activities (Gommerman & Monroe 2012; Hadj-Hammou *et al.* 2017). For example, RAs monitor water quality variables at over 1,000 river and lake sites across NZ as part of SoE monitoring, but monitoring coverage is inconsistent across the country, with monitoring networks denser in areas of greater population pressure and insufficient reference sites (Ausseil 2010; PCE 2010). Working with communities, particularly remote communities, could help to improve coverage without overextending available resources.

The development of higher level support, i.e., 'national leadership' to support CBWM in NZ expressed by RA staff should promote data use by government (Peters *et al.* 2015a). In this regard, MTSCT, through its nationwide delivery of the Whitebait Connection programme, is well placed to support both volunteers and researchers in meeting their goals. Gibson (2017) discussed the desire of volunteers, through training and assessments, to be certified in data collection techniques as part of a quality assurance/quality control plan.

CURRENT RESEARCH AND DEVELOPMENT DIRECTIONS

Table 2 lists seven current research and development initiatives associated with volunteer stream monitoring in NZ, with commentaries on each. The research and development is mostly being led by NIWA in collaboration with a variety of other NZ agencies. We expect to widen scope in the near future to foster volunteer monitoring of lakes and estuaries in NZ. There are numerous linkages or dependencies between the different initiatives in Table 2, but for simplicity these linkages are not shown.

We are expanding SHMAK (Item 2 in Table 2) to cover a wider range of variables including stream and riparian habitat as well as refining water quality and biomonitoring 'coverage'. The upgraded SHMAK will incorporate findings from a comparison of *E. coli* methods (Item 1) that are potentially suitable for volunteers and will include improved training resources and quality assurance.

A web-based system is under development for uploading (and immediate interpretation) of SHMAK data (Item 3). Ultimately it will also have facilities to foster an online 'community' of volunteer monitors in NZ (as has been achieved in other citizen science programmes such as the NZ Garden Bird Survey). The development of such cyberinfrastructure has been identified as a key pathway to enthuse and

Table 2 | Current research and development initiatives in community volunteer monitoring of streams in NZ

Initiative	Rationale and notes
1. Low-cost *E. coli* methods comparison	Assess different methods of *E. coli* measurement for reproducibility and 'usability' by volunteers.
2. SHMAK upgrade and extension	Improve existing capability and extend to new attributes (see Table 1). Also, to provide better training resources, quality assurance (QA), and web-based data recording.
3. Database and online community	Develop a database, and a mobile app for data entry. Embed within a website with tools for data interpretation and advice.
4. National CBWM advisory group	Bring together the agencies required to develop a national strategy for supporting CBWM in NZ, including for establishing volunteer protocols in SHMAK.
5. National riparian experiment	Engage volunteer monitors to assess stream health in response to riparian planting (of different age and on different-sized streams).
6. Swimming quality of waters	Engage volunteer monitors to assess suitability of water for swimming based on measurement of *E. coli*, visual clarity, and other key variables.
7. Guidance material for water managers	Provide guidance and resources for water management agencies (esp. regional authorities in NZ) to foster CBWM groups and provide ongoing support to the volunteers. The support could include: training, encouragement, QA, loan of equipment, analysis of samples (notably for nutrients), and use of volunteer data in reporting.

These initiatives are being led by NIWA in collaboration with a range of NZ agencies including: Wai Care, Whitebait Connection, DairyNZ, Beef and Lamb NZ, NZ Landcare Trust, several Regional Authorities, Department of Conservation and Ministry for the Environment.

motivate volunteers and promote data use by other agencies (Roy *et al.* 2012). In addition, through the registration of CBWM groups contributing to the database, we can begin to establish a nationwide inventory of groups. This will be useful for facilitating collaborations among groups and in obtaining a more accurate picture of the efforts of citizens engaged in CBWM in NZ.

To improve networking between agencies supporting volunteer monitors in NZ, we have initiated a national CBWM advisory group (Item 4) to foster well-resourced and coordinated CBWM in NZ. An associated national CBWM protocols group has also met to advise on the upgrades of SHMAK. 'On-the-ground' SHMAK training and support for stream care groups and schools is currently being met by our partners: Wai Care, MTSCT, and Mountains to Sea Wellington.

A national 'riparian experiment' will use citizen scientist monitoring data obtained with the refined SHMAK at numerous riparian projects (target ~ 50) to define the benefits and trajectories of recovery (Item 5 in Table 2). The study will build on a national stock-take of riparian rehabilitation projects in NZ that is underway. We are also trialing volunteer assessment of swimming quality of river waters (Item 6), including measurements of visual clarity and faecal contamination status, and observations of periphyton (including toxic cyanobacteria), and type and abundance of trash items in and near the river channel.

Finally, we envisage developing guidance for water managers (RAs in NZ) for fostering community monitoring groups and supporting volunteer monitoring efforts – including approaches for quality-assuring and reporting volunteer data. RAs could also assist with hard-to-measure, but crucial, field attributes (for example, river discharge and riparian shade) and arrange analysis of water samples for some variables, such as total nutrients (Table 1).

SUMMARY AND CONCLUSIONS

NZ research, consistent with the findings in a comprehensive review by Stepenuck & Green (2015), shows that there are major benefits from engaging community volunteers in water monitoring – for water management agencies as well as the volunteers. Our research and other studies have shown that volunteers can obtain reliable data if suitably trained and supported by professionals. We expect rapid advancement of CBWM in NZ once improved tools are available (notably the upgraded SHMAK) and systems are in place (such as a website for data sharing and promoting online 'community', and guidance for water management agencies to support CBWM). These will encourage and support volunteers for the long term while generating reliable and scientifically robust data that contribute to improved water management outcomes.

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