CAWTHRON

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NGĀ AWA MONITORING PROGRAMME: WAIKANAE CATCHMENT REPORTING 2023

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Prepared for Department of Conservation

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EXECUTIVE SUMMARY

This report provides the Department of Conservation (DOC) with an analysis of the data collected from the Waikanae catchment in the 2022/23 monitoring season as part of the Ngā Awa river restoration programme being implemented by DOC in partnership with other organisations.

The data comprised indicators and measures of freshwater ecological integrity collected from nine sites within the Waikanae catchment between January and April 2023. Sites were located on both public conservation land (PCL) and private land. The indicators and measures were classed into three high-level categories:

- aquatic life (including fish, macroinvertebrates, megainvertebrates, aquatic plants and periphyton)
- habitat (including habitat types, discharge, substrate stability and deposited sediment)
- water quality (including nutrients, other water chemistry data and visual clarity / suspended sediment).

Where possible, the data were analysed with respect of guideline values or attribute bands from the New Zealand National Policy Statement for Freshwater Management (NPS-FM) and compared with data from other Ngā Awa catchments and DOC's National Freshwater Monitoring Programme (NFMP). Interpretation of results relative to NPS-FM attribute bands has been included to provide context, although the sampling regime used does not allow attribute bands to be designated for each metric. In addition to various environmental metrics, threat classifications and species distributions were determined for selected aquatic life data. The relationships between metric scores and covariates from other metrics and the River Environment Classification variables were explored to investigate potential drivers of the observed results. The analytical approach closely follows the process taken by Kelly et al. (2023) for analysing data from the NFMP.

Across the attributes measured at the nine sites surveyed in 2022/23, the results indicate generally good water quality and ecosystem health. Aquatic life metrics suggest there is high biodiversity at most sites, although fish diversity at one site was lower than expected. Periphyton biomass was high at one site, despite the periphyton cover assessments indicating that low periphyton cover was present. Habitat and water quality measures were good, with substantial habitat diversity, although there was some evidence of elevated nutrient concentrations. The results presented here provide an overview of the water quality conditions within the catchment. The data also help to fill previously identified gaps, particularly in relation to fish communities in the headwaters of the catchment, and will be invaluable as baseline data to support restoration efforts that are underway throughout the catchment.

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GLOSSARY

Average score per metric (ASPM)	The average score obtained from the MCI, EPT taxa richness and %EPT results for macroinvertebrates.
Backpack electric fishing	A fishing method where a backpack machine is used to create an electric current, which temporarily stuns fish and enables their capture for identification and measurement.
Ecological integrity	The degree to which the physical, chemical and biological components (including composition, structure and process) of an ecosystem and their relationships are present, functioning and maintained.
Fish index of biotic integrity (F-IBI)	A measure of the overall health of a fish community, taking into account factors such as species richness and diversity of taxa with varied habitat preferences and pollution tolerance.
Hard-bottomed	Freshwater environments with more than 50% hard substrates, such as rocks or gravel, as opposed to soft substrates like mud or sand.
Macroinvertebrate Community Index (MCI)	A biotic index used to determine stream or river health based on the presence (or absence) of different macroinvertebrate taxa.
Megainvertebrates	Very large invertebrates, such as crayfish (kōura), mussels (kākahi), shrimp and crabs.
Meso-habitat	Habitat types determined by channel and flow characteristics, such as runs, riffles and pools.
National Environmental Monitoring Standards (NEMS)	A set of technical standards used to ensure national consistency in environmental monitoring in Aotearoa New Zealand.
New Zealand Freshwater Fish Database (NZFFD)	A database containing information on the distribution of freshwater fish species in Aotearoa New Zealand.
New Zealand National Policy Statement for Freshwater Management (NPS-FM)	A government policy aimed at ensuring the sustainable management of freshwater resources, approved in 2020 and updated in 2023. See MfE (2023).
New Zealand River Environment Classification (REC) system	A system used to classify freshwater environments in Aotearoa New Zealand, based on physical characteristics and land cover.
New Zealand Threat Classification System (NZTCS)	A system that classifies species in New Zealand based on their risk of extinction. NZTCS category is the category into which the species is placed, and NZTCS status is the overall conservation status of a species, taking into account factors such as population size, habitat quality and threats.
Percent EPT (%EPT)	The percentage of distinct Ephemeroptera, Plecoptera and Trichoptera taxa present. These groups of insects are commonly used as indicators of water quality and ecological integrity because they are sensitive to pollution.
Periphyton	Micro-organisms, including algae, fungi and bacteria, that are attached to the river substrate.

Physico-chemical factors	Physical and chemical factors that can affect the health and quality of freshwater environments, such as temperature, dissolved oxygen levels and nutrient levels.
Primary production	The production of energy by primary producers, such as periphyton, in an ecosystem.
Public conservation land and waters (PCL)	Areas of land (and waters) managed by the Department of Conservation.
Quantitative Macroinvertebrate Community Index (QMCI)	A quantitative variant of the MCI based on both the number and relative abundance of different taxa present in a macroinvertebrate sample.
Soft-bottomed	Freshwater environments with more than 50% soft substrates, such as mud or sand, as opposed to hard substrates such as cobbles, boulders and bedrock.
Taxon-Independent Community Index (TICI)	An environmental DNA-based taxon-free, biotic index of riverine ecological health recently developed by Wilderlab NZ Ltd.

1. INTRODUCTION

1.1. Background

As part of the Ngā Awa river restoration programme being implemented by the Department of Conservation (DOC) in partnership with other organisations to restore the biodiversity of 14 rivers from mountains to sea, freshwater monitoring is being carried out to establish a baseline ecological state. This monitoring collects data on plant and animal communities and habitat characteristics at a range of monitoring locations throughout the catchments being restored. The objective of this programme is to provide data to enable robust status and trend assessment of the ecological integrity of focus catchments to aid in directing and assessing the effectiveness of restoration actions.

As part of this programme, DOC has engaged Cawthron Institute (Cawthron) to analyse the initial data collected in three of the catchments included in the Ngā Awa programme. The analysis of these data will enable DOC to realise the intent of the monitoring programme by providing outputs of the field-collected data and interpretation with reference to additional national-scale datasets. Further, data manipulation and analysis scripts generated for this report are provided to facilitate future analysis.

This report is one of a series of three reports, each focusing on a different catchment (Waikanae, Waipoua and Te Hoiere / Pelorus), and outlines the results of monitoring undertaken in the Waikanae catchment at nine sites between January and April 2023. These metrics have been organised by their overarching theme (aquatic life, habitat and water quality) to facilitate analysis, grouping and discussion. Site groupings were explored using the New Zealand River Environment Classification (REC) system (Snelder et al. 2010).

The purpose of this report and accompanying R-code for data analysis was to:

- report on state and, in future years, trends in components of ecological integrity in rivers and streams within each catchment
- demonstrate the utility and value of the data collected.

1.2. Catchment and monitoring programme description

The Waikanae River is located in the Kapiti Coast District at the southern end of the North Island. The catchment spans steep tributaries in the Tararua Ranges through to coastal plains, with increasing human impact closer to the coast. Major tributaries include the Maungakōtukutuku Stream, Reikorangi Stream, Rangiora River and Ngatiawa River.

Monitoring of the Ngā Awa catchments was based on the monitoring protocols developed for DOC's National Freshwater Monitoring Programme (NFMP; see Kelly et al. 2023). For the Waikanae River, an assessment of existing ecological data available for the catchment identified gaps in fish and macroinvertebrate distribution knowledge, particularly in the headwaters (Dewson 2022). As a result, the 2023 monitoring sampled first- to third-order streams and rivers in the headwaters of the catchment. Sites were selected by DOC using Halton iterative partitioning to generate an ordered list of randomised sample locations that were spatially balanced across the study area using the REC river network and stratified by stream order (Larsen et al. 2008; Snelder et al. 2010). As public conservation land and waters (PCL) cover only a small area of the headwaters, indigenous forest was used as a proxy to spatially delineate the sample frame area.

As established in the NFMP, the environmental indicators and metrics were chosen to enable assessment of the broad categories of aquatic life, habitat and water quality. A range of parameters were measured at each site, encompassing stream metrics for sediment and sedimentation, primary production, waterway biological function, water chemistry and physicochemical factors, and assessments of habitat availability. Environmental DNA (eDNA) samples were collected using Wilderlab kits, with six replicates collected per site.

1.3. Description of ecological indicators measured

1.3.1. Aquatic life

The presence and abundance of different functional groups at different trophic levels is one indicator of ecological integrity (Schallenberg et al. 2011). Key groups for which metrics have been developed are macroinvertebrates and fish. The metrics of waterway biological condition are the Macroinvertebrate Community Index (MCI), Quantitative Macroinvertebrate Community Index (QMCI), macroinvertebrate taxonomic richness and diversity (including %EPT by taxa richness), fish index of biotic integrity (F-IBI), and presence / absence of key taxa, including freshwater crayfish, shrimp and mussels.

There are few metrics associated with aquatic plants in relation to waterway health. Thus, the primary metric associated with macrophytes and bryophytes (hornworts, liverworts and mosses) is diversity and the presence of taxa classified as At Risk or Threatened (de Lange et al. 2020).

Primary production can provide an indication of the trophic state of a waterway. Primary production is typically assessed using periphyton cover and chlorophyll-*a* concentrations. The NPS-FM separates sites into productive and default periphyton classes, reflecting that some sites by virtue of their climate and geological attributes naturally have higher primary production (MfE 2023, appendix 2C). The productive classes are defined as having a dry climate (either warm-dry or cool-dry) and geological categories with higher levels of nutrient enrichment: soft-sedimentary, volcanic-basic and volcanic-acidic. All other REC class combinations are considered to belong to the default category.

The guideline values specified in the NPS-FM are intended for sites that are monitored regularly, and the numeric attribute states for most metrics relate to the percentage of times the site exceeds this state or to long-term means or medians for the site. As sites from the Ngā Awa monitoring programme are unlikely to be monitored with the intended frequency outlined in these guidelines, the values are provided only for context, and metrics cannot be classed into an attribute band.

1.3.2. Habitat

The suite of metrics associated with stream habitat provides information on the presence and diversity of habitat components that can support a range of species typical of unmodified habitats. For these analyses, metrics used consisted of those characterising hydrological diversity (the presence of habitat types such as pools, riffles, runs, rapids and gravel beds), along with specific characteristics (such as bank vegetation and woody debris) that provide habitat for fish and other species such as *Hymenolaimus malacorhynchos* (blue duck / whio).

Discharge can provide an indication of the size of the streams that is separate to stream order and can be considered as a covariate that helps to explain patterns observed in other data. For example, deposited sediment can be associated with flow rates, as can fish species that have differing flow preferences.

Broadly, the substrate metrics assessed include an evaluation of the overall geological stability of each site (Pfankuch 1975), the composition and broad size distribution of the fine sediment (sediment assessment methods 1, 3 and 6; Clapcott et al. 2011), and the presence of non-nutrient contaminants (herbicides and pesticides).

1.3.3. Water quality

The metrics collected in this section are necessary both for identifying and monitoring sites subject to human-derived stressors, and also to provide background information for unmodified sites in relation to the other ecological integrity indicators. To aid interpretation, monitoring results were compared to guideline values from ANZECC (1992) and attribute band values from the NPS-FM. Water quality data were divided into nutrient-related data (dissolved reactive phosphorus, nitrogen and ammonia), other water chemistry data (pH, dissolved oxygen, conductivity and the presence of other ions) and water clarity (black disc, turbidity).

1.4. Overview of sites

Nine sites were monitored over the 2022/23 monitoring season (Figure 1), with each site visited once. Sites spanned from first order to fourth order, including three first-order sites, three second-order sites, two third-order sites and one fourth-order site. Two sites were located in the Kapakapanui Stream sub-catchment, three sites were in the Maungakōtukutuku Stream sub-catchment, two sites were in the Ngatiawa River sub-catchment, one site was in the Reikorangi Stream sub-catchment, and one site was in the Rangiora River sub-catchment. There were no sites in the lower Waikanae sub-catchment. Sites were located on both PCL and private land. See Appendix 1 for a full list of sites and locations.

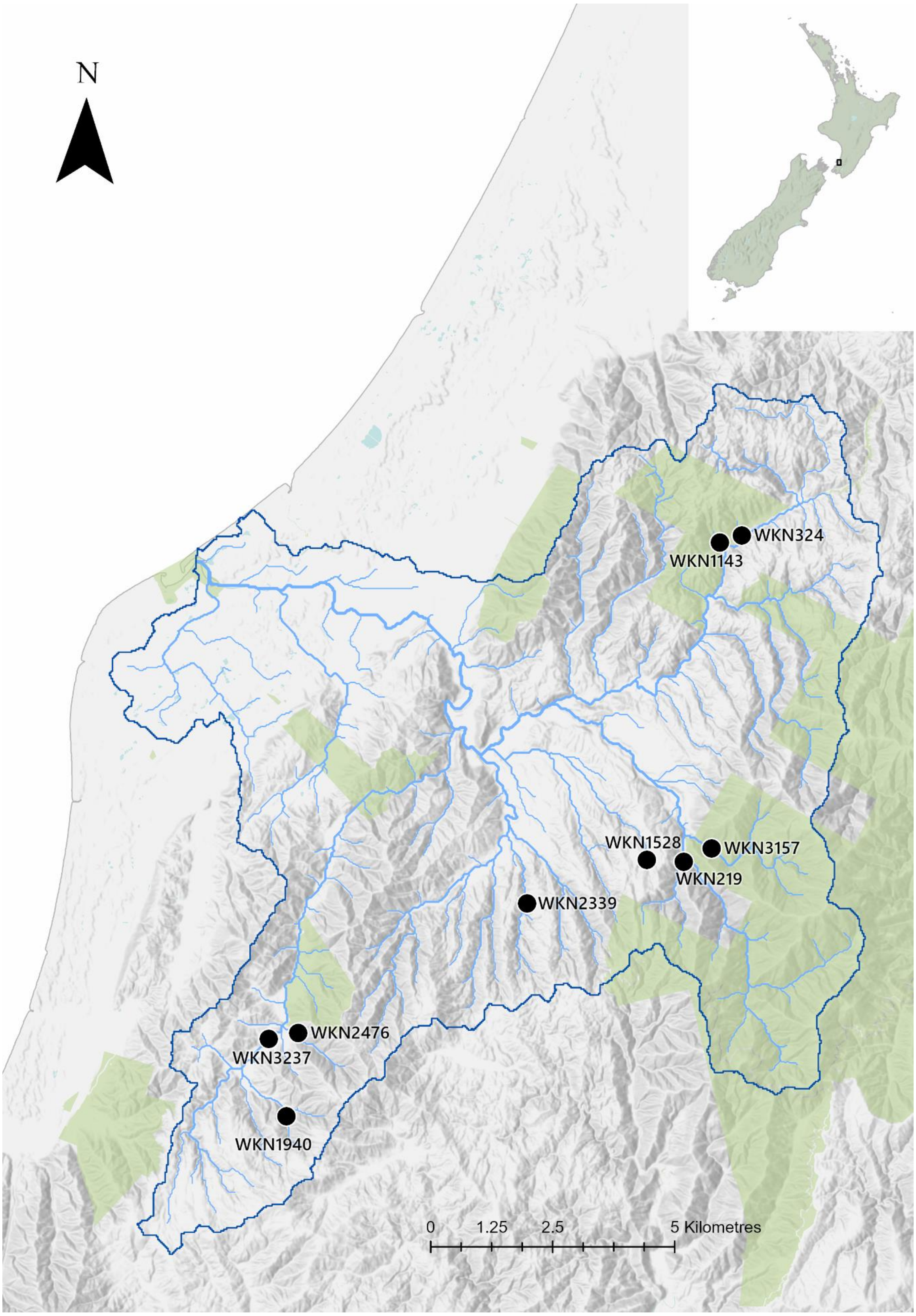

Figure 1. Map of sampling locations within the Waikanae catchment. Green areas indicate public conservation land. Basemaps generated by Eagle Technologies (2023), sourced from LINZ Data Service (2023) and licensed for reuse under CC BY 4.0.

2. ANALYTICAL APPROACH AND RESULTS

The analytical approach used closely followed the process taken by Kelly et al. (2023) for analysing data from the NFMP, involving three phases of aggregating and curating of the dataset, calculation of the relevant metrics and values, and analysis and plotting of the data. All data analysis steps were undertaken using the R programming language in the RStudio graphical user interface and coding was scripted using R-markdown. A summary of the information flow between stages is illustrated in Figure 2, and the specific package versions used are included in Appendix 2. The full outline of the analytical process followed is presented in Kelly et al. (2023).

ArcGIS Pro was used to create all maps in this report, using the datasets exported from the analytical pipeline outlined above.

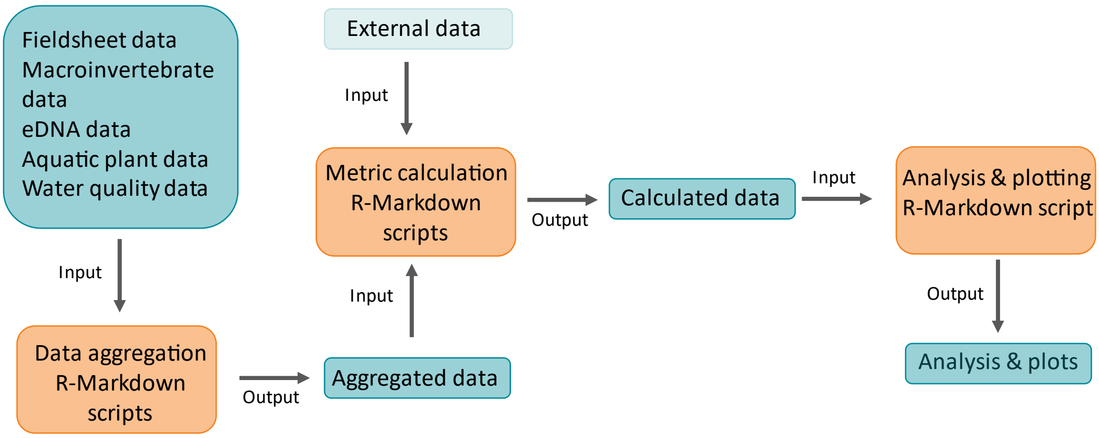

Figure 2. A conceptual overview of the flow of information and relationship between data files and analysis scripts.

3. AQUATIC LIFE

3.1. Fish

3.1.1. Metric calculation

Fish index of biotic integrity (F-IBI)

The F-IBI is one metric used to assess the overall fish communities in Aotearoa New Zealand (Joy and Death 2004). The F-IBI uses six attributes to assess the integrity of fish communities: number of native taxa present, number of native benthic pool-dwelling taxa, number of native benthic riffle-dwelling taxa, number of native pelagic pool-dwelling taxa, number of native intolerant taxa and proportion of native to non-native taxa. Low scores for the F-IBI indicate the absence (or lower diversity) of taxa that belong to these attributes, reflecting loss of biological integrity of the fish communities. This can be interpreted as the consequence of a lack of suitable habitat for those species or pollution reducing the number of pollution-intolerant taxa. For the purposes of the F-IBI calculations, trout are considered as 'native' species as they are indicators of good water quality.

Data from the Ministry for the Environment (MfE) F-IBI dataset (MfE 2019), including data from the New Zealand Freshwater Fish Database (NZFFD) on fish records nationally from 1998 to 2018, was downloaded for the construction of quantiles against which to score metrics. As distance inland and elevation are known variables that affect the composition of native fish communities, the reference dataset was used to regress each of the first five metrics against both distance inland and elevation (giving 10 regressions). Quantiles were calculated for each of the 10 regressions at the 33rd and 66th percentiles. Although the methods followed were those outlined by MfE (2019), some quantiles fell to zero for two of the metrics: number of pelagic pool species (both 33rd and 66th percentiles were zero) and number of intolerant species (33rd percentile was zero). This matches the experience of the Bay of Plenty Regional Council (BOPRC 2016), which similarly could not calculate quantiles using national-level data from the NZFFD, and previous experience with data from the NFMP (Kelly et al. 2023). Cross-checking the results of the calculations with the scores output from the MfE data indicated that the outcome was the same using their dataset, indicating the method may need refinement. The result is that the presence of any pelagic pool species results in the maximum score of 5, while for the intolerant species, scores were either 3 or 5.

To ensure consistency in scores and enable future comparison with new data, the dataset used to generate the species richness lines and subsequent quantiles was the same as that used by Statistics New Zealand in the 2018 update to the national picture of F-IBI scores. In addition, the same R script used to calculate F-IBI for the NFMP analyses (Kelly et al. 2023) was used here. The authors are aware that MfE has recently released an online F-IBI calculator through an R Shiny app.[1] However, there is potential that differences in how sites with no fish are treated could introduce artificial variation, thus we used the same method as the NFMP to ensure consistency among datasets.

Threat classes

For each individual fish recorded to species level, the New Zealand Threat Classification System (NZTCS) status and category were assigned. The proportion of individuals belonging to each of the NZTCS threat classes (Dunn et al. 2018) was then determined for the national dataset, and for each site. These data included both fish that were measured, and those identified to species level but not measured in the field data.

Environmental DNA (eDNA)

Environmental DNA metabarcoding is the term used for a method of collecting DNA from an environmental sample rather than from the organism itself. This DNA is then amplified and the resulting sequences are attributed to specific organisms based on their similarity to reference sequences. Environmental DNA metabarcoding data consisted of taxon names and read numbers for replicate samples collected per site at the time of sampling. Environmental DNA metabarcoding can be prone to sequencing error, contamination and tag-jumping, which may result in sequences appearing in samples erroneously. Generally, such errors result in sporadic detections of sequences with low read numbers. To reduce the risk of this, all eDNA data were subject to a data-filtering step commonly undertaken when working with eDNA metabarcoding data to reduce the potential for errors in the final data (Pearman et al. 2023). The filtering steps required a taxon to be present in at least two replicate samples and with a minimum of 20 reads in each of those to be recorded as present, or, if a taxon was present in a single sample, it needed at least 100 reads to be considered present. These are very permissive rules in the context of typical bioinformatic data-filtering protocols.

Environmental DNA glossary

Amplicons are short pieces of an organism's genome that have been amplified to a measurable amount by PCR.

Metabarcoding is using PCR to amplify a region of the genome to produce amplicons that will distinguish each taxon in a community.

Multiplexing is when a unique sequence (tag) is added to the PCR, and then multiple samples are combined and sequenced together.

PCR is polymerase chain reaction, a method of multiplying a piece of an organism's genome to a measurable amount.

Reads / read numbers are the number of times a sequence is detected in a sample.

Sequencing errors are mistakes in the sequence that occur during the laboratory PCR and sequencing steps of eDNA metabarcoding.

Tag-jumping is the process when the unique identifying tag in a multiplexed reaction is incorporated onto a sequence from a different sample.

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[1] https://mfenz.shinyapps.io/fish-ibi-calculator

Following the filtering steps, the presence of the fish taxa for both electric fishing data and eDNA data was filtered to remove genus-level results if a species for that genus was recorded at that site. If no species-level results were recorded for the site, then the genus-level result was retained in the dataset. This was to avoid artificially inflating species richness estimates due to missed fish in the case of electric fishing, or insufficient taxonomic resolution in the case of eDNA data.

Finally, the fish communities found at each site by each method were compared to generate lists of taxa found only with electric fishing and only with eDNA, and taxa found with both methods.

3.1.2. Catchment state

Species present

Eight fish taxa were physically caught and identified in the Waikanae catchment. Six fish taxa were caught using electric fishing and identified to species level, including banded kōkopu (*Galaxias fasciatus*), brown trout (*Salmo trutta*), dwarf galaxias (*Galaxias divergens*), kōaro (*Galaxias brevipinnis*), longfin eel (*Anguilla dieffenbachii*), redfin bully (*Gobiomorphus huttoni*), shortjaw kōkopu (*Galaxias postvectis*) and torrentfish (*Cheimarrichthys* fosteri). Further individuals of *Anguilla* spp., *Galaxias* sp. and *Gobiomorphus* sp. could not be identified to species level. In general, the number of species detected at each site increased with increasing stream size (Figure 4). It is likely that some migratory species were not found in low-order tributaries due to either natural fish passage barriers or unsuitable habitat conditions. Kōaro and longfin eel were the most widely distributed species among the sites, which likely reflects their excellent climbing abilities.

Shortfin eel (*Anguilla australis*) was the only additional species detected using eDNA and not caught using electric fishing. A full table of the fish found at each site using all methods is presented in Appendix 3. Environmental DNA picked up the majority of species present; however, even following best-practice guidelines (six replicate samples), some species (e.g. torrentfish and shortjaw kōkopu) were not detected at some sites even when they were caught using electric fishing. This reinforces the need to consider eDNA as one tool in the toolbox and highlights that there are questions associated with detection probabilities and DNA transport that are yet to be fully assessed.

Fish lengths

For fish taxa where more than 15 individuals were caught across all sites, fish length distribution was plotted and compared with the national records from the NZFFD. No lengths outside of the minimum and maximum lengths recorded for each species in the NZFFD were observed. Plots showing the distribution of data compared with the NZFFD are presented in Appendix 4.

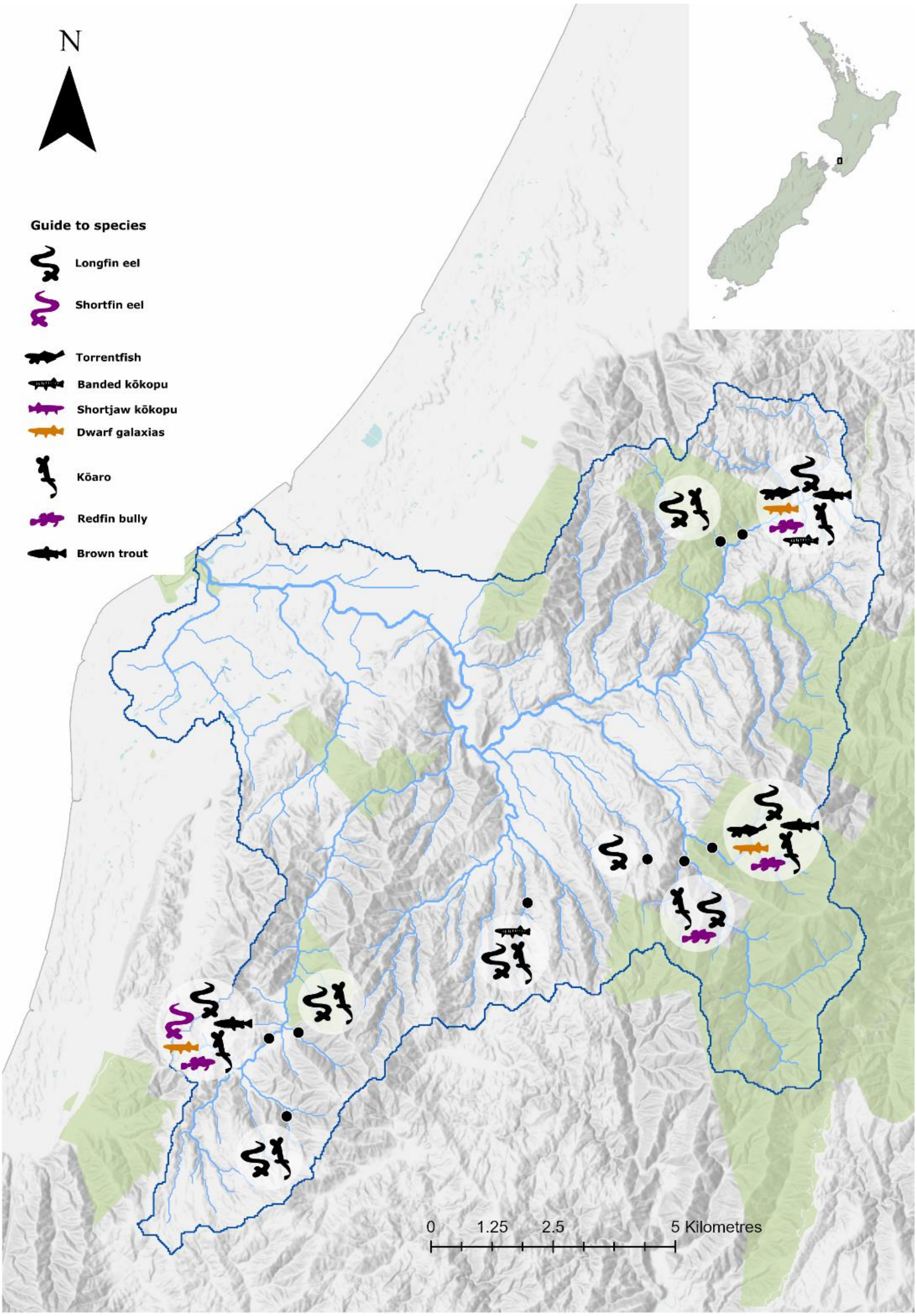


Figure 3. Sites where fish species were found within the Waikanae catchment (all detection methods). Basemaps generated by Eagle Technologies (2023), sourced from LINZ Data Service (2023) and licensed for reuse under CC BY 4.0. See Appendix 3 for a full table of the species found at each site.

Threat classes

Of the fish detected in the Waikanae catchment, shortjaw kōkopu are classified as Threatened and Nationally Vulnerable. Dwarf galaxias, kōaro, longfin eel and torrentfish are classified as At Risk and Declining. All other fish species found are listed as Not Threatened.

F-IBI

Scores for the F-IBI ranged from a maximum of 60 to a minimum of 22 (out of a possible maximum score of 60), with all but one site meeting the threshold for the NPS-FM A band (Figure 3). Site WKN1528 fell into the C band, indicating a low fish community integrity due poor habitat condition or lack of fish passage. All sites could be sampled using electric fishing and fish were caught at all nine sites.

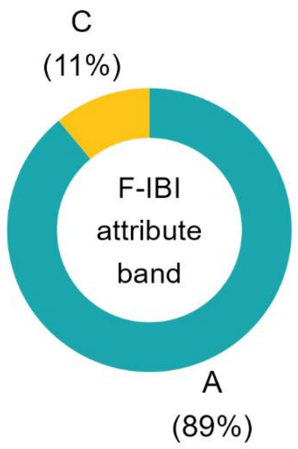


Figure 4. Proportion of sites in each NPS-FM attribute band for the Fish Index of Biotic Integrity (F-IBI).

3.2. Macroinvertebrates

3.2.1. Metric calculation

Metrics calculated to assess macroinvertebrate diversity and communities included the Macroinvertebrate Community Index (MCI), Quantitative MCI (QMCI), percentage of Ephemeroptera, Plecoptera and Trichoptera by taxa richness (%EPT), and average score per metric (ASPM). The calculation of MCI, QMCI and ASPM followed the methods set out in the NEMS Macroinvertebrates (National Environmental Monitoring Standards Working Group 2022), with tolerance scores taken solely from Clapcott et al. (2017) to align with the requirements of the NPS-FM 2020 and follow nationally consistent practices. This ensures that MCI, QMCI and ASPM calculations use the same reference values employed nationally and so are comparable to other datasets.

As specified by the field sheets, hard-bottomed tolerance scores were used for metric calculations for all sites.

In calculating MCI and QMCI, multiple macroinvertebrate taxa could not be assigned tolerance scores. This was primarily because the taxa could not be identified to a high enough taxonomic resolution, likely due to early-instar individuals being collected in macroinvertebrate samples. For hard-bottomed sites, the taxa that could not be assigned tolerance scores were Hydrobiosidae, Hydropsychidae and Leptoceridae (all caddisfly families), and Gripopterygidae (a stonefly family). The omission of these taxa may have affected metric values, but there is no suitable method to allocate tolerance scores where specimens cannot be identified to a sufficient resolution or no tolerance scores exist. The approach taken follows national convention for calculating macroinvertebrate metrics.

Other metrics calculated were taxa richness, the number of taxa found, the proportion of exotic species and the proportion of taxa within each conservation category / status. The number of taxa included the total number of taxa present at each site, irrespective of the identification level reached. Information on macroinvertebrate conservation category / status was taken from the NZTCS database,[2] primarily based on the Grainger et al. (2018) assessment. The presence of any potential pest macroinvertebrate species was assessed by comparing the taxon found to species designated as pest species by NIWA (2020).

3.2.2. Catchment state

Macroinvertebrate diversity metrics

A total of 90 individual taxa were identified across the nine sites sampled, and macroinvertebrate diversity metrics could be calculated for all sites. The taxon count for each site ranged from 24 to 43 taxa, while MCI values ranged from 127 to 140, QMCI values ranged from 6.04 to 7.68, ASPM ranged from 0.64 to 0.75, and %EPT ranged from 59.1% to 64.3% (Table 1, Figure 5). The variation in macroinvertebrate diversity metrics differed between metrics, and lower diversity at some sites did not result in lower MCI / QMCI scores. While metrics are related, each indicates different characteristics of macroinvertebrate communities – e.g. taxa richness indicates the diversity present at a site, while MCI / QMCI score indicates the tolerance of the macroinvertebrate community present.

[2] https://nztcs.org.nz

Table 1. Macroinvertebrate metrics calculated for all monitoring sites. Average score per metric (ASPM) is the normalised average of MCI, %EPT and EPT richness.

Site identifier	MCI score	QMCI score	Number of EPT taxa	Percentage of EPT taxa	ASPM	Number of taxa
WKN1143	138	6.04	20	60.61	0.69	38
WKN1528	140	6.65	18	62.07	0.70	32
WKN1940	131	7.32	13	59.09	0.65	24
WKN219	139	6.84	19	63.33	0.70	31
WKN2339	138	6.67	21	63.64	0.69	39
WKN2476	139	6.94	18	64.29	0.70	33
WKN3157	149	7.27	19	63.33	0.75	32
WKN3237	129	6.59	24	63.16	0.64	43
WKN324	127	7.68	19	63.33	0.64	31

When interpreted using the NPS-FM attribute bands to relate macroinvertebrate diversity metrics to ecological conditions, seven sites met the MCI threshold of 130 for A band, indicative of pristine or reference conditions, while two sites fell into the B band, indicating good conditions. A similar spread of results was observed for QMCI, with eight sites meeting the threshold for A band and one site falling into B band. For ASPM, all nine sites met the threshold for A band (Figure 6).

Threat category and status

Only 41% of taxa found could be assigned to an NZTCS threat category and status. Of the taxa that could be assigned, only one At Risk taxon was found. The dragonfly *Antipodochlora braueri* is listed as At Risk: Naturally Uncommon, and was found only at WKN3237.

Pest species

No macroinvertebrate pest species were found at any sites.

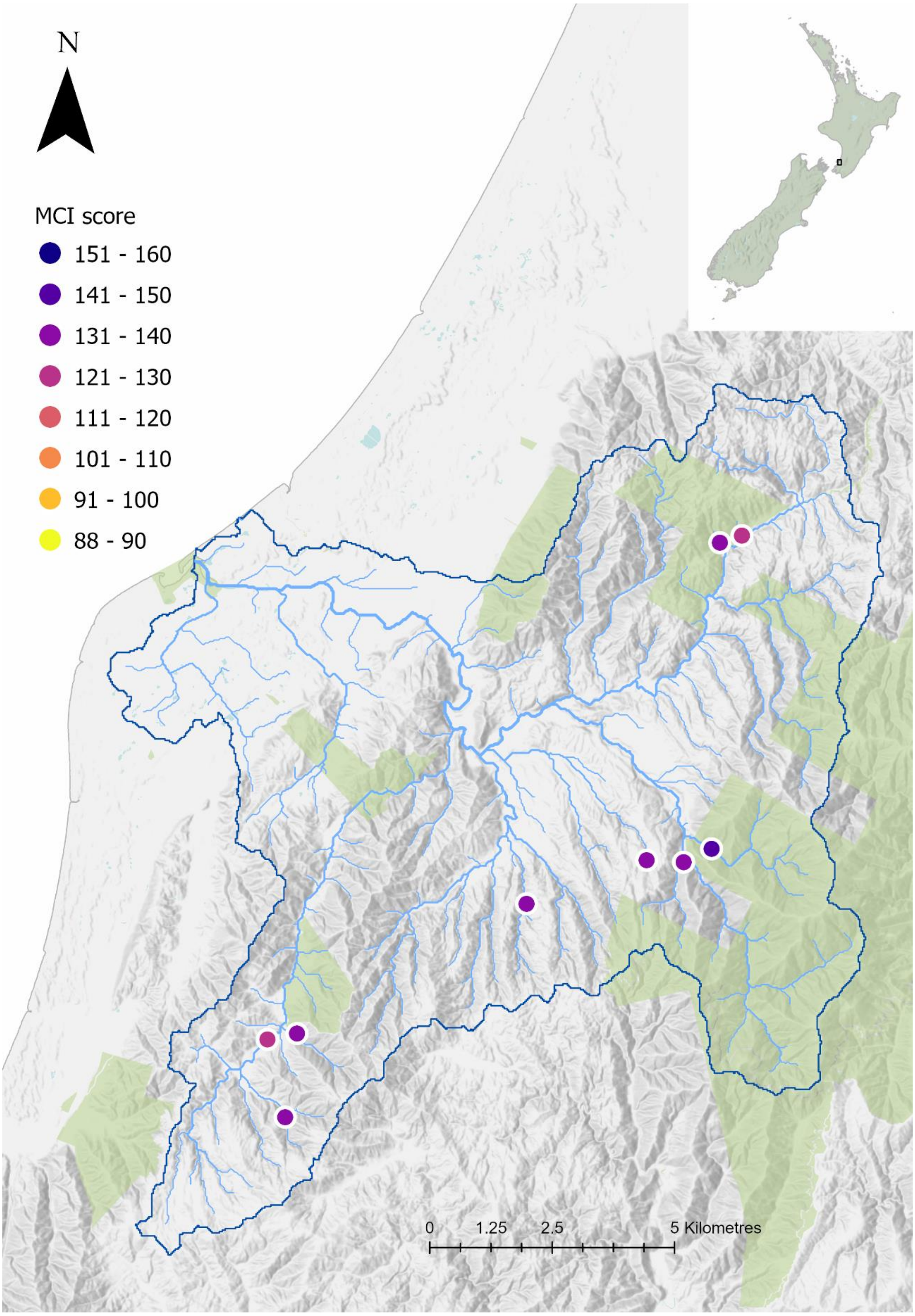


Figure 5. Map of Macroinvertebrate Community Index values across the Waikanae catchment. Basemaps generated by Eagle Technologies (2023), sourced from LINZ Data Service (2023) and licensed for reuse under CC BY 4.0.

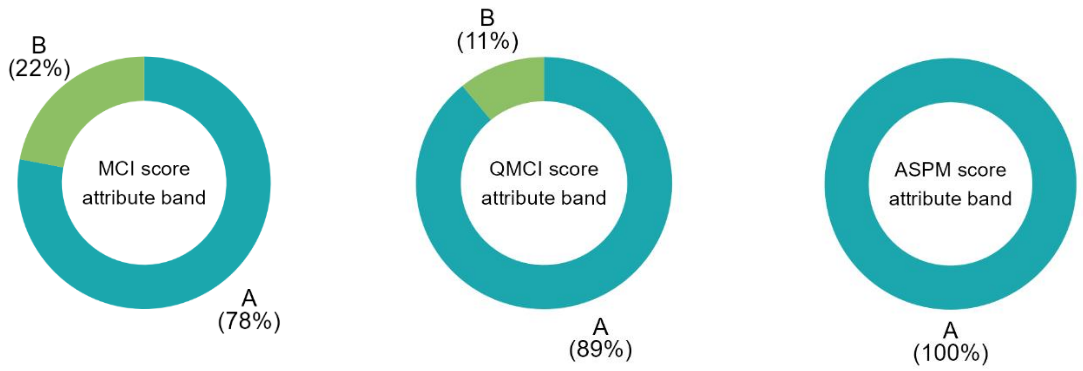


Figure 6. Proportion of sites in each NPS-FM attribute band for Macroinvertebrate Community Index (MCI), Quantitative Macroinvertebrate Community Index (QMCI) and average score per metric (ASPM).

3.3. Megainvertebrates

3.3.1. Metric calculation

The data relating to the detection of megainvertebrates were collated to determine where crabs, kōura, mussels or shrimp were present. These data comprised information from mussel surveys, electric fishing and records of megainvertebrates removed from macroinvertebrate samples.

As with the analyses of the NFMP data (Kelly et al. 2023), we note that information about the presence of megainvertebrates at a site is compiled from information gathered during multiple protocols. Given the potential for inconsistencies in the recording of megainvertebrates in the field data sheets and among field teams, it would be beneficial to apply a specific megainvertebrate protocol if information on megainvertebrate presence or abundance is of interest.

3.3.2. Catchment state

Mussel surveys were not conducted at any sites. Kōura (*Paranephrops planifrons*) were found at six of the nine sites during electric fishing.

3.4. Aquatic plants

Aquatic plants sampled as part of the Ngā Awa monitoring programme included macrophytes and bryophytes (liverworts, hornworts and mosses). Where these plants were present in the periphyton transects, samples were collected to enable taxonomic identification.

3.4.1. Metric calculation

Results for bryophytes are presented as presence–absence data, with accompanying threat classifications from the NZTCS, primarily based on the de Lange et al. (2020) assessment.

There are presently no national standards for macrophytes or bryophytes in Aotearoa New Zealand rivers. Matheson et al. (2012) suggested that, in the absence of guidelines for aquatic plants in rivers, percentage cover of the streambed by surface-growing plants and percentage cross-sectional area volume (CAV) of macrophytes should be less than 50% to avoid adverse ecological effects.

3.4.2. Catchment state

Presence of bryophytes and macrophytes

No bryophytes or macrophytes were recorded at the sites surveyed in the Waikanae catchment.

3.5. Periphyton

3.5.1. Metric calculation

The periphyton cover was calculated as the average cover of each periphyton type across all the views in the periphyton surveys. Periphyton biomass was assessed at all nine sites and was supplied in the Hills Laboratory data files as chlorophyll-*a* per square metre sampled, calculated from the analyses of rock scrapings.

3.5.2. Catchment state

Periphyton cover

No sites exceeded 30% of long filament (> 2 cm) cover or more than 60% of thick (> 3 mm) benthic mats (Figure 7), which are thresholds associated with adverse effects on benthic macroinvertebrate communities (Biggs 2000). Bare substrate comprised a large proportion of the benthos at many sites, although three sites were dominated by thin mats and films.

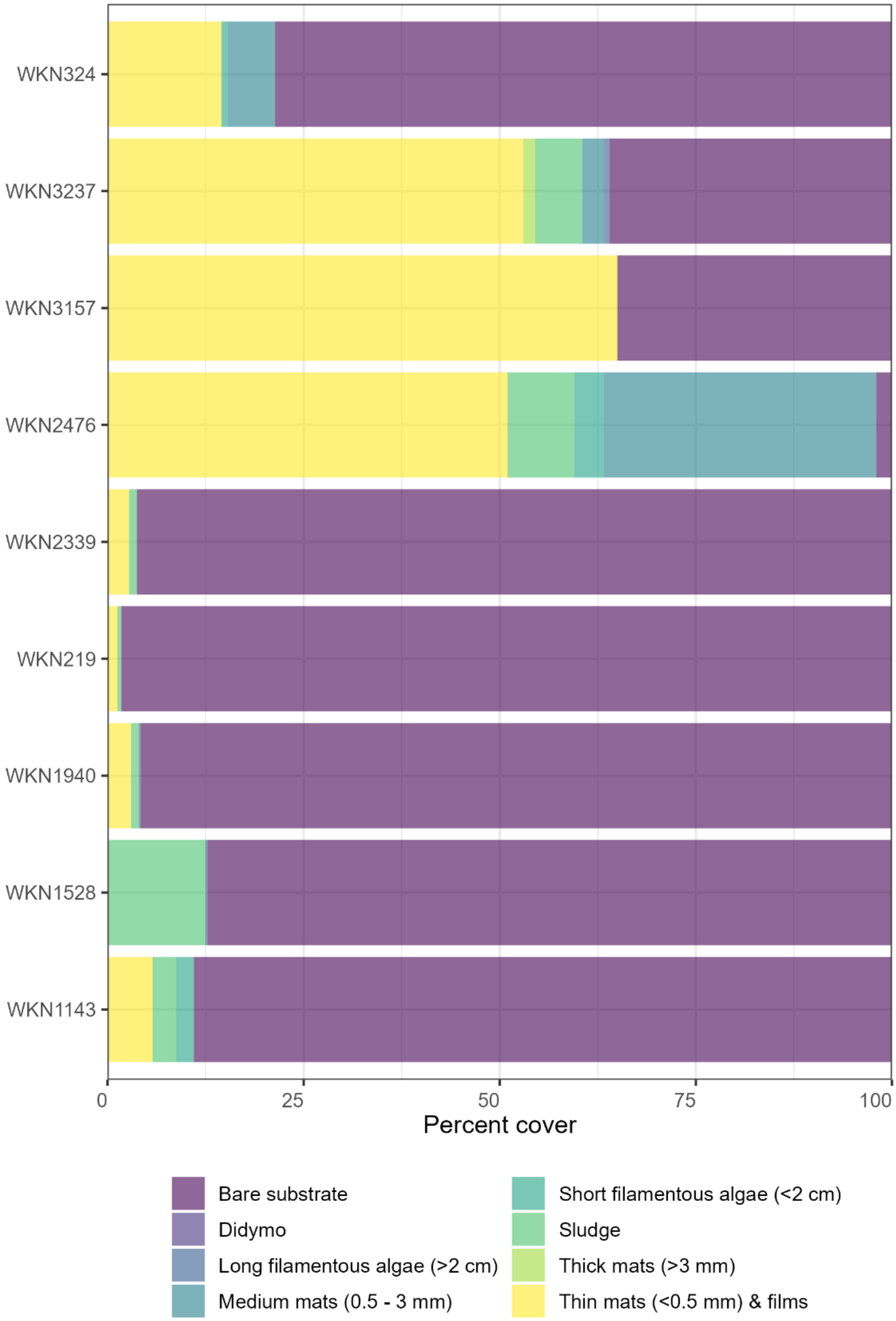


Figure 7. Periphyton cover by type for each site. Mats included green, brown, diatom and cyanobacterial mats.

Periphyton biomass

The periphyton biomass recorded was variable (mean = 41.1 mg/m^2, minimum = 5.8 mg/m^2, maximum = 164 mg/m^2), indicating low growth rates and accumulation at many sites within the catchment, but up to four times greater growth and accumulation at other sites. While eight sites were below the A band threshold in the NPS-FM and the chlorophyll-*a* concentrations that are estimated to adversely affect benthic communities (Biggs 2000; Biggs and Kilroy 2000), three of these sites were approaching the threshold value. The remaining site fell within the C band, indicative of moderate nutrient enrichment or flow regime alteration. Occasional elevations in periphyton biomass are part of the natural variability within these ecosystems and can occur even in low-nutrient streams when prolonged stable flow conditions supply a constant source of nutrients (Wilcock et al. 2007). These results indicate that there is a potential for periphyton biomass to approach levels that could impact the biotic communities. Interpreting these results in concert with the other metrics assessed at the sites could help contextualise these impacts, although no impacts on the biotic communities present were evident from the data collected. If concern remains, more intensive or regular sampling in summer months would be recommended. Generally, these results indicate that while most of the sampled streams had low primary production, increased periphyton biomass may be a concern at some sites.

3.6. Taxon-Independent Community Index

The Taxon-Independent Community Index (TICI) is an ecosystem health metric developed by Wilderlab NZ Ltd (Wellington, New Zealand). The TICI was developed by relating eDNA metabarcoding data from 40 rivers to MCI scores for those sites[3]. The Wilderlab website notes, ‘The TICI is still in development and should be interpreted as an experimental tool at this stage’. The Ngā Awa samples were assessed using the Riverine V1 version of the TICI index.

In the Waikanae catchment, seven sites yielded a TICI score with the Wilderlab rating of ‘Pristine’, with the remaining two sites rated as ‘Excellent’ (Table 2). The ranking of these sites matches the expectations based on MCI and other variables, although the relationship between MCI and TICI scores is not linear (Figure 8). The TICI index result provided is solely numeric (with a text qualifier for the state) and based on scores related to the presence of certain amplicon sequence variants (ASV). As the scores associated with each ASV are unknown, the index operates like a black box, making it impossible for users of the data to investigate why sites have been given unexpectedly low scores that are not explained by any other variables at those sites.

[3] https://www.wilderlab.co.nz/tici

Table 2. Median Taxon-Independent Community Index (TICI) values for all monitoring sites. Scores calculated from individual replicates, the number of sequences included and the degree of reliability stated by Wilderlab are included in Appendix 5.

Site identifier	Median TICI value	TICI rating
WKN1143	128	Pristine
WKN1528	127	Pristine
WKN1940	127	Pristine
WKN219	125	Pristine
WKN2339	121	Pristine
WKN2476	128	Pristine
WKN3157	128	Pristine
WKN3237	113	Excellent
WKN324	118	Excellent

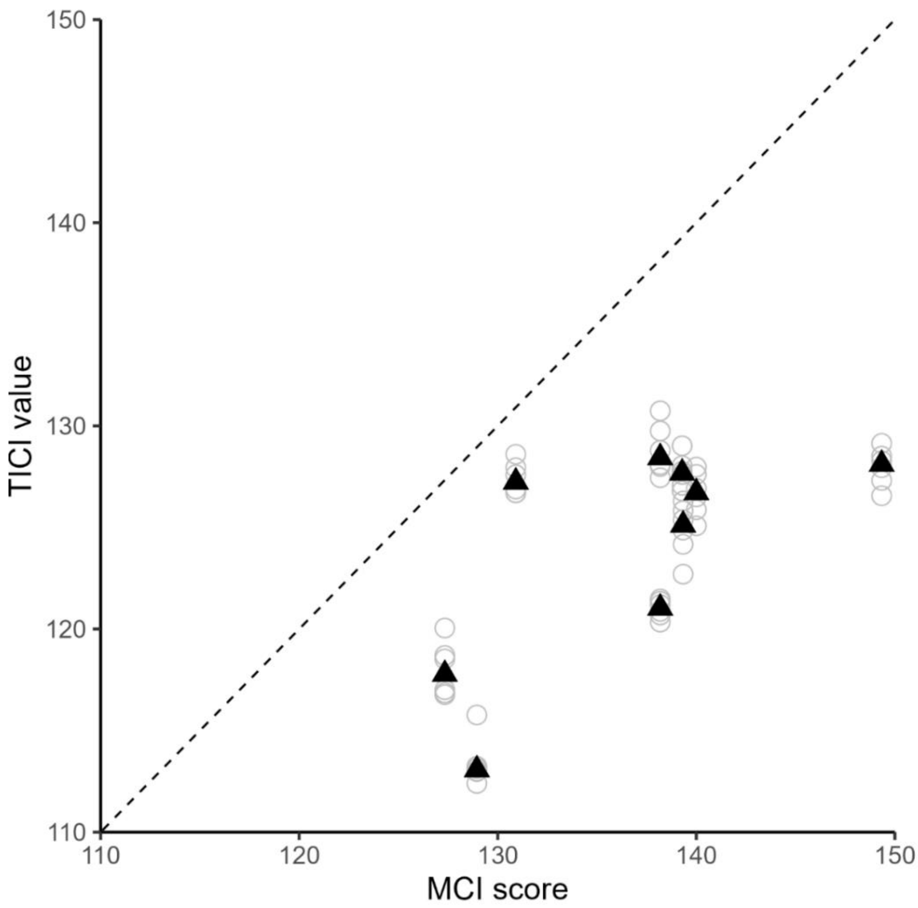


Figure 8. Taxon-Independent Community Index (TICI) scores plotted against Macroinvertebrate Community Index (MCI) scores for each site. Filled triangles are median TICI values for each site, while open circles are individual TICI values from each replicate. The dashed line is a 1-to-1 regression line to provide context when interpreting the plot.

Although there is a strong linear relationship between the TICI and 5-year median MCI score for the sites used in the development of the index, this relationship was not as clear in the samples from Waikanae (Figure 8). The interpretation of the MCI metric is aided by its long history of use (> 30 years) and that it was developed specifically to reflect pressures from organic enrichment on macroinvertebrate communities (Stark 1985; Stark and Maxted 2007). As the TICI has, to the best of our knowledge, been developed by calibrating scores to MCI scores rather than drivers or pressures, it cannot be considered equivalent for the purpose of interpretation. In addition, although the TICI is taxon-independent in its development, the presence of non-aquatic taxa in the indicator dataset means that the index conflates in-stream responses with potential drivers (e.g. from land use) and the implication of this on interpreting the results requires more investigation. A further consideration is that sampling approaches used for eDNA rely on water samples. The eDNA in these water samples could have originated many kilometres upstream and may not reflect the conditions at the site. In contrast, the macroinvertebrates collected for the MCI are presumed to mostly live at the site.

Across all the samples, a reliability score is assigned by Wilderlab (Appendix 5). A threshold of 250 sequences is used by Wilderlab to denote a 'highly reliable' score. This is an extremely low number of sequences in contrast with other eDNA metabarcoding-based indices available in Aotearoa New Zealand – for example, the Lake Health Index (Pearman et al. 2022) and Benthic Fish Farm Index (Pochon et al. 2020; Pochon et al. 2021) – and raises questions about the robustness of the method. This is likely the result of the degree of multiplexing by Wilderlab to include a broad range of different taxonomic groups in a single sequencing run. To enable robust assessment of the reliability of the index score and to aid interpretation of the results, both the number of indicator ASVs and the total number of sequences belonging to those ASVs need to be included.

4. HABITAT

4.1. Meso-habitat

Hydrological diversity provides an indication of the variety of flow habitats available at a site (referred to here as meso-habitats). Generally, the greater the meso-habitat heterogeneity (the more habitat types), the more potential for species diversity because differing habitat preferences are catered for. A wide variety of meso-habitat types were available across sites in the Waikanae catchment, with all sites having three or more meso-habitat types (Figure 9). Runs and riffles were the most common dominant habitat type; however, cascades were also a notable habitat at some sites.

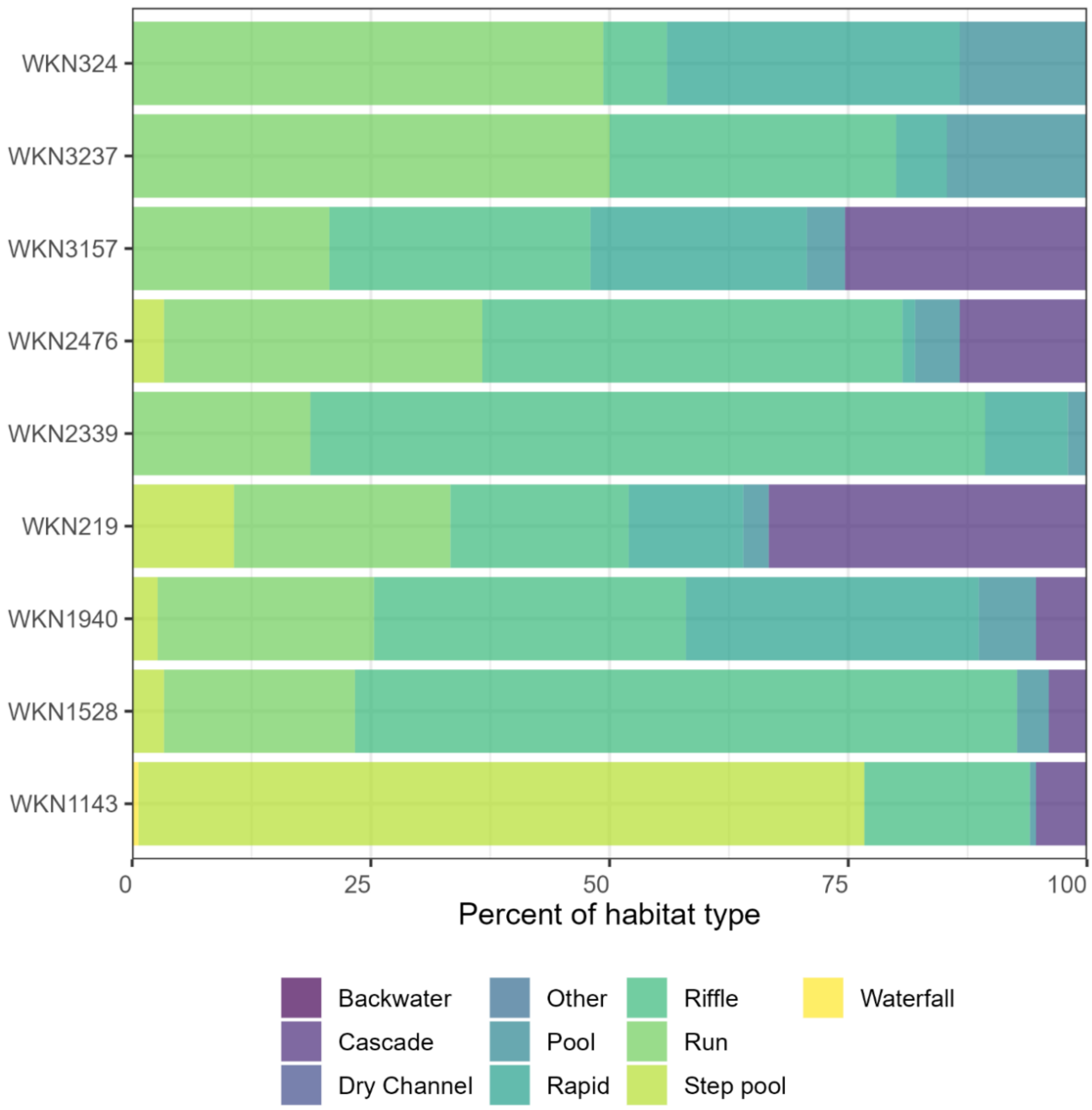


Figure 9. Meso-habitat diversity as a percentage of the 150 m stream length. The higher the number of types represented, the more diverse the habitat at the site.

4.2. Discharge

Stream discharge is calculated from the cross-sectional area of the stream and the mean velocity measurement (taken at 0.6 × the water depth). Taken by itself, this is a descriptive measure of the site at the time of sampling and will be highly influenced by preceding rainfall conditions in the catchment.

All survey sites had low discharge at the time of sampling, with the greatest recorded discharge being 0.22 m^3/s at WKN324 (Figure 10).

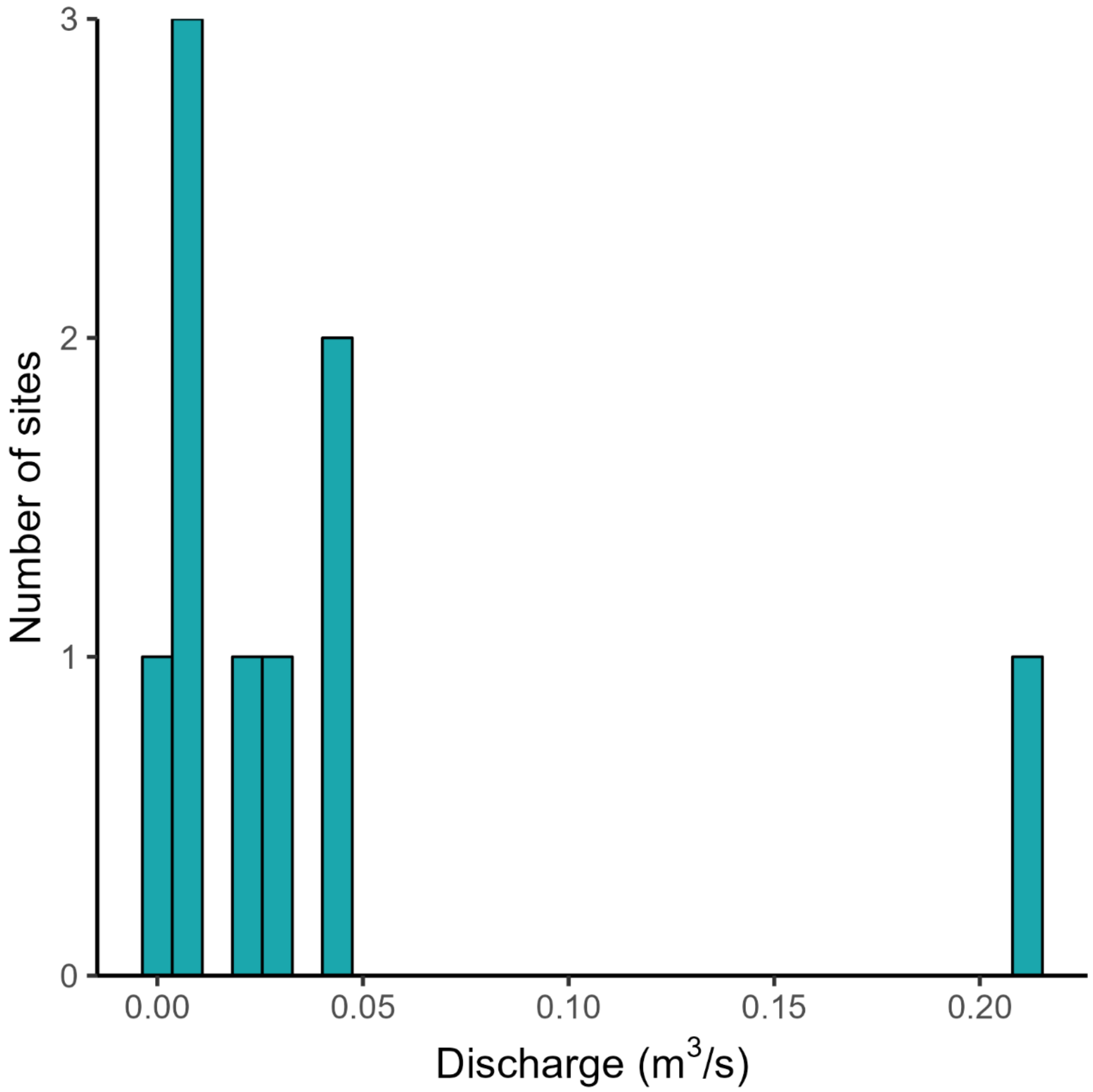


Figure 10. The range of discharge rates in cubic metres per second among sites sampled.

4.3. Substrate stability

The Pfankuch index of substrate stability (Pfankuch 1975) is a measure of the ability of a reach to resist the mobilisation of streambed and streambank materials under variable flow conditions. In Aotearoa New Zealand and overseas, the stability of a reach has been correlated with periphyton biomass (Death 1991) and the taxonomic richness and density of macroinvertebrates (Rounick and Winterbourn 1982; Collier et al. 1993). In Aotearoa New Zealand, it is also associated with habitat quality for *Hymenolaimus malacorhynchos* (blue duck / whio) (Collier et al. 1993). The index comprises a range of factors relating to the upper banks, lower banks and streambed of the site. Collier et al. (1993) provides an excellent introduction to scoring the index in an Aotearoa New Zealand context, with explanatory notes for each scoring category.

Recently, the Pfankuch index has been applied by various regional councils in Aotearoa New Zealand. This has resulted in the Pfankuch score being categorised into broad stream stability bands, representing very high stability (scores < 38), high stability (39–76), moderate stability (77–114) and low stability (> 115) (NRC 2011). It has been suggested that the association between benthic macroinvertebrate communities and Pfankuch index scores is stronger when considering only the streambed component of the index (Death and Winterbourn 1994).

The Pfankuch index demonstrated that most sites were highly stable, with one being moderately stable (WKN1528).

4.4. Deposited sediment and substrate heterogeneity

4.4.1. Fine sediment cover

High levels of fine sediment cover can impact the habitat quality of cobble-bedded rivers for macroinvertebrates and fish. The sediment fills interstitial spaces (the gaps between rocks), reducing habitat availability and refugia for both macroinvertebrates and fish (Clapcott et al. 2011).

Fine sediment cover was low at all sites, with all but one site recorded as having no fine sediment cover (minimum = 0 %, mean = 0.80 %, maximum = 1.75 %). The only site where fine sediment cover was recorded was WKN1528, with 1.75% cover. WKN1528 was also the site recorded as having moderate stability using in the Pfankuch index.

4.4.2. Substrate heterogeneity

The Wolman pebble count (method SAM-3) is a component of the sediment assessment protocols (Clapcott et al. 2011). The purpose of the metric is to quantify the contribution of different size classes of substrate to the overall substrate composition at a site. Like the other sediment assessment metrics, this protocol is intended for use at hard-bottomed sites. In particular, the Wolman pebble count is intended to quantify the percentage of fine sediment relative to guideline values for the preservation of instream values of biodiversity and salmonid spawning habitat. The guideline values for preservation of biodiversity are less than 20% of the substrate as fine sediment or within 10% of a reference condition. For salmonid spawning habitat, the guideline value is less than 20% of substrate composition as fine sediment. There were no sites where fine sediment exceeded 20% of the substrate composition (Figure 11).

Although metrics such as the dominant size class and some indices of substrate diversity can be calculated from the Wolman pebble count data, these are largely habitat descriptors for the sites. There are no anticipated ecological relationships between macroinvertebrate communities based on these metrics, beyond the known relationships between fine sediment and macroinvertebrate and fish communities.

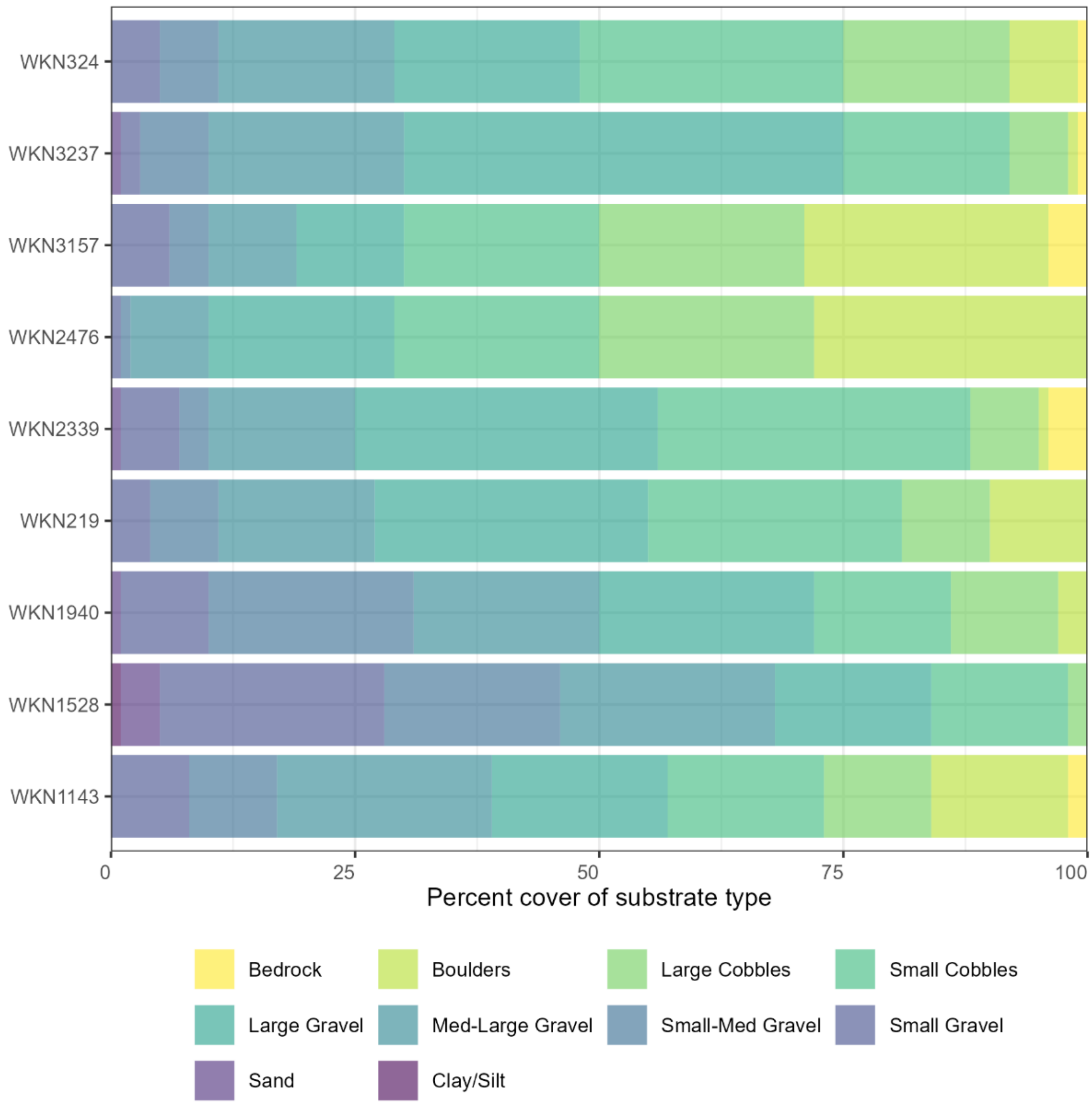


Figure 11. Substrate composition from the Wolman pebble count (SAM-3) assessment. Sand and clay / silt are considered fine sediment using this method. Note that no Wolman pebble count was conducted at the two soft-bottomed sites.

4.4.3. Pesticides

Sediment samples could be collected from five sites, and sediment was tested for a range of pesticide residues by Hills Laboratories (including acid herbicides, multiresidue pesticides and organochlorine pesticides). All samples were below detection limits for all pesticides tested.

5. WATER QUALITY

5.1. Visual clarity

Visual clarity was assessed using black disc measurements at six sites (Figure 12). Of these six sites, a maximum observable clarity distance was measured for four sites as the habitat available for black disc measurements was not long enough to get a reading (WKN1143, WKN2339, WKN2476 and WKN3157). For the two sites where a complete black disc reading was collected (WKN324 and WKN3237), one site met the requirement for A band for visual clarity based on its suspended sediment class in the NPS-FM, while the other fell in the C band (indicating a moderate to high impact from suspended sediment). For the four sites where a maximum observable clarity distance was measured, two sites met the requirement for A band for visual clarity based on their suspended sediment class in the NPS-FM, and the remaining two fell into D band (although it was noted that maximum observable distance was an underestimate due to the available length of habitat). The remaining three sites were too shallow to collect any black disc measurements. Given that complete black disc readings were collected at only two sites, there is insufficient information to draw conclusions regarding how the amount of suspended sediment in the water column varies across the catchment.

Turbidity (field measurements) was low across all sites, with a mean of 0.65 FNU and a median of 0.56 FNU. The maximum turbidity value was 2.16 FNU at WKN2339.

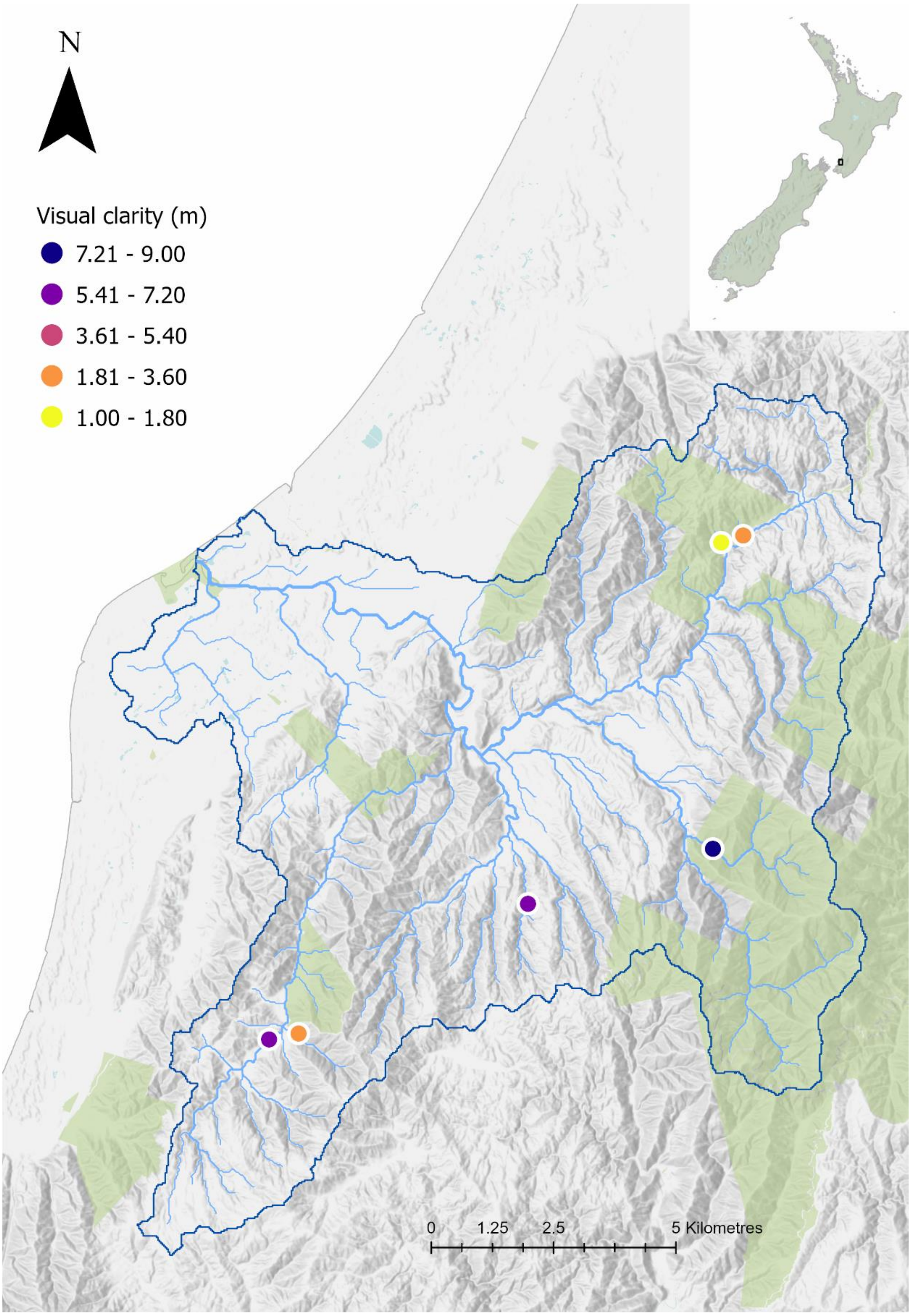


Figure 12. Visual clarity readings across the Waikanae catchment presenting black disc readings or maximum observable clarity for sites where the habitat available prevented a black disc reading from being taken. Basemaps generated by Eagle Technologies (2023), sourced from LINZ Data Service (2023) and licensed for reuse under CC BY 4.0.

5.2. Nutrient concentrations

5.2.1. Dissolved reactive phosphorus

Concentrations of dissolved reactive phosphorus (DRP) ranged from 0.004 g/m^3 to 0.018 g/m^3, with concentrations for two samples below the laboratory detection limit (Figure 13, Table 3). When compared to the NPS-FM attribute bands for DRP (which assess median concentrations over 5 years of monthly samples), six sites met the threshold for A band, indicating pristine conditions. The remaining three sites corresponded to C band, suggesting moderate DRP elevation.

5.2.2. Nitrogen

Concentrations of nitrate-N ranged from 0.004 g/m^3 to 0.21 g/m^3, with five samples below detection limits (Figure 14, Table 3). The observed concentrations of nitrate-N were well below the threshold for the nitrate (toxicity) A band in the NPS-FM, although bands are assessed using annual medians from monthly samples. Concentrations of total ammoniacal nitrogen and nitrite-N were below detection limits for all but one site, which had a nitrite-N concentration of 0.005 g/m^3. This indicates that dissolved inorganic nitrogen within the catchment consists primarily of nitrate-N.

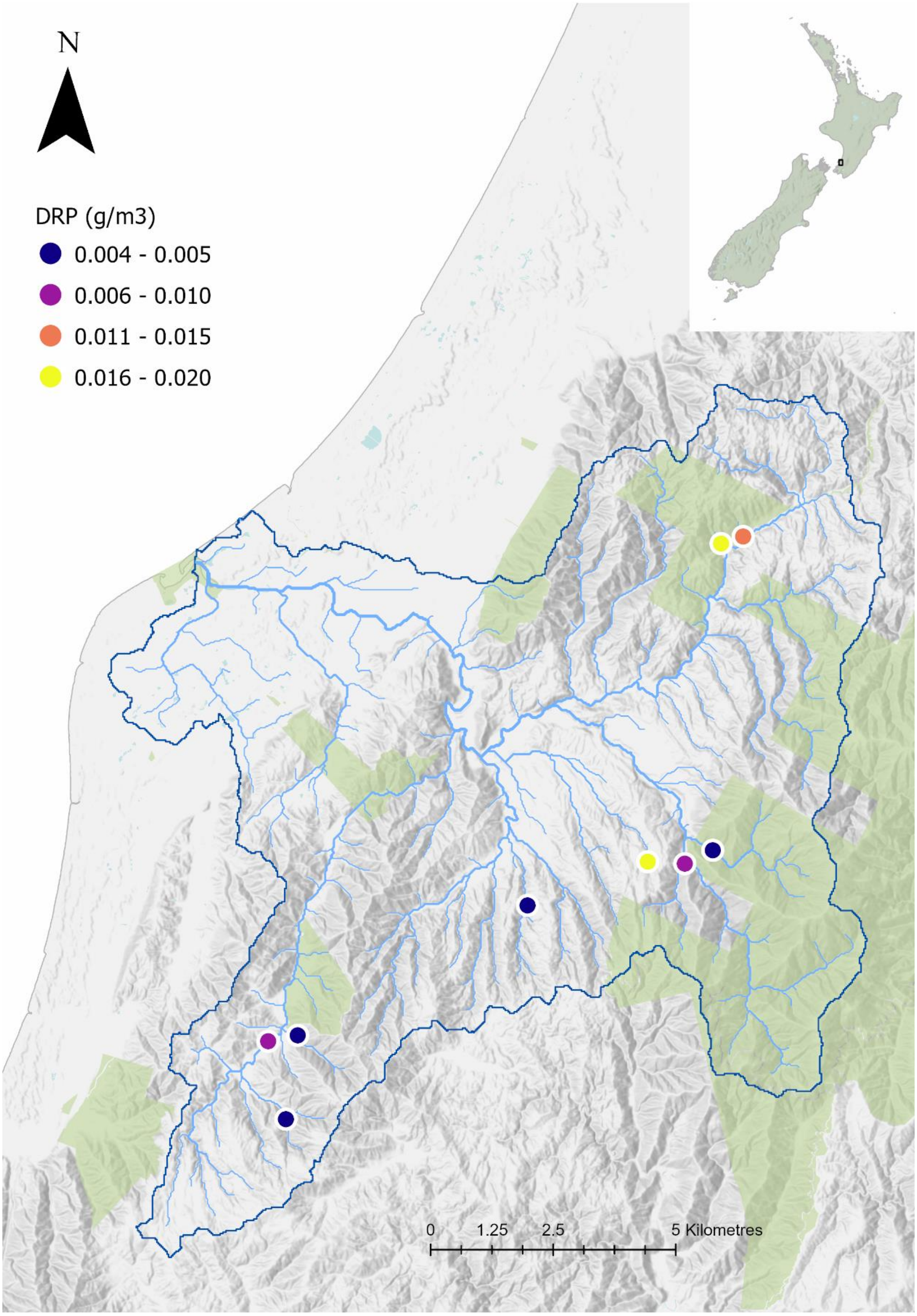


Figure 13. Dissolved reactive phosphorus (DRP) concentrations across the Waikanae catchment. Basemaps generated by Eagle Technologies (2023), sourced from LINZ Data Service (2023) and licensed for reuse under CC BY 4.0.

Table 3. Nutrient concentrations recorded for all sites.

Site identifier	Total nitrogen (g/m^3)	Total ammoniacal-N (g/m^3)	Nitrite-N (g/m^3)	Nitrate-N (g/m^3)	Nitrate-nitrite (g/m^3)	Total Kjeldahl nitrogen (g/m^3)	Dissolved reactive phosphorus (g/m^3)	Total phosphorus (g/m^3)
WKN1143	0.24	< 0.01	< 0.002	0.196	0.196	< 0.1	0.018	0.021
WKN1528	0.11	< 0.01	< 0.002	0.066	0.068	< 0.1	0.016	0.018
WKN1940	< 0.11	< 0.01	< 0.002	0.004	0.005	< 0.1	< 0.004	0.004
WKN219	0.14	< 0.01	< 0.002	0.108	0.109	< 0.1	0.006	0.011
WKN2339	0.23	< 0.01	0.005	0.178	0.183	< 0.1	< 0.004	0.011
WKN2476	< 0.11	< 0.01	< 0.002	0.058	0.058	< 0.1	0.005	0.008
WKN3157	0.12	< 0.01	< 0.002	0.112	0.112	< 0.1	0.004	0.008
WKN3237	0.21	< 0.01	< 0.002	0.159	0.159	< 0.1	0.006	0.007
WKN324	0.25	< 0.01	< 0.002	0.21	0.21	< 0.1	0.014	0.016

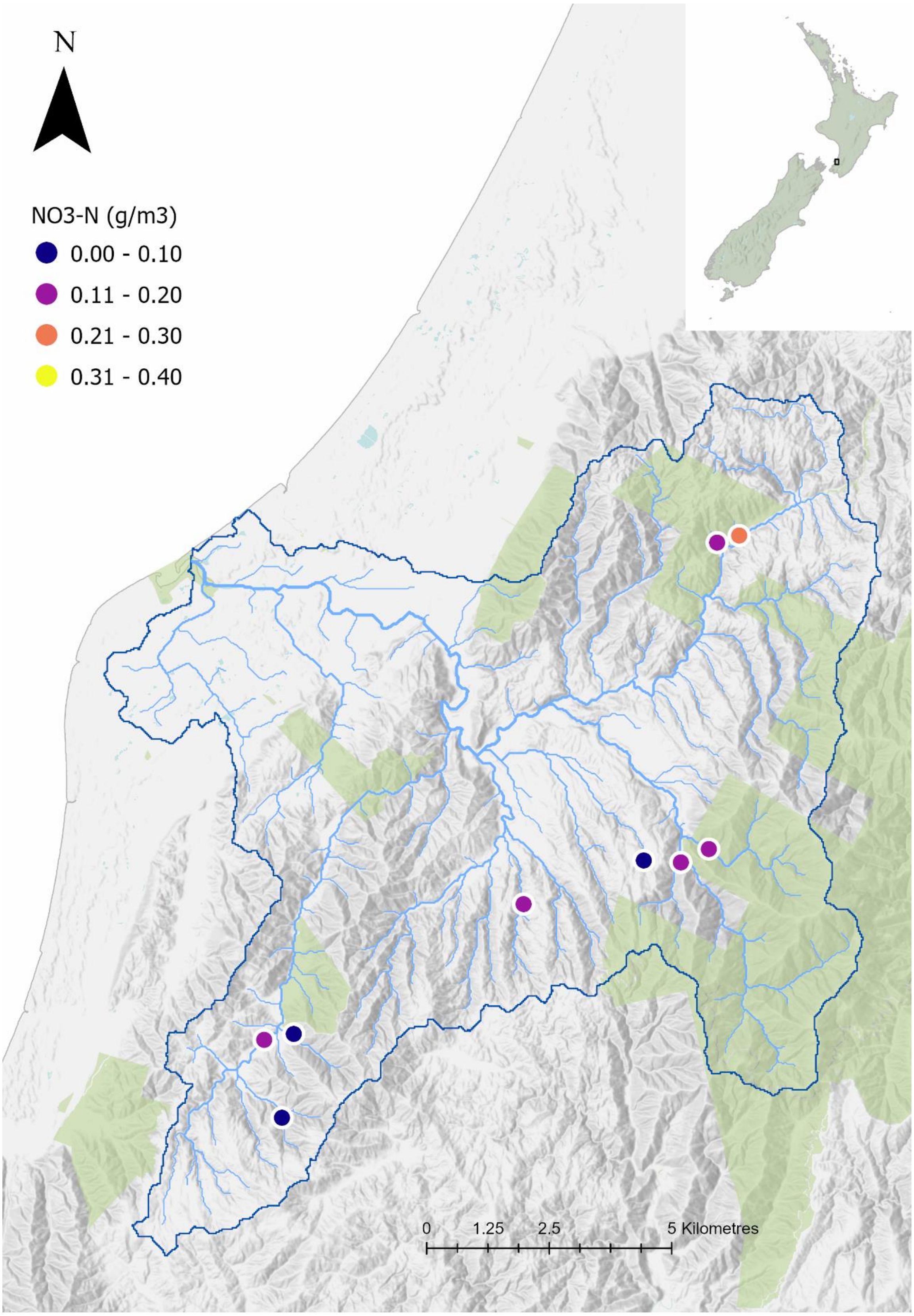


Figure 14. Nitrate concentrations across the Waikanae catchment. Basemaps generated by Eagle Technologies (2023), sourced from LINZ Data Service (2023) and licensed for reuse under CC BY 4.0.

5.3. Water chemistry

The pH is a measure of the acidity or alkalinity of the water and is largely influenced by the underlying geology and land cover. Field pH measurements were recorded for only six sites due to a pH probe malfunction during one sampling trip; these sites were approximately circumneutral (minimum = 6.96, mean= 7.88, maximum = 8.75). Laboratory-measured pH values for all sites displayed less variation (minimum = 7.00, mean = 7.28, maximum = 7.4), indicating that all sites were circumneutral. While field pH measurements are generally preferred because of the potential for biological activity and carbon dioxide equilibrating within the sample to alter the pH between sample collection and processing (US EPA 2023), consideration of laboratory measurements can aid in validating field measurements.

Dissolved oxygen was high (> 8 mg/L) at all sites where it was measured (minimum = 10.05 mg/L, mean = 10.49 mg/L, maximum = 11.30 mg/L), although no DO concentration was recorded for WKN3237. As these values are from single daytime spot measurements, they cannot be compared with the 7-day mean minimum or 1-day minimum values presented in the NPS-FM, as minimum DO typically occurs at night-time / dawn. However, the values observed significantly exceed the ANZECC minimum limit of 6 mg/L for the protection of the early life stages of aquatic organisms (ANZECC 1992).

A broad range of other water physicochemical data were collected, including the conductivity and summaries of dissolved ions such as bicarbonate, dissolved metal ions, sodium, chloride, sulphate and carbon (Appendix 6). The values associated with these results do not have specific guideline values; rather, the data are helpful on a site-by-site level to contextualise other results. Much of the water chemistry is influenced by the underlying geology and can impact primary and secondary production in streams.

6. NATIONAL CONTEXT

To investigate how monitoring results in the Waikanae catchment compared to other streams and rivers on PCL, 25%, 50% and 75% quantiles were calculated from a combined dataset of recent monitoring conducted on or near PCL. This included data from the NFMP (Kelly et al. 2023), as well as other data collected as part of the Ngā Awa river restoration programme from the Waikanae (reported here), Te Hoiere / Pelorus (Eveleens and Kelly 2023a) and Waipoua (Eveleens and Kelly 2023b) catchments, spanning 109 sites located across the North and South Islands.

Quantiles were calculated for periphyton biomass, MCI, QMCI, ASPM, F-IBI, deposited fine sediment cover, visual clarity, nitrate, ammoniacal nitrogen, total nitrogen, DRP and total phosphorus. For all metrics, quantiles are arranged so that quantile 1 represents the best condition for each water quality or ecosystem health metric. Given that many sites included in the combined dataset displayed good water quality and ecosystem health, the quantiles presented here represent only those instances where metric values fall in relation to other sites in the NFMP and Ngā Awa programmes – i.e. metric values in quantile 4 are likely still indicative of a relatively undegraded state. This is because most of the sites that comprise the dataset are from within the conservation estate. For specific detail on the state of metrics for each site, refer to Sections 3, 4 and 5 of the report.

Compared to the combined dataset, sites in the Waikanae catchment displayed good results for aquatic life metrics and poorer results for periphyton and water quality metrics (Figure 15). Six sites were in the best 25% of the combined dataset for MCI and ASPM, and five sites were in the best 25% of the combined dataset for F-IBI. Eight sites were in the worst 25% of the dataset for nitrate and six were in the worst 35% of the dataset for periphyton biomass. We do note, however, that even sites within the lowest quantile may still have excellent water quality and ecological health.

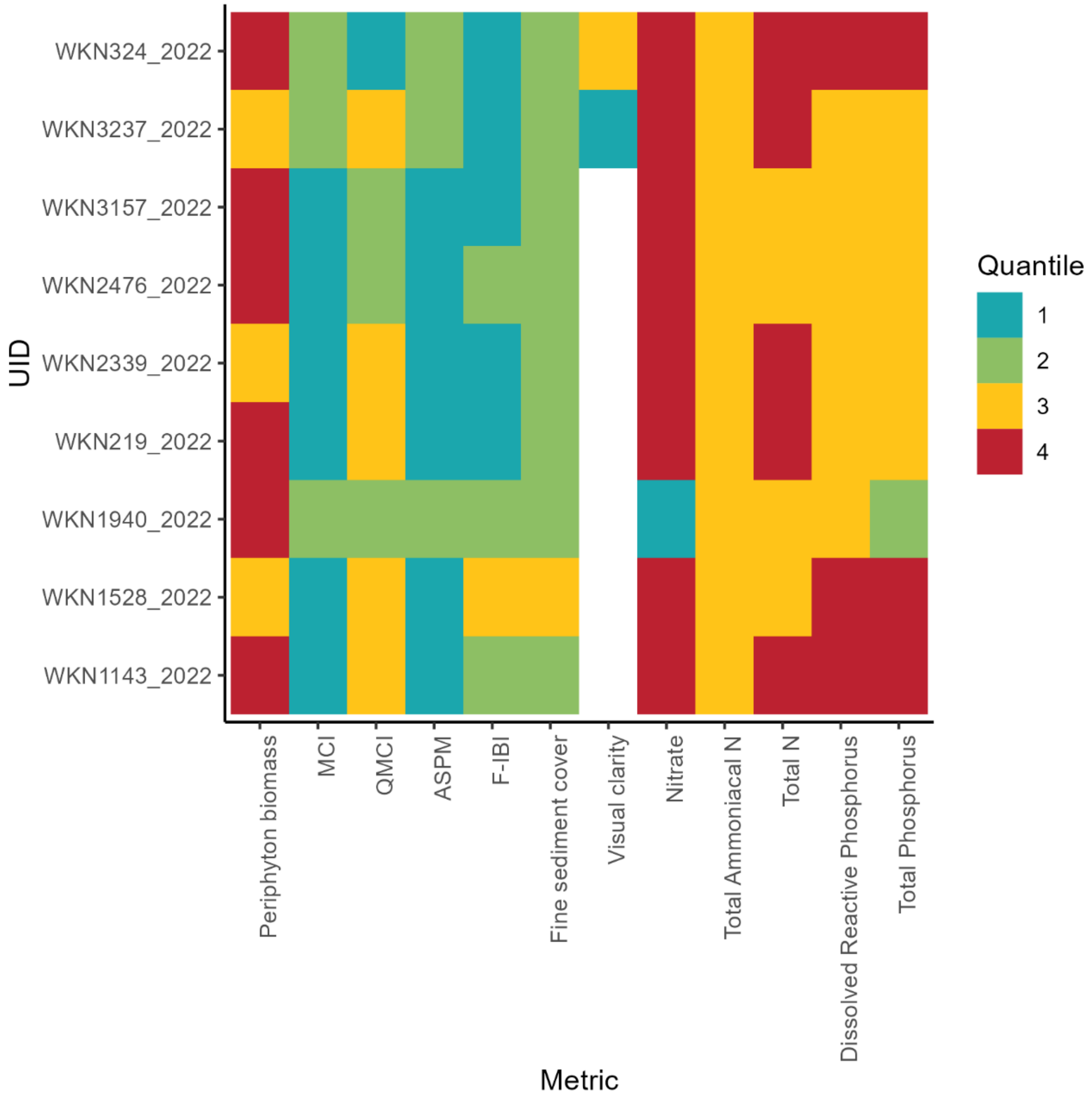


Figure 15. Quantiles for selected ecological health and water quality metrics in the Waikanae catchment calculated from a combined national dataset of 109 sites. Quantile 1 represents sites in the best 25% of recorded values for each metric, quantile 2 represents sites between the best 25% and 50% of recorded values, quantile 3 represents sites between 50% and 75% of recorded values, and quantile 4 represents sites in the worst 25% of recorded values. Blank squares represent metrics where a complete measurement could not be collected at a site.

7. DISCUSSION

7.1. Overview of findings

Across the attributes measured at the nine sites surveyed in the 2022/23 monitoring season, results were generally good. Where relevant, interpretation of results relative to NPS-FM attribute bands has been included for the purpose of providing context. However, because the sampling regime needed to meet the data thresholds for the NPS-FM, the data for many of the metrics cannot be specifically designated to these bands.

Aquatic life scores were indicative of healthy biodiversity at most sites. One site had a reduced score for F-IBI, which could not be attributed to a specific cause from the data available. The survey site reaches harboured a significant number of At Risk and Threatened native freshwater fish taxa, with five species in these categories found.

Macroinvertebrate communities were indicative of good or reference conditions at all sites. While most macroinvertebrates (approximately 59%) could not be assigned to a threat class due to taxonomic resolution issues or lack of information, one At Risk: Naturally Uncommon dragonfly species (*Antipodochlora braueri*) was found. Kōura were the only megainvertebrate observed and were caught at six sites.

Primary production was variable across the survey sites, with low periphyton biomass results at eight sites and high biomass (four times higher than the lowest biomass site) at the remaining site. Periphyton cover was almost entirely absent, with bare streambed substrate occurring at most of the sites, although a high cover of thin mats and films was observed at three sites. No bryophytes or macrophytes were recorded as present.

A diverse array of habitats were recorded across the survey sites. Most sites had more than three meso-habitats available for a range of organisms. Discharge was biased towards relatively low-flow sites, but this reflects both the survey intent to sample all stream orders present and the size of the waterways present within the Waipoua catchment. Substrate stability spanned from moderate to high, with most sites being highly stable.

Deposited fine sediment cover was low, with many sites having no deposited sediment cover. A variety of substrate size classes were observed, offering good-quality habitat for macroinvertebrates and fish. Nutrient concentrations were low at all sites and no pesticide residues were detected. Measurements of visual clarity were restricted by the available habitat. While turbidity was low across all sites, one site where visual clarity could be measured indicated moderate to high impacts from suspended sediment.

When compared with other recent monitoring of streams and rivers in or near PCL, sites displayed good results for aquatic life, although periphyton biomass and water quality results were poorer than at many sites in the Ngā Awa river restoration programme and NFMP.

7.2. Potential future investigations

The data presented here give insight into the current state of the Waikanae catchment and provide a foundation for guiding restoration efforts and the future assessment of change over time. In terms of potential future investigations, we have grouped our recommendations into risks requiring follow-up, the design of repeated sampling, knowledge gaps, hypotheses-driven questions and the use of other datasets, with further detail provided below.

Risks requiring follow-up

No risks requiring follow-up were identified.

Design of repeated sampling

Repeated sampling will enable assessment of changes over time. Many of the sites sampled effectively remain in reference condition but are likely to be affected by changes in temperature and rainfall patterns arising from climate change. As a result, the wide-ranging dataset collected and presented here offers a baseline to inform future analyses of temporal change. Given the relatively high accumulation of periphyton biomass at some sites, it may be important to include this attribute in future monitoring.

Knowledge gaps

Future monitoring could examine the upstream extent of migratory fish distributions to determine the extent of species habitat within the Waikanae catchment, as some migratory fish species were not recorded in smaller-order tributaries.

Hypotheses-driven questions

No specific hypotheses-driven questions were identified from the analyses presented here.

Use of other datasets

Combining the data presented here with other monitoring efforts within the lowland and more modified parts of the Waikanae catchment could help to identify areas under particular stress and inform decision-making around restoration efforts. Dewson (2022) has already identified existing data sources and pressures within the catchment, and so provides a basis for further analyses.

8. APPENDICES

Appendix 1. Site information for all sites in the Waikanae catchment measured in the 2022/23 monitoring season. The GPS coordinates are for the midpoint of the site. Note that the waterway names have been reproduced here from the field data sheets and are not necessarily the official names for these features.

Site identifier	Waterway name	Easting (NZTM)	Northing (NZTM)	NZ reach number
WKN1143	Waikanae River Tributary	1779839	5473834	9253418
WKN1528	Rangiora River	1778340	5467336	9255027
WKN1940	Maungakōtukutuku Stream Tributary	1770960	5462078	9256433
WKN219	Ngatiawa River Tributary	1779094	5467296	9255215
WKN2339	Reikorangi Stream Tributary	1775890	5466440	9255177
WKN2476	Maungakōtukutuku River Tributary	1771202	5463788	9256026
WKN3157	Ngatiawa River Tributary	1779670	5467569	9255091
WKN3237	Maungakōtukutuku Stream Tributary	1770597	5463668	9256070
WKN324	Waikanae River	1780286	5473979	9253438

Appendix 2. R packages and versions used for data curation, analysis and plotting.

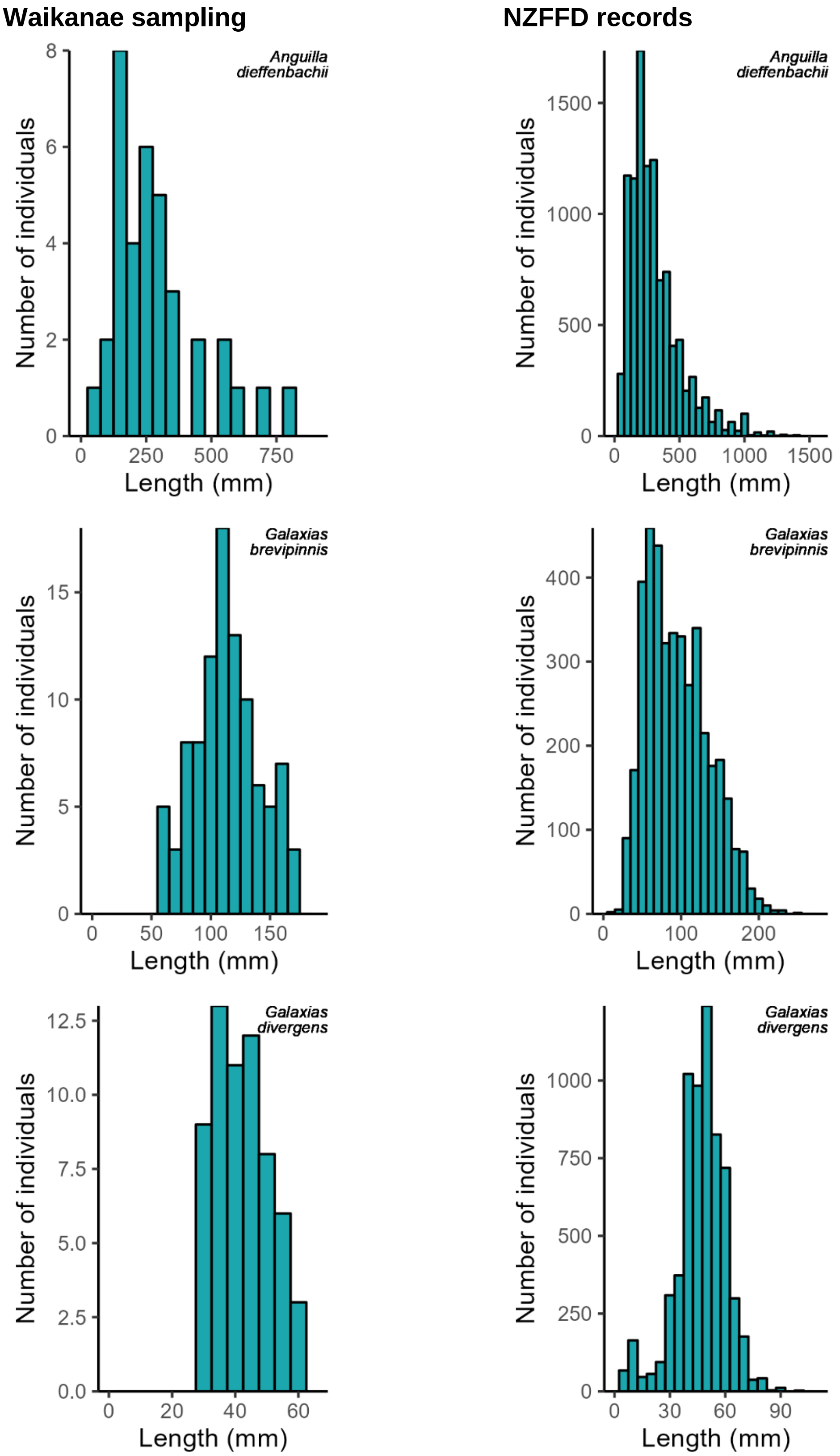
Package	Version	Reference
base	4.3.0	R Core Team (2023)
colorblindcheck	1.0.2	Nowosad (2019)
ggnewscale	0.4.9	Campitelli (2023)
ggpubr	0.6.0	Kassambara (2023)
ggVennDiagram	1.2.2	Gao (2022)
grafify	3.2.0	Shenoy (2021)
gridExtra	2.3	Auguie (2017)
gt	0.9.0	Iannone et al. (2023)
knitr	1.43	Xie (2014, 2015, 2023)
maptools	1.1.7	Bivand and Lewin-Koh (2023)
moonBook	0.3.1	Moon (2015)
nzffdr	2.1.0	Lee and Young (2021)
plotrix	3.8.2	Lemon (2006)
quantreg	5.95	Koenker (2023)
rgeos	0.5.9	Bivand and Rundel (2021)
rmarkdown	2.22	Xie et al. (2018, 2020), Allaire et al. (2023)
rprojroot	2.0.3	Müller (2022)
sf	1.0.13	Pebesma (2018), Pebesma and Bivand (2023)
tidyverse	2.0.0	Wickham et al. (2019)
viridisLite	0.4.2	Garnier et al. (2023)
webr	0.1.5	Moon (2020)

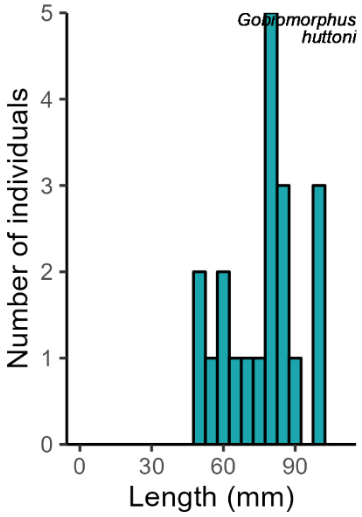
Appendix 3. Fish observations at all sites, including all methods used.

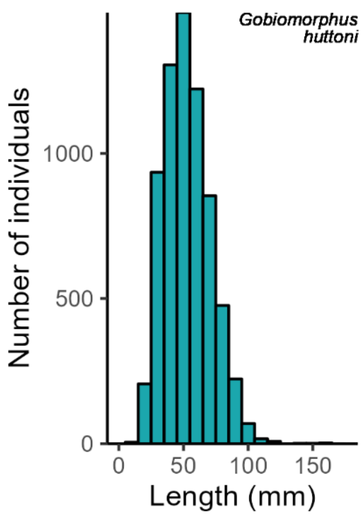
Site identifier	Scientific name	Common name	Category	Status	Bio status	Detection method
WKN1143	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
WKN1528	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
WKN1940	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Anguilla sp.	NA	NA	NA	NA	Electric fishing
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
WKN219	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
	Gobiomorphus huttoni	Redfin bully	Not Threatened	Not Threatened	Endemic	Electric fishing & eDNA
WKN2339	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Anguilla sp.	NA	NA	NA	NA	Electric fishing
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
	Galaxias fasciatus	Banded kōkopu	Not Threatened	Not Threatened	Endemic	Electric fishing & eDNA
WKN2476	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Anguilla sp.	NA	NA	NA	NA	Electric fishing
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
	Galaxias sp.	NA	NA	NA	NA	Electric fishing
WKN3157	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Anguilla sp.	NA	NA	NA	NA	Electric fishing
	Cheimarrichthys fosteri	Torrentfish	At Risk	Declining	Endemic	Electric fishing
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA

Site identifier	Scientific name	Common name	Category	Status	Bio status	Detection method
	Galaxias postvectis	Shortjaw kōkopu	Threatened	Nationally Vulnerable	Endemic	Electric fishing
	Galaxias sp.	NA	NA	NA	NA	Electric fishing
	Gobiomorphus huttoni	Redfin bully	Not Threatened	Not Threatened	Endemic	Electric fishing & eDNA
	Salmo trutta	Brown trout	Introduced and Naturalised	Introduced and Naturalised	Exotic	eDNA
WKN3237	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Anguilla sp.	NA	NA	NA	NA	Electric fishing
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
	Galaxias divergens	Dwarf galaxias	At Risk	Declining	Endemic	Electric fishing & eDNA
	Gobiomorphus huttoni	Redfin bully	Not Threatened	Not Threatened	Endemic	Electric fishing & eDNA
	Gobiomorphus sp.	NA	NA	NA	NA	Electric fishing
	Salmo trutta	Brown trout	Introduced and Naturalised	Introduced and Naturalised	Exotic	Electric fishing & eDNA
	Anguilla australis	Shortfin eel	Not Threatened	Not Threatened	Non-endemic	eDNA
WKN324	*Anguilla dieffenbachii*	Longfin eel	At Risk	Declining	Endemic	Electric fishing & eDNA
	Anguilla sp.	NA	NA	NA	NA	Electric fishing
	Cheimarrichthys fosteri	Torrentfish	At Risk	Declining	Endemic	Electric fishing
	Galaxias brevipinnis	Kōaro	At Risk	Declining	Endemic	Electric fishing & eDNA
	Galaxias divergens	Dwarf galaxias	At Risk	Declining	Endemic	Electric fishing
	Gobiomorphus huttoni	Redfin bully	Not Threatened	Not Threatened	Endemic	Electric fishing & eDNA
	Gobiomorphus sp.	NA	NA	NA	NA	Electric fishing
	Galaxias fasciatus	Banded kōkopu	Not Threatened	Not Threatened	Endemic	eDNA
	Salmo trutta	Brown trout	Introduced and Naturalised	Introduced and Naturalised	Exotic	eDNA

Appendix 4. Length distributions of fish taxa where more than 15 individuals were caught across all sites sampled in the Waikanae catchment, compared to length records stored in the NZFFD.




Gobiomorphus huttoni
Number of individuals
0
1
2
3
4
5
0
30
60
90
Length (mm)


Gobiomorphus huttoni
Number of individuals
0
500
1000
0
50
100
150
Length (mm)

Appendix 5. Taxon-Independent Community Index (TICI) results for all replicates collected at all monitoring sites. The reliability of each result is presented as received from Wilderlab.

Site identifier	TICI value	TICI rating	Number of sequences included	Reliability
WKN1143	129.75	Pristine	248	Average
	127.45	Pristine	189	Average
	128.79	Pristine	213	Average
	128.09	Pristine	200	Average
	130.74	Pristine	186	Average
	128.00	Pristine	253	High
WKN1528	126.50	Pristine	243	Average
	125.87	Pristine	247	Average
	127.61	Pristine	249	Average
	126.92	Pristine	264	High
	127.97	Pristine	262	High
	125.08	Pristine	209	Average
WKN1940	127.94	Pristine	146	Low
	127.59	Pristine	178	Average
	128.60	Pristine	181	Average
	126.89	Pristine	192	Average
	126.70	Pristine	179	Average
	126.71	Pristine	180	Average
WKN219	122.70	Pristine	300	High
	124.87	Pristine	246	Average
	125.82	Pristine	224	Average
	126.30	Pristine	217	Average
	125.38	Pristine	250	High
	124.17	Pristine	227	Average
WKN2339	120.87	Pristine	266	High
	120.34	Pristine	283	High
	121.37	Pristine	277	High
	121.20	Pristine	239	Average
	120.69	Pristine	274	High
	121.48	Pristine	285	High

Site identifier	TICI value	TICI rating	Number of sequences included	Reliability
WKN2476	128.04	Pristine	285	High
	126.80	Pristine	259	High
	127.07	Pristine	291	High
	129.02	Pristine	209	Average
	127.76	Pristine	222	Average
	127.61	Pristine	267	High
WKN3157	129.14	Pristine	252	High
	126.56	Pristine	227	Average
	128.28	Pristine	223	Average
	127.94	Pristine	248	Average
	128.51	Pristine	230	Average
	127.31	Pristine	272	High
WKN3237	115.77	Excellent	391	Very high
	112.40	Excellent	460	Very high
	113.01	Excellent	376	Very high
	112.98	Excellent	398	Very high
	113.14	Excellent	369	Very high
	113.24	Excellent	501	Very high
WKN324	117.01	Excellent	328	High
	116.86	Excellent	396	Very high
	116.77	Excellent	472	Very high
	118.53	Excellent	434	Very high
	120.05	Pristine	285	High
	118.70	Excellent	406	Very high

Appendix 6. Supplementary water chemistry results for each site. TSS = total suspended solids, DOC = dissolved organic carbon, TOC = total organic carbon.

Site identifier	Anions (mEq/L)	Cations (mEq/L)	Turbidity (FNU)	Conductivity (mS/m)	TSS (g/m^3)	Calcium (g/m^3)	Magnesium (g/m^3)	Potassium (g/m^3)	Sodium (g/m^3)	Chloride (g/m^3)	Sulphate (g/m^3)	DOC (g/m^3)	TOC (g/m^3)
WKN1143	0.94	0.98	0.23	10.4	3	6.50	1.97	0.79	11.0	13.4	4.5	1.5	2.2
WKN1528	0.69	0.78	0.84	8.2	3	2.80	1.53	0.88	11.3	12.7	2.8	1.5	2.0
WKN1940	0.89	0.92	0.37	10.0	3	3.70	1.90	0.60	13.1	17.5	3.8	1.0	1.9
WKN219	0.90	0.91	0.17	9.9	3	5.90	1.76	0.70	10.3	11.6	6.2	0.5	1.0
WKN2339	0.77	0.82	0.48	9.2	3	3.20	1.49	0.77	11.8	13.3	3.0	3.2	10.0
WKN2476	1.04	1.12	0.21	12.5	3	6.00	2.30	0.70	14.1	17.2	4.1	1.1	1.1
WKN3157	0.83	0.87	0.29	9.8	3	6.60	1.75	0.62	8.8	10.1	4.0	1.0	0.8
WKN3237	1.06	1.16	0.21	12.4	3	4.40	2.40	0.95	16.5	21.0	4.0	0.9	1.6
WKN324	0.79	0.79	1.78	8.6	3	3.50	1.55	0.80	10.7	13.6	3.1	0.9	1.3

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