

An assessment of water quality, benthic macroinvertebrates and adult freshwater insect biodiversity from Awapoto, Ōruru, and Ōruaiti river catchments of Doubtless Bay, Northland



Technical report prepared by:

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for the Doubtless Bay Ngā Awa River Restoration Programme,
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Cover photos: Main photo: Ōtangaroa Stream, a second order stream in the Ōruaiti River catchment (Dean Baigent-Mercer). Insets of adult insects: top – mayfly *Zephlebia borealis*, middle – stonefly *Stenoperla prasina*, bottom – *Pycnocentroides* sp. (Olly Ball & Steve Pohe Collection).

An assessment of water quality, benthic macroinvertebrates and adult freshwater insect biodiversity from Awapoto, Ōruru, and Ōruaiti river catchments of Doubtless Bay, Northland

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Report summary

Healthy invertebrate communities are essential for clean water and ecosystem balance, and underpin the food webs that sustain terrestrial and freshwater taonga species like our endangered or threatened native bats, birds and fish, while serving as sensitive indicators of stream health. Investment in knowledge of what is present in a freshwater system, and what is likely missing, is an important management action for the future of our rivers and the species that depend on them.

During the summers of 2023–24 and 2024–25, using national protocols, freshwater macroinvertebrate sampling was carried out by mana whenua and DOC staff at 16 sites across Doubtless Bay, after training with the lead author. In addition to benthic macroinvertebrate sampling, comprehensive light trapping was undertaken at three sites for the adult life stages of aquatic insects, to assess biodiversity values. Samples were processed to the highest resolution possible by the lead author using protocols written specifically for DOC.

The results from this comprehensive assessment showed;

- native vegetation habitat had significantly better water quality and more diverse macroinvertebrate communities
- good or excellent water quality at most sites, based on benthic macroinvertebrate sampling, with high aquatic insect biodiversity and ecological richness, but some degradation was evident in agriculturally influenced areas, habitat without riparian vegetation, and in lower catchment reaches that are likely to accumulate sediment from upstream
- high aquatic insect biodiversity within the catchment were recorded, based on light trapping, and a reasonable number of species of conservation interest, including new species to science. The new species will need to be formally described; a process that kaitiaki will be encouraged to be involved in. Species of conservation interest were found at the following sites:

At Risk

Dragonfly *Antipodochlora braueri* – [Toatoa, Maungaroa, Ōtangaroa, Parau SR](#)

Mayfly *Maiulus aquilus* – [Kohumaru](#)

Mayfly *Oniscigaster wakefieldi* – [Ōtangaroa](#)

Mayfly *Zephlebia tuberculata* – [Parapara, Kohumaru, Maungaroa, Mangawhero, Parau SR, Waikohatu](#)

Caddisfly *Oecetis iti* – [Parau SR](#)

Data Deficient

Amphipod *Phreatogammarus waipoua* – [Māra whenua, Maungakawa, Puhangatohoraka, Forest Waters](#)

New species

Mayfly *Zephlebia* aff. *tuberculata* n. sp. – [Pirikahu, Paekauri](#)

Caddisfly *Tiphobiosis* "Marawhenua" n. sp. – [Māra whenua](#)

Caddisfly *Paroxyethira* "Doubtless Bay" n. sp. – [Ōtangaroa, Parau SR](#)

Caddisfly *Diplectrona* "Otangaroa" n. sp. – [Ōtangaroa](#)

It is recommended that future restoration efforts focus on:

- protecting habitats with rare, unique and "new" species, particularly when these restoration sites can be connected to existing native forest or fragmented forest
- prioritise sites with no riparian cover or sparse cover for restoration, and preferably those sites with active community support
- prioritise sub-catchments with high-risk erosion and focus restoration efforts from upper catchment to lower catchment (work your way downstream if possible)

More rare and unique species likely remain undiscovered, undervaluing Doubtless Bay's ecological distinctiveness. To guide restoration priorities at both landscape and site scales, it is recommended to continue to build on these findings and consider them alongside other research e.g. revegetation for climate resilience research. There is also an opportunity for an *ad hoc* adult insect light-trapping programme, as part of the biodiversity and knowledge sharing collaboration between the Ngā Awa Programme and Mana whenua.

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1. Introduction

Macroinvertebrates, comprising both benthic (bottom-dwelling) juvenile and terrestrial adult life stages, are fundamental to the structure and function of freshwater ecosystems. They occupy key positions in the food web, acting as consumers that break down organic matter e.g. algae, leaves and wood, and as food for fish and birds. This dual role ensures energy transfer between trophic levels, supporting biodiversity within aquatic and riparian habitats.

Globally, including in New Zealand, macroinvertebrates serve as sensitive bioindicators of stream health. Species vary in their tolerance to stressors such as sedimentation, nutrient enrichment, and contaminants. For example, the presence of pollution-sensitive taxa like mayflies and stoneflies signals high water quality, whereas dominance by tolerant species such as worms or midges often reflect degraded conditions. Because they integrate environmental changes over time, macroinvertebrate communities provide a cost-effective and robust measure of ecological integrity, making them valuable for monitoring and restoration programmes. Assessments of freshwater invertebrates can be used to detect changes in the aquatic environment resulting from human-induced stresses e.g. contaminants entering the waterway. Invertebrates are normally abundant in streams and rivers, and are commonly used in the assessment of water quality as their diverse communities provide varied responses to changing environmental conditions (Boothroyd & Stark 2000). They are good indicators of local conditions because they tend to be limited in their in-stream movements, therefore are affected by the environmental conditions over an extended period of time, unlike water quality measurements that are snapshots of the waterway at that point, at that moment.

In 2019 Department of Conservation (DOC) launched the 'Ngā Awa River Restoration Programme' to improve the knowledge and management of native freshwater biodiversity. Specifically, the Ngā Awa initiative seeks to restore the freshwater biodiversity of 14 priority catchments from mountains to sea, including in Doubtless Bay, Northland. The Doubtless Bay Ngā Awa project is broad-reaching, with focuses on habitat restoration and biodiversity enhancement, that includes efforts to increase resilience against impacts of a changing climate. However, the Doubtless Bay catchment also holds significant cultural and heritage values, and a restoration approach grounded in Te Ao Māori (Māori worldview that identifies interconnectedness) is vital to achieving successful freshwater restoration outcomes here.

Since 2021, the Ngā Awa initiative has developed a large network of relationships with tangata whenua, landcare groups and commercial enterprises, and has been involved in many catchment planning hui, school education programmes, community training and workshop events, freshwater fish surveys and inanga spawning site surveys. Doubtless Bay Ngā Awa has also invested considerable resources into science-based outcomes, commissioning studies into wetland mapping, geomorphic assessments (McCord et al. 2023), catchment revegetation analyses (Forbes & Case 2024, Forbes 2025), and a summary report on the cultural and ecological values of Doubtless Bay (Boffa Miskell Limited 2023). A collective environmental economic assessment for the Doubtless Bay, Waihou and Waipoua Rivers in Northland was also prepared (Kaval 2021).

In 2022, several streams in the catchment were surveyed for taonga species using eDNA, electric fishing, and traditional whakaweku (binded bundles of bracken fern, *Pteridium esculentum*), resulting in new knowledge of freshwater fish and invertebrate species presence. Most recently, hapū kaitiaki and DOC staff have undertaken macroinvertebrate surveys to build on existing knowledge of the catchment and to inform community catchment restoration efforts and the Community Led Catchment Plan (under development).

DOC is charged with managing and protecting New Zealand's biodiversity, and an important component of this role is the sustained assessment of the conservation status of species'. The New Zealand freshwater invertebrate fauna is characterised by high levels of regional and national endemism. Many of the taxa are considerably understudied, and current assessment and sampling

methods generally have a biomonitoring focus (e.g. identification to genus level for water quality assessment), rather than a biodiversity focus (identification to species level for conservation management), so are likely to significantly underrepresent the actual biodiversity present. For example, a biomonitoring approach would record the mayfly genus *Zephlebia* as present, but a biodiversity assessment (in a Northland catchment) could record all eight described *Zephlebia* species in one stream. Diversity studies by their very nature require species-level identifications, which in turn often require adult specimens collected by sampling methods tailored for the task. To conserve biodiversity, understanding what species are present is probably the largest knowledge gap faced. Two other major knowledge gaps facing freshwater invertebrate conservation in New Zealand are insufficient data on taxa distributions, and a lack of autecological information (Drinan et al. 2021).

Here we report results of a two-pronged study using conventional stream sampling of benthic macroinvertebrates to assess water quality across the catchment, and three preliminary light trap surveys, to understand the true biodiversity present (species-level resolution), and to start to document the presence of species of conservation interest (species listed as Threatened, At Risk, Data Deficient or new to science).

2. Methods

2.1 Insect sampling and processing

During summers of 2023–24 and 2024–25, a collective of hapū kaitiaki and DOC staff, after training with the lead author, carried out benthic macroinvertebrate monitoring at 16 sites across the Doubtless Bay catchment (Table 1, Figures 1–3, Appendix 1). Sampling sites were chosen by a range of methods; strict scientific selection by random means is not always the best approach, thus here we also stratified by habitat, sub-catchment, as well as specific locations of importance to community stakeholders. Sampling was done following national protocols (NEMS 2022). Each sample was taken using a handheld D-net, 300 mm at the base (400 mm deep) with 500-micron mesh, from an area of ~1m², made up of six 0.15 m² composite sub-samples. Sub-samples were collected while moving progressively upstream, targeting all available habitats including riffles, bank margins, macrophytes/weeds and wood, in proportion to their occurrence along 50 m stream reaches. After all sub-samples were taken, rinsed in a bucket of water and strained through a 500-micron mesh sieve in the field, the composite sample was transferred into 1000 ml plastic containers and preserved with generous volumes of 80% ethanol, ready for processing.

Sample processing was done by the lead author following protocols written for DOC for identification to the highest resolution possible (Smith 2021). Each sample was carefully rinsed through stacked 8, 2 and 0.5 mm Endecotts sieves and sorted in Bogorov counting chambers under a stereomicroscope (Leica M205C, 3.9–160x magnification). All organisms were picked from the chambers and identification to genera or species was done by microscopic examination following relevant identification keys and original species descriptions.

In addition to benthic macroinvertebrate samples, biodiversity surveys with light traps were used to obtain samples of adult aquatic insects from the numerically dominant Ephemeroptera, Plecoptera, Trichoptera and Megaloptera (hereafter EPTM), known commonly as mayflies, stoneflies, caddisflies and dobsonflies. Light traps fitted with 8-Watt ultraviolet fluorescent tubes were set during warm stable weather, 17th–20th December 2024, activated with a timer at dusk and deactivated three hours later. The following morning traps were cleared and specimens placed into plastic containers with strong ethanol (~80%). For more details of sampling protocols and equipment used see Pohe et al. (2023, 2024). Light trap samples were pre-sorted under a 3-Diopter magnifying light (22W) and identification to species was done with a Leica M205C dissecting microscope following relevant taxonomic literature. Picked specimens and raw detritus for each sample were re-preserved and returned to DOC.

Table 1. Sampling sites, stream names, sub-catchments and coordinates of the 16 benthic sampling sites. Sites marked with a bold asterisk (*) indicate the addition of light trapping.

Site names	Streams	Sub-catchment	Latitude ; Longitude
1. Māra whenua *	Peria River (headwaters)	Ōruru	-35.157507°; 173.506483°
2. Pekerau	Pekerau Stream (Pekerau Road)	Awapoko	-35.019237°; 173.377677°
3. Maungakawa	Peria River (headwaters)	Ōruru	-35.148204°; 173.475533°
4. Forest Waters	Peria River (headwaters)	Ōruru	-35.157146°; 173.499087°
5. Puhangatohoraka	Waikainga Stream tributary	Ōruru	-35.110235°; 173.527282°
6. Toatoa	Toatoa Stream (headwaters)	Awapoko	-35.069360°; 173.458223°
7. Parapara	Parapara Stream	Awapoko	-35.019679°; 173.422427°
8. Te Kauhanga	Peria River (near Marae)	Ōruru	-35.108130°; 173.488200°
9. Maungaroa	Maungaroa Stream	Ōruaiti	-34.990570°; 173.602130°
10. Pirikahu	Kenana River	Ōruaiti	-35.066223°; 173.591641°
11. Kohumaru	Kohumaru Stream (near Kenana)	Ōruaiti	-35.041440°; 173.567140°
12. Paekauri	Waikohatu Stream	Ōruaiti	-34.977480°; 173.623020°
13. Mangawhero	Mangawhero Stream (near Marae)	Ōruaiti	-35.089150°; 173.650250°
14. Paranui SR *	Toatoa Stream (Toatoa Road)	Awapoko	-35.067617°; 173.444453°
15. Ōtangaoroa *	Wainui River tributary	Ōruaiti	-35.123280°; 173.595016°
16. Waikohatu	Waikohatu Stream (Sawyer Road)	Ōruaiti	-35.030645°; 173.614740°



Figure 1. Hapū and DOC collective sampling and processing benthic macroinvertebrates to assess water quality (photo credits: hapū kaitiaki).



Figure 2. Sampling benthic macroinvertebrates in forest habitat (photo credit: hapū kaitiaki & Maddy Jopling).



Figure 3. Sampling for aquatic insect biodiversity using light traps. Left: Steve Pohe (Freshwater Ecologist) and Robert King (Ōtangaroa hapū kaitiaki) setting a pan trap with UV light. Middle: UV light trap with baffles set beside a stream (stream out of shot). Right: Close up photo of aquatic insect catch comprising mayflies, caddisflies and moths (photo credits: hapū kaitiaki & Maddy Jopling).

2.2 Data analyses

Full counts of all benthic macroinvertebrate and adult light trap data are presented in Microsoft Excel spreadsheets provided to DOC with this report. Microsoft Excel spreadsheets were also used to keep track of site metadata, species presence and abundance, biotic index and ordination calculations and graph summary data. Species lists of light trap catches are also recorded in Appendix 2 of this report. For all species obtained, their conservation threat status was checked and recorded following Grainger et al. (2018).

Benthic macroinvertebrate samples were used to calculate the biotic indices of taxonomic richness, %EPT* and the Macroinvertebrate Community Index (MCI), to help describe and compare the community assemblages and inferred water quality at each site. Interpretation of MCI scores into water quality classes followed Stark and Maxted (2007).

From the benthic sampling dataset (16 sites, 83 taxa), a principal coordinates analysis (PCoA) ordination based on the Sørensen (Bray–Curtis) distance measure was used to examine similarities and differences in the invertebrate communities. Raw data expressed as presence–absence were used in the ordination; no data transformations or rare species removals were done before analysis. We also included in the ordination matrix group-level categories of each site, indicating types of habitats found at each site (native forest, native fragment, native/exotic forest mix, riparian margins, no riparian). A Multi-Response Permutation Procedure (MRPP) using Sørensen (Bray–Curtis) distance was used to test whether invertebrate stream communities from the five habitat types were significantly different. The multivariate analyses (PCoA and MRPP) were performed using the statistical software PC-ORD v6.22 (McCune & Mefford 2011).

2.3 DNA barcoding and phylogenetics

Towards the end of this project, during progress reporting, it was indicated to DOC that a number of species of conservation interest, including tentative new species, had been found in these surveys, and that DNA barcoding and analyses would be needed at a later date, to establish their true placements. DOC decided to extend the project, to include some DNA barcoding investigations, to better understand these new discoveries.

Leg tissue from a number of tentative new species, and also their congener taxa, were DNA barcoded by University of Otago Sequencing Service (20 individuals, COI gene). Sequences were manually aligned and trimmed to 658 base pairs by the lead author using BioEdit Sequence Alignment Editor v7.7.1 (Hall 1999). New specimen sequences, together with other available congener sequences, were analysed in MEGA 12 (Kumar et al. 2024) using Maximum Likelihood (ML) or Neighbour-Joining (NJ) modelling (ML for small datasets and NJ for large overview, 1000 replicates for both). The best-fit model of sequence evolution was GTR + G + I, determined by the Akaike Information Criterion (Akaike 1973), and was used to construct phylogenetic trees for visualising species evolutionary relationships. The 20 full-length barcode sequences have been provided to DOC in an Excel spreadsheet for future use.

3. Results and Discussion

3.1 Aquatic insect biodiversity

Benthic macroinvertebrate samples were collected by ngā hapū kaitiaki and DOC at 16 sites across the Doubtless Bay catchment to assess the condition of water quality and macroinvertebrate habitat. From the processed samples, the biotic indices MCI, taxonomic richness and %EPT* were calculated (Figures 4, 5). Based on a composite assessment of these biotic indices, one site (Pekerau) was considered "Poor" water quality, at three sites it was "Fair", and the remaining 12 sites (75%) were considered either "Good" or "Excellent".

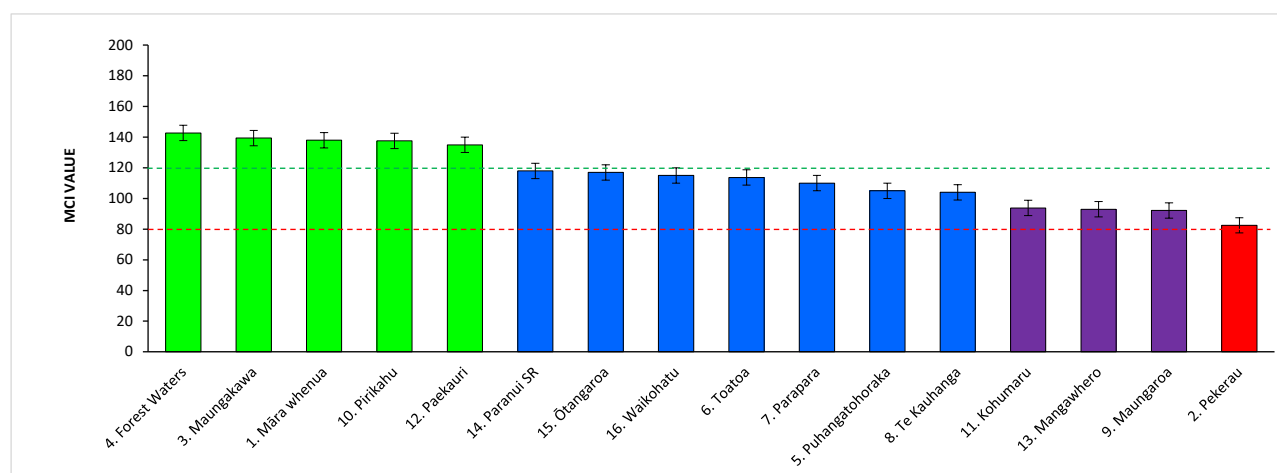


Figure 4. Water quality results for the 16 sites across the Doubtless Bay catchment, presented in the order of best to worst, based on the Macroinvertebrate Community Index. Coloured bars represent water quality classes (Green = Excellent, Blue = Good, Purple = Fair, Red = Poor). The red dashed line represents the upper limit of the 'Poor' water quality class, the green dashed line represents the lower limit of the 'Excellent' water quality class, and the error bars indicate an accuracy buffer of 5 MCI units. Note that Site 2. Pekerau technically falls just above the 'Poor' water class (MCI = 82.5) but based on the MCI buffer and the low taxonomic richness and %EPT* scores, it is deemed sit in the 'Poor' water quality class.

For the benthic invertebrate sampling, taxonomic richness ranged from 10 at Parapara, where the streambed was predominantly soft substrate and the riparian vegetation sparse, to 33 taxa at Maungakawa and Pirikahu sites, in forested catchments. Average taxonomic richness per site was 24.2 taxa. Six species of conservation interest were collected by benthic sampling; four being considered 'At Risk', one 'Data Deficient' and one being undescribed and new to science (Table 2). In addition to benthic macroinvertebrate sampling, comprehensive light trapping was undertaken at three sites for the adult life stages of aquatic insects, to assess biodiversity values. Trap catches varied considerably for the three sites, reflecting the range of physical stream factors, habitats available and environmental conditions on the nights of sampling. Māra whenua had an average catch of 2918 specimens; dominated by *Deleatidium* mayflies, and hydrobiosid and conoesucid caddisflies, insects typical of faster water and rocky substrates. Paranui SR and Ōtangaroa had average catches of 610 and 303 specimens, respectively, and were dominated by *Pycnocentodes* and leptocerid caddisflies, insects more associated with slower flows and finer gravel substrates. A complete list of benthic macroinvertebrate species, and where they were found, is provided as an Excel spreadsheet with this report. Light trap results for all three sites are presented in Appendix 2.

Beta diversity for the three light trap sites was 64 species, which is considered reasonably high for a one-off exercise (Figure 6). Alpha diversity ranged from 19–40 species; Māra whenua having particularly high diversity recorded (beta = 50 species, alpha = 38–40 species). Of the 64 species recorded by light trap, all were identified to species-level, but four could not be confidently assigned to known species, and were considered new species (Table 2). In addition, the mayfly *Zephlebia tuberculata* and the caddisfly *Oecetis iti* (both 'At Risk') were also recorded. New species will need to be formally described; a process that ngā hapū kaitiaki will be encouraged to be involved in.

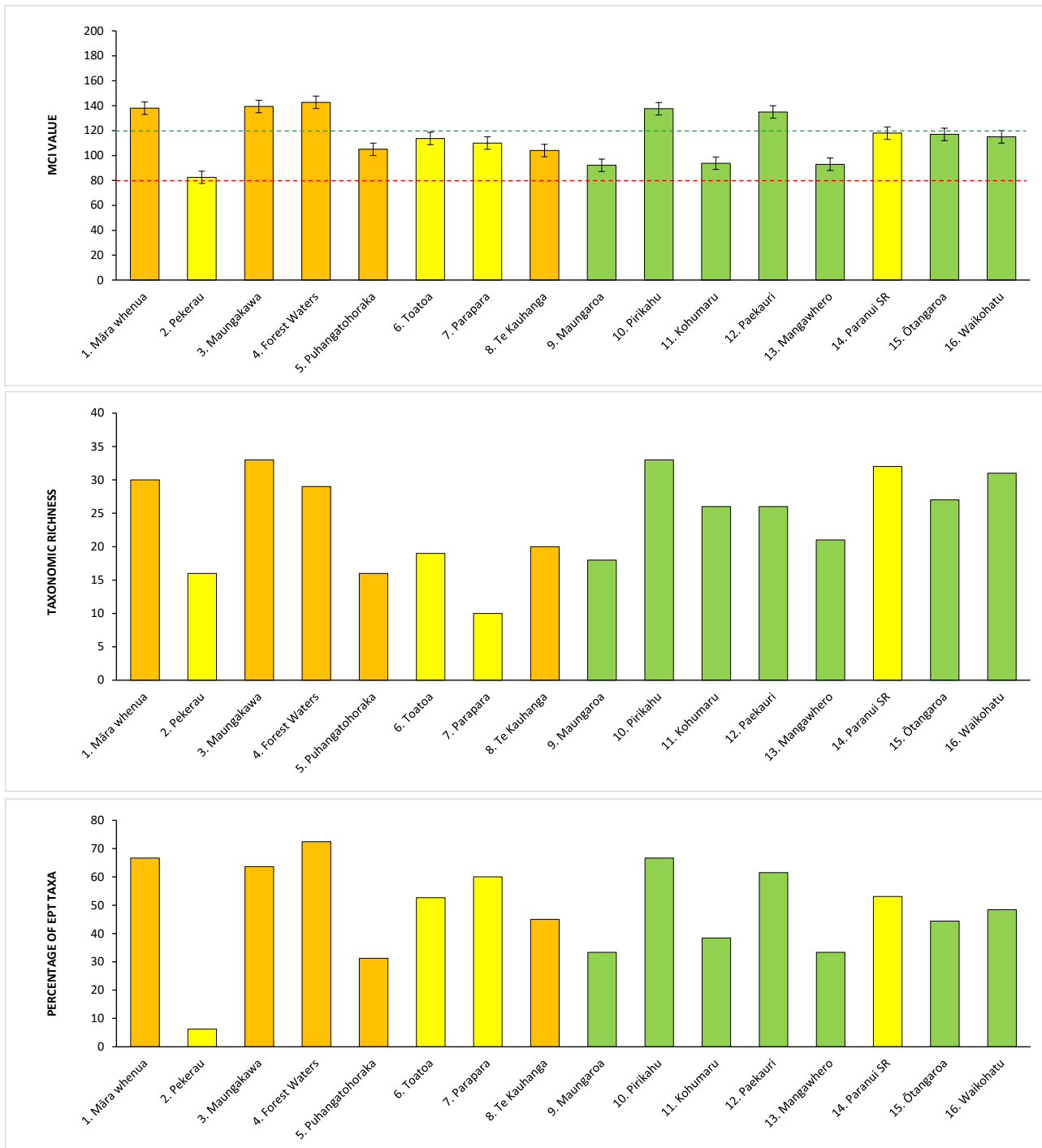


Figure 5. Water quality results for the 16 sites across the Doubtless Bay catchment, presented as the biotic indices MCI, taxonomic richness and percentage of EPT taxa (excluding Hydroptilidae caddisflies). Colours of the bars indicate the three main sub-catchments (Orange = Ōruru, Yellow = Awapoko, Green = Ōraitī). In the MCI graph (top graph), the red dashed line represents the upper limit of the ‘Poor’ water quality class, the green dashed line represents the lower limit of the ‘Excellent’ water quality class, and the error bars indicate an accuracy buffer of 5 MCI units.

Table 2. Species recorded that are of interest to conservation and freshwater management. A specific list of sites is also provided in the report summary on Page 3. For location and abundance details of specific benthic macroinvertebrates, refer to the Excel data provided with this report, and for adult insects see Appendix 2.

Species	Taxon group	Conservation interest	Sites	Collected by
<i>Phreatogammarus waipoua</i>	Amphipoda	Data Deficient	4	Benthic
<i>Antipodochlora braueri</i>	Dragonfly	At Risk (NU)	4	Benthic
<i>Maiulus aquilus</i>	Mayfly	At Risk (NU)	1	Benthic
<i>Oniscigaster wakefieldi</i>	Mayfly	At Risk (NU)	1	Benthic
<i>Zephlebia</i> aff. <i>tuberculata</i> n. sp.	Mayfly	New species	2	Benthic
<i>Zephlebia tuberculata</i>	Mayfly	At Risk (NU)	6	Benthic & Light
<i>Paroxyethira</i> cf. <i>teika</i>	Caddisfly	Possible new species	2	Light
<i>Tiphobiosis</i> "Marawhenua" n. sp.	Caddisfly	New species	1	Light
<i>Oecetis iti</i>	Caddisfly	At Risk (NU)	1	Light
<i>Paroxyethira</i> "Doubtless Bay" n. sp.	Caddisfly	New species	2	Light
<i>Diplectrona</i> "Otangaroa" n. sp.	Caddisfly	New species	1	Light

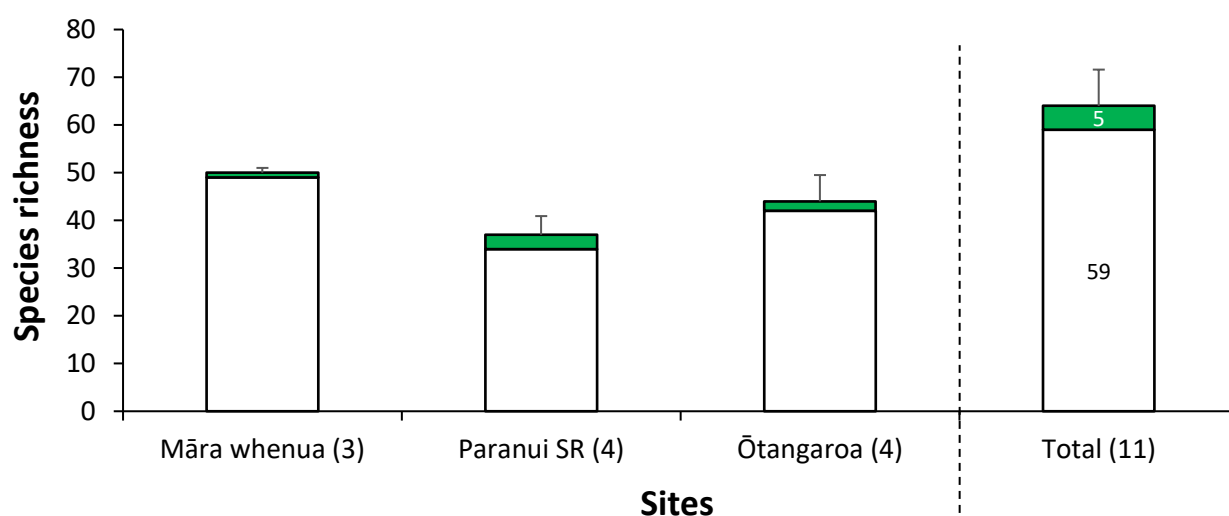


Figure 6. Aquatic insect beta biodiversity (EPTM taxa) recorded by light trapping at three sites in Doubtless Bay catchment. Green in bars represents the contribution of species of conservation interest (At Risk and new species). Error bars indicate standard deviation. Numbers in parentheses are the number of traps set per site.

3.2 Sites and their macroinvertebrate community relationships

A principal coordinates analysis (PCoA) was used to group sites sampled across the catchment in relation to the macroinvertebrate species found. The ordination calculated that the first five axes were significant and explained 81.5% of the variation in the data. The first two axes explained 47.1% of the variation, with the primary axis (Axis 1) revealing a clear gradient of sites based on their benthic macroinvertebrate communities (Figure 7). Survey sites associated with 'native forest', and also Pirikahu with 'native/exotic forest', plotted to the right side of the ordination and strongly correlated with high-scoring macroinvertebrate indices (see Taxon richness, MCI & %EPT vectors presented in the graph). In contrast, survey sites associated with 'riparian' margins or 'no riparian', plotted to the left side of the ordination and strongly correlated with low MCI scores. Survey sites associated with 'native fragment' forests, and also the Waikohatu site (deemed to be 'riparian'), plotted in the centre of the ordination, suggesting those sites have species shared with both ends on the spectrum. The Pekaerau site was a clear outlier, falling at the far left of Axis 1 (low MCI score and poor macroinvertebrate habitat), but also to the far extent of Axis 2, suggesting it has a very different community of aquatic macroinvertebrates; part of the explanation will likely be due to its low number of taxa recorded.

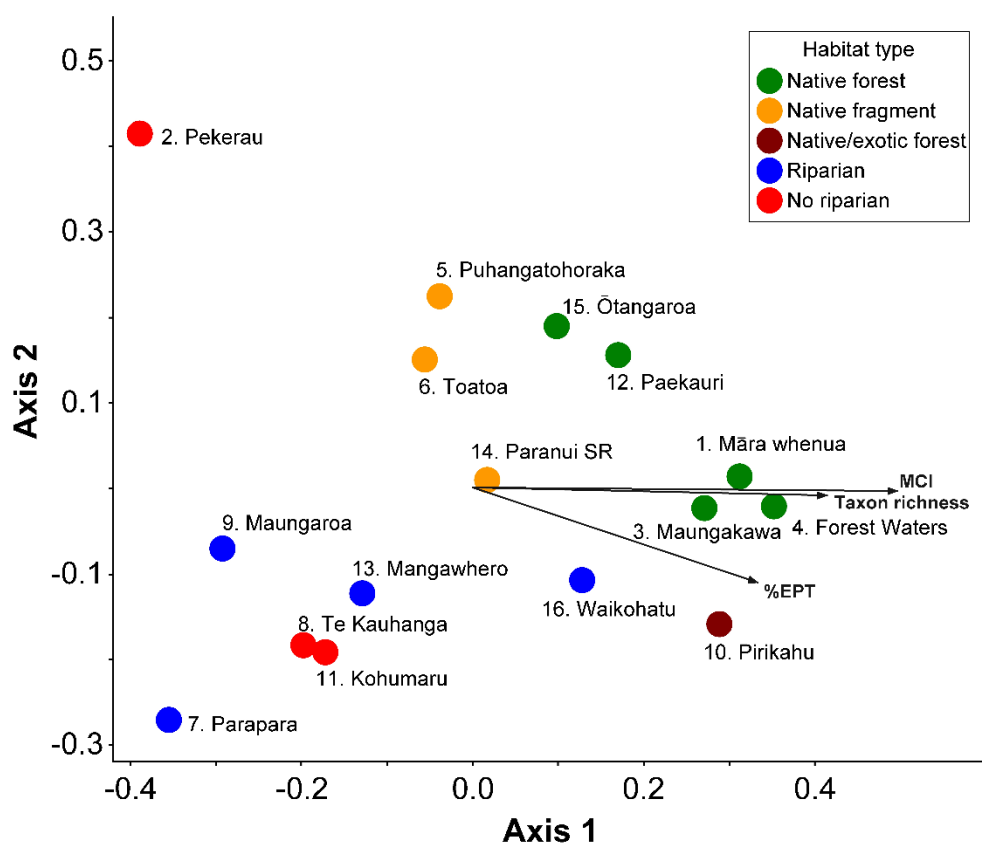


Figure 7. Principal coordinates analysis (PCoA) of the Doubtless Bay sampling sites showing relationships between the sites based on the presence of their macroinvertebrate communities (Axis 1 = 30.0%; Axis 2 = 17.1%). Coloured points represent the types of habitats found at each site. Vectors (black arrows) indicate the strength and direction of correlations between water quality index values and the ordination axes scores (Pearson’s $r^2 > 0.5$ with Axis 1). Site names align with those in Table 1 and Appendix 1.

As an additional measure, a Multi-Response Permutation Procedure (MRPP) was used to test whether invertebrate stream communities between the different habitats were significantly different. The analysis indicated that differences in the macroinvertebrate communities were highly significant between ‘native forest’ and ‘no riparian’ habitats, and also between ‘native forest’ and ‘riparian’ habitats, but differences between macroinvertebrate communities in the other habitats were not (Table 3).

Table 3. MRPP pairwise comparisons between the macroinvertebrate communities found within the different habitats. Group comparisons and *P*-values in **bold** are statistically significant. Note: native/exotic forest could not be included because it only had one sample (Pirikahu).

Groups compared	T	A	P-value
Native forest vs no riparian	-3.68	0.24	0.005
Native forest vs native fragment	-1.16	0.10	0.13
Native forest vs riparian	-3.24	0.21	0.01
No riparian vs native fragment	-0.97	0.06	0.17
No riparian vs riparian	1.28	0.05	0.91
Native fragment vs riparian	-0.39	0.03	0.35

4. Conclusions

During the summers of 2023–24 and 2024–25, after training with the lead author, a collective of ngā hapū kaitiaki and DOC staff carried out freshwater macroinvertebrate monitoring at 16 sites across the Doubtless Bay catchment. Sampling was done following national protocols (NEMS 2022), and sample processing followed protocols written specifically for DOC for identification to the highest resolution possible.

Based on a composite of biological index results (MCI, taxonomic richness, %EPT*), water quality and/or macroinvertebrate habitat at one site (Pekerau) was considered "Poor", at three sites it was "Fair", and the remaining 12 sites (75%) were considered either "Good" or "Excellent". Average taxonomic richness per site was 24.2 taxa (range 10–33 taxa). Six species of conservation interest were collected by benthic sampling; four being considered 'At Risk', one 'Data Deficient' and one being undescribed and new to science.

In addition to benthic macroinvertebrate sampling, comprehensive light trapping was undertaken at three sites for the adult life stages of aquatic insects, to assess biodiversity values. Trap catches varied considerably for the three sites, reflecting the range of physical stream factors, habitats available and environmental conditions on the nights of sampling. Māra whenua had a very large catch average of 2918 specimens, dominated by *Deleatidium* mayflies and hydrobiosid and conoesucid caddisflies, insects typical of fast water and rocky substrates. Paranoi SR and Ōtangaroa had average catches of 610 and 303 specimens, respectively, and were dominated by *Pycnocentroides* and leptocerid caddisflies, insects more associated with slower flows and finer substrates. Beta diversity (total diversity) for the three light trap sites was 64 species (average of 43.6 per site), which is considered reasonably high for a one-off exercise. Alpha diversity (diversity per trap) ranged from 19–40 species (average 29); Māra whenua having particularly high diversity recorded (beta = 50 species, alpha = 38–40 species). Of the 64 species recorded by light trap, all were identified to species-level, but four could not be confidently assigned to known species, and were considered new species (Table 2). In addition, the mayfly *Zephlebia tuberculata* and the caddisfly *Oecetis iti* (both 'At Risk') were also recorded. New species will need to be formally described; a process that kaitiaki will be encouraged to be involved in.

This study represents the first comprehensive macroinvertebrate water quality assessment across Doubtless Bay catchment, and suggests generally good water quality, with some degradation in mid to lower reaches where horticulture/agriculture predominate. The national 'Ngā Awa River Restoration Programme' is also the first to undertake light trapping for assessing freshwater insect biodiversity, firstly in Waipoua catchment (Feb 2024) and now in Doubtless Bay (Dec 2024). Aquatic insect biodiversity appears high within the catchment, and we recorded a reasonable number of species of conservation interest, including new species to science. Based on these results, more rare and new aquatic insects will likely be found in the catchment, as more surveys are conducted.

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7. Appendix 1



Figure A1. Map of Doubtless Bay catchment in Northland. Triangles mark sampling sites and triangle colours represent water quality classes.

8. Appendix 2

Table A2. Lists of adult aquatic insects recorded by light trapping during December 2024. Species in **bold** are of conservation interest. Note: New species names in quotations (" ") are placeholder tag names only.

Māra whenua	Paranui SR	Ōtangaoroa
<u>Ephemeroptera</u>	<u>Ephemeroptera</u>	<u>Ephemeroptera</u>
<i>Acanthophlebia cruentata</i>	<i>Acanthophlebia cruentata</i>	<i>Acanthophlebia cruentata</i>
<i>Ameletopsis perscitus</i>	<i>Austronella planulata</i>	<i>Austronella planulata</i>
<i>Atalophlebioides cromwelli</i>	<i>Coloburiscus humeralis</i>	<i>Coloburiscus humeralis</i>
<i>Coloburiscus humeralis</i>	<i>Deleatidium cf. angustum</i>	<i>Deleatidium cf. angustum</i>
<i>Deleatidium cf. autumnale</i>	<i>Ichthybotus hudsoni</i>	<i>Deleatidium cf. fumosum</i>
<i>Deleatidium cf. cerinum</i>	<i>Mauiulus luma</i>	<i>Ichthybotus hudsoni</i>
<i>Deleatidium cf. fumosum</i>	<i>Zephlebia dentata</i>	<i>Zephlebia borealis</i>
<i>Ichthybotus hudsoni</i>	<i>Zephlebia spectabilis</i>	<i>Zephlebia spectabilis</i>
<i>Neozephlebia scita</i>	<i>Zephlebia tuberculata</i>	<i>Zephlebia versicolor</i>
<i>Nesameletus ornatus</i>		
<i>Zephlebia borealis</i>	<u>Trichoptera</u>	<u>Plecoptera</u>
<i>Zephlebia versicolor</i>	<i>Costachorema hecton</i>	<i>Acroperla trivacuata</i>
	<i>Helicopsyche albescens</i>	
	<i>Helicopsyche zealandica</i>	
<u>Trichoptera</u>	<i>Hudsonema amabile</i>	<u>Trichoptera</u>
<i>Beraeoptera roria</i>	<i>Hydrobiosis budgei</i>	<i>Beraeoptera roria</i>
<i>Costachorema hecton</i>	<i>Hydrobiosis gollanis</i>	<i>Costachorema xanthopterum</i>
<i>Costachorema xanthopterum</i>	<i>Hydrobiosis parumbripennis</i>	<i>Diplectrona "Otangaroa" n. sp.</i>
<i>Helicopsyche albescens</i>	<i>Hydropsyche colonica</i>	<i>Helicopsyche albescens</i>
<i>Helicopsyche zealandica</i>	<i>Hydropsyche fimbriata</i>	<i>Helicopsyche zealandica</i>
<i>Hudsonema amabile</i>	<i>Hydropsyche raruraru</i>	<i>Hudsonema alienum</i>
<i>Hydrobiosella mixta</i>	<i>Neurochorema confusum</i>	<i>Hudsonema amabile</i>
<i>Hydrobiosis budgei</i>	<i>Oecetis iti</i>	<i>Hydrobiosella mixta</i>
<i>Hydrobiosis gollanis</i>	<i>Oecetis unicolor</i>	<i>Hydrobiosis budgei</i>
<i>Hydrobiosis parumbripennis</i>	<i>Oeconesus maori</i>	<i>Hydrobiosis gollanis</i>
<i>Hydrobiosis soror</i>	<i>Olinga feredayi</i>	<i>Hydrobiosis parumbripennis</i>
<i>Hydrobiosis spatulata</i>	<i>Oxyethira albiceps</i>	<i>Hydrobiosis soror</i>
<i>Hydropsyche colonica</i>	<i>Paroxyethira "Doubtless Bay" n. sp.</i>	<i>Hydrobiosis umbripennis</i>
<i>Hydropsyche fimbriata</i>	<i>Polyplectropus altera</i>	<i>Hydropsyche colonica</i>
<i>Hydropsyche raruraru</i>	<i>Psilochorema mimicum</i>	<i>Hydropsyche fimbriata</i>
<i>Neurochorema confusum</i>	<i>Pycnocentria evecta</i>	<i>Neurochorema confusum</i>
<i>Oecetis unicolor</i>	<i>Pycnocentria gunni</i>	<i>Oecetis unicolor</i>
<i>Oeconesus maori</i>	<i>Pycnocentroides cf. aeris</i>	<i>Oeconesus maori</i>
<i>Olinga feredayi</i>	<i>Pycnocentroides cf. aureolus</i>	<i>Olinga feredayi</i>
<i>Oxyethira albiceps</i>	<i>Triplectides cephalotes</i>	<i>Oxyethira albiceps</i>
<i>Paroxyethira cf. teika</i>	<i>Triplectides dolichos</i>	<i>Paroxyethira "Doubtless Bay" n. sp.</i>
<i>Plectrocnemia maclachlani</i>	<i>Triplectides obsoletus</i>	<i>Paroxyethira cf. teika</i>
<i>Polyplectropus altera</i>	<i>Zelandoptila moselyi</i>	<i>Plectrocnemia maclachlani</i>
<i>Polyplectropus aurifusca</i>		<i>Polyplectropus altera</i>
<i>Psilochorema donaldsoni</i>		<i>Polyplectropus aurifusca</i>
<i>Psilochorema macroharpax</i>	<u>Megaloptera</u>	<i>Polyplectropus impluvii</i>
<i>Psilochorema mimicum</i>	<i>Archichauliodes diversus</i>	<i>Psilochorema donaldsoni</i>
<i>Pycnocentria evecta</i>		<i>Psilochorema mimicum</i>
<i>Pycnocentria gunni</i>		<i>Pycnocentria evecta</i>
<i>Pycnocentroides cf. aeris</i>		<i>Pycnocentroides cf. aureolus</i>
<i>Pycnocentroides cf. aureolus</i>		<i>Triplectides dolichos</i>
<i>Tiphobiosis cowiei</i>		<i>Triplectides obsoletus</i>
<i>Tiphobiosis "Marawhenua" n. sp.</i>		<i>Zelandoptila moselyi</i>
<i>Triplectides cephalotes</i>		
<i>Triplectides dolichos</i>		
<i>Triplectides obsoletus</i>		
<i>Zelandoptila moselyi</i>		
		<u>Megaloptera</u>
<u>Megaloptera</u>		<i>Archichauliodes diversus</i>
<i>Archichauliodes diversus</i>		