MANGERE WASTEWATER TREATMENT PLANT

HARBOUR MONITORING 2024–25

COAST & CATCHMENT

ENVIRONMENTAL CONSULTANTS

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HARBOUR MONITORING 2024–25

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Cover photo: Shelly seabed in the northern Manukau Harbour with scattered seagrass, sea lettuce and red macroalgae.

CONTENTS

1 EXECUTIVE SUMMARY

This report presents the 2024–25 results of Watercare Service's Manukau Harbour monitoring programme. The monitoring programme has been designed to track the effects of the Mangere Wastewater Treatment Plant (MWWTP) on water quality, sediment quality, shellfish (oyster) quality, benthic ecology, and nuisance macroalgae as required under Watercare Service's discharge consent. The required monitoring frequency of the above parameters varies from one to four years. Monitoring carried out in the 2024–25 financial year included the sampling of water quality, sediment quality and benthic ecology. Reporting of discharge volumes and loads from the MWWTP is not required, but trends have been analysed to aid in the interpretation of the harbour monitoring results.

Overall, the monitoring results indicate that the MWWTP influences water quality in the north-eastern Manukau Harbour, leading to elevated nutrient concentrations and higher, and more

variable, chlorophyll *a* concentrations in that area. Ten-year trends in discharge volumes and loads of nutrients, total suspended solids (TSS) and biochemical oxygen demand (BOD_5) have been stable or reducing over the past 10 years. However, since 2021–22 loads of nitrate-nitrite-nitrogen (NNN), soluble reactive phosphorus (SRP) and total phosphorus (TP) have increased substantially, and in 2025 were comparable to those in 2015. In contrast, only slight fluctuations occurred in ammoniacal-N, TSS, and BOD_5 loads over the same period.

The recent upswings in discharge loads of NNN, SRP and TP were mirrored in corresponding upswings in the concentrations of those variables at the Puketutu water quality monitoring site, and in the case of SRP and TP, at sites along Wairopa Channel. Specifically, for the period between July 2015 and June 2025, statistical trends and other notable results from the analysis of key water quality parameters included:

- No significant 10-year trends in ammoniacal-N, total inorganic nitrogen (TIN), SRP, water temperature or pH, but:
    - An upswing was apparent in TIN concentrations at the Puketutu site in 2022, with a subsequent increase in TIN variability since 2023 (this mirrors the patterns below for NNN). Concentrations at other sites have fluctuated over time without displaying consistent patterns.
    - An upswing in SRP concentrations and variability at the Puketutu site since 2022, which coincides with the similar upswing in discharge loads. An increase in SRP concentrations at sites along Wairopa Channel since 2022 also mirrored the recent increases in discharge loads.
    - Strong seasonality in temperature readings, but interannual patterns were not apparent over the 10-year period.
    - Similar temporal fluctuations in pH at all sites, with no consistent trend.
- A significant increasing 10-year trend in NNN concentrations at the Puketutu site, which appears to be related to an upswing in NNN concentrations since 2022, and a subsequent increase in NNN variability since 2023. NNN concentrations at other sites have fluctuated over time without displaying consistent patterns or trends.
- Significant declining 10-year trends in TP at six of the 11 monitoring sites, and a significant increasing trend at the Puketutu site. The increasing trend is related to an upswing in TP concentrations and variability at the Puketutu site since 2022, and coincides with a similar upswing in discharge loads. Total phosphorus concentrations at sites along Wairopa Channel have also increased since 2022, mirroring the recent increases in discharge loads.
- Significant declining 10-year trends in turbidity at eight of the 11 monitoring sites.
- Significant declining 10-year trends in TSS at two of the four sites with sufficient data for trend analyses[1] (HWQ 30 and HWQ 80), and a significant increase at the HWQ 70 site.

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[1] Ammoniacal-N, TN, chlorophyll *a* and TSS at Auckland Council sites underwent laboratory related step-changes from mid-2017 onwards. Total nitrogen also underwent a separate laboratory related step-change around the beginning of 2016.

- Significant declining 10-year trends in chlorophyll *a* concentrations at three of the four sites with sufficient data for trend analyses (HWQ 30, HWQ 60, HWQ 70).

- Seasonal fluctuations in DO concentrations with a slight, but statistically significant, declining 10-year trend at the HWQ 60 site.

While formal trend analyses were not carried out on TN concentrations, plotted data from the period after laboratory-related changes[1], suggests that significant trends are unlikely to have occurred at all sites except Puketutu, where total nitrogen displayed an upswing in concentrations in 2022, and a subsequent increase in variability since 2023.

Strong positive relationships were detected between mean summer TN concentrations and mean and maximum summer chlorophyll *a* concentrations at Watercare's four sites, and most of Auckland Council sites. Surprisingly, negative relationships were detected between mean summer concentrations of TN, and mean and maximum concentrations of chlorophyll *a* in pooled data from the Puketutu and Wairoa sites. The reasons for the negative relationship are not known.

Sediment metal concentrations did not exceed sediment quality guidelines at any of the sites monitored in 2024. Total DDT and dieldrin concentrations in all sediment samples were also below detection limits. It is recommended that the HEMP be amended to remove future requirements for DDT and dieldrin monitoring. As DDT and dieldrin have not been used for decades, and sediment concentrations have now fallen below detection limits, ongoing monitoring of those contaminants is not warranted. It is therefore recommended that the HEMP be amended to remove that requirement.

Two high-level patterns emerge from analyses of benthic ecological data:

- Consistent differences in benthic community composition exist among sites, with patterns likely to be associated with variation in sediment characteristics, hydrodynamics and water quality, along with the habitat preferences/tolerances of individual species. Community composition varies along a gradient running from sheltered, muddy and enriched Pond and Outfall sites, to the exposed, sandy outer harbour sites. Changes in composition arise through differences in the relative abundance of taxa among sites, as well as differences in the distributions of taxa, with some largely restricted to particular habitat conditions, with others tending to be more ubiquitous.

- There are differences in the amount of temporal variation in community composition, with the Pond and Outfall sites displaying much less variation than the Purakau and Cape Horn sites. Discrete shifts in the composition of benthic communities were detected at all Watercare monitoring sites between 2011 and 2024. Temporal variation in community composition is likely to be related to multiple factors, which potentially include:

    - Natural variation in climatic conditions that affect sea and air temperature, wind direction and strength, and rainfall.

    - Variation in the physical and biological characteristics of the seabed, particularly at the Purakau Mid, Outer and Cape Horn sites, where significant changes have occurred in the extent and density of seagrass.

- Variation in discharge volumes and loads from Mangere WWTP. The latest trend analyses in this report indicates that while 10-year trends have been stable or declining, a recent upswing has occurred in the loads of several parameters.

The discharge has a clear effect on the organic content of sediments in the NE Manukau Harbour, and has a strong and persistent influence on benthic community composition at the Outfall site, which is within the non-compliance zone. The sediment characteristics and the composition of the benthic community of the Outfall site are consistent with habitats that have intermediate levels of organic enrichment, including:

- elevated concentrations of organic matter (content) and benthic primary productivity, as indicated by benthic chlorophyll *a* concentrations;
- moderate taxa diversity and elevated counts of individuals, due to the proliferation of one, or a few, enrichment-tolerant species (such as the deposit-feeding polychaete, *Aonides trifida,* whose numbers have fallen over the past 10 years).

Benthic communities in the pond sites seem to have 'stabilised' following the decommissioning of the historic treatment ponds and a period of colonisation. As noted in previous monitoring reports, further changes in the benthic communities at those sites are likely to be constrained by muddy sediments.

The three Purakau Channel, and Cape Horn monitoring sites are very dynamic, with significant physical and ecological changes occurring between 2011 and 2024. Observed changes have included switching from largely homogeneous sandflat habitats with sparse seagrass, to a complex matrix of sandy habitats with extensive seagrass and *Solieria* cover (particularly in the Purakau Outer site), and the increasing presence of other habitat-forming taxa such as Asian date mussels (a habitat-forming, boom-and-bust species) and epifaunal taxa. Those changes are highly likely to have influenced the relative abundances of individual infaunal taxa, as well as overall taxa diversity and abundance. Overall, the ecological monitoring results show that the northern, central harbour continues to sustain a complex and highly dynamic benthic ecosystem.

2 BACKGROUND

Watercare Services Ltd has consent to discharge treated wastewater from the Mangere Wastewater Treatment Plant (MWWTP) to Manukau Harbour (Figure 1). Consent conditions require the effects of the discharge on Manukau Harbour to be monitored in accordance with an approved Monitoring Plan.

The Harbour Environment Monitoring Programme (HEMP) is a component of the Monitoring Plan. Among other things, it is used to assess compliance with conditions related to the "*non-compliance zone*". The non-compliance zone is defined by condition 17(1) of the resource consent as a zone "*within which adverse effects associated with effluent discharged from the MWWTP are to be confined at all times*." Condition 17(3) relates specifically to the discharge into the Manukau Harbour stating that "*the discharge shall not cause any significant adverse effects on marine life beyond the non-compliance zone*." Figure 2 to Figure 6 show the boundaries of the non-compliance zone as defined by Condition 17(1)(b), and in relation to harbour monitoring locations.

The original HEMP covered the period five years before and after the commissioning of the MWWTP upgrade (i.e., 1997–2007). At the conclusion of the HEMP, an interim monitoring programme (the Harbour Monitoring Assessment and Prediction Programme (MAPP)) was continued until a detailed review of the HEMP was completed in 2011. That review led to amendments to the Monitoring Plan, which were subsequently approved by Auckland Council and implemented by Watercare Services in 2011.

In accordance with the revised plan, Watercare Services is now required to monitor the following environmental parameters:

1. Monthly water quality at four sites. This monitoring is complemented by Auckland Council's water quality monitoring programme at another seven Manukau Harbour sites (Figure 2).
2. Yearly benthic ecology monitoring at seven sites, supplemented by data from Council monitoring at two additional sites (Figure 3).
3. Three-yearly monitoring of benthic macroalgae using high-resolution aerial photography (Figure 4).
4. Two to four-yearly monitoring of sediment metal concentrations at 13 sites, and dichlorodiphenyltrichloroethane (DDT) and dieldrin concentrations at two decommissioned treatment pond sites (Figure 5).
5. Four-yearly monitoring of organic contaminants in Pacific oysters (*Magallana gigas*) at two sites (Figure 6).

The revised programme began with the sampling of water quality in September 2011 and benthic ecology in November 2011. The first round of sediment quality and benthic macroalgae monitoring was carried out in 2012–13, and organic contaminant monitoring in oysters commenced in 2014. Future monitoring dates for the various monitoring components are outlined in Table 1.

This report presents the monitoring results of the 2024–25 water quality, benthic macroalgae and benthic ecology programmes, and compares them to previous monitoring results.

To assist in the interpretation of the harbour monitoring results, discharge volumes and loads from the MWWTP between July 2015 and June 2025 have also been plotted and analysed for trends. Major changes to the operation of MWWTP are also listed in Appendix G.

Figure 1: Manukau Harbour showing water depth, major physical features, the location of the Mangere Wastewater Treatment Plant (MWWTP), and the non-compliance zone specified in the discharge consent.

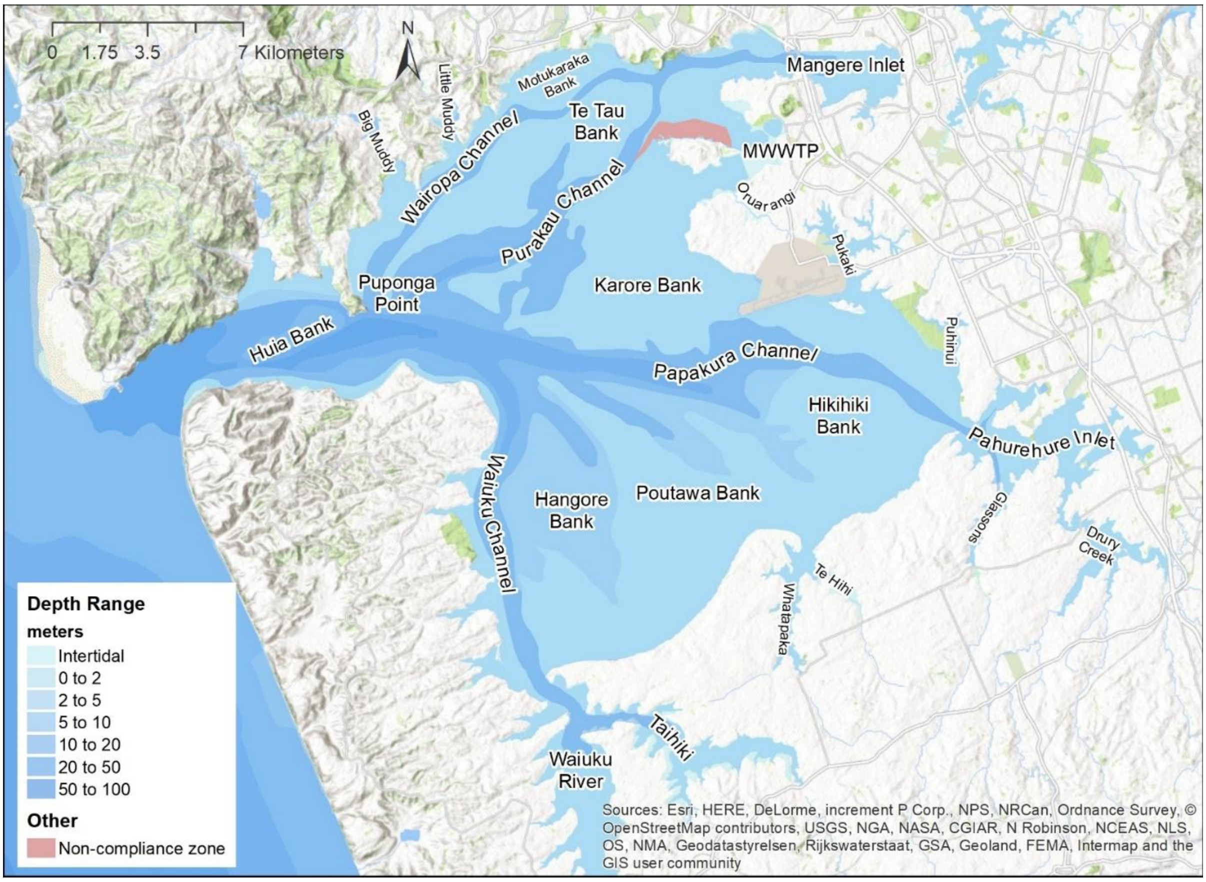


Table 1: Summary of monitoring sites, parameters, and sampling frequencies.

Component	Monitoring Management Plan Reference	Monitoring site details	Test parameters	Frequency
Marine water quality	Section 5.7.2	Four Watercare and seven Council sites: see Figure 2.	Ammoniacal-N, chlorophyll *a*, dissolved oxygen (mg/L and % saturation), enterococci, faecal coliforms, nitrate-nitrite-nitrogen, total nitrogen, pH, reactive phosphorus, total phosphorus, salinity, conductivity, total suspended solids, water temperature, and turbidity.	Monthly sampling from September 2011 onwards.
Sediment quality	Section 5.7.3	Thirteen sites: see Figure 5.	Total concentrations of cadmium, copper, lead, mercury, zinc and sediment texture at all sites, plus total organic carbon, DDT, and dieldrin at sites Pond 14 and Pond 16.	Two-yearly sampling of sites 1 to 6 and Pond sites 14 and 16, from 2012 onwards. Four-yearly sampling of sites 7 to 11 from 2013 onwards.
Benthic ecology	Section 5.7.4	Seven Watercare and two Council sites: see Figure 3.	Chlorophyll *a*, sediment grain size, shellfish abundance, soft sediment community composition.	Annual sampling in October (except in 2011 when they were collected in November).
Benthic macroalgae	Section 5.7.4	Approximately 4000 ha area in the northern Manukau Harbour: see Figure 4.	Extent of beds and percent cover within beds assessed using aerial photographs.	Three-yearly intervals sampling from March 2013 onwards. Note that cloud cover that coincided with planned flights in 2019 and 2020 prevented aerial photos from being taken in those years. This resulted in a gap of 5 years between 2016 and 2021.
Marine biota (shellfish)	Section 5.7.4	Two sites: see Figure 6.	DDT and dieldrin.	Four-yearly sampling from October 2014 onwards.
Reporting Schedule	Section 6.2 and Table 6.1			Annually, by the end of September.

Figure 2: Water quality monitoring sites monitored by Watercare and Auckland Council. Note that Titirangi site is the Council's Shag Point site.

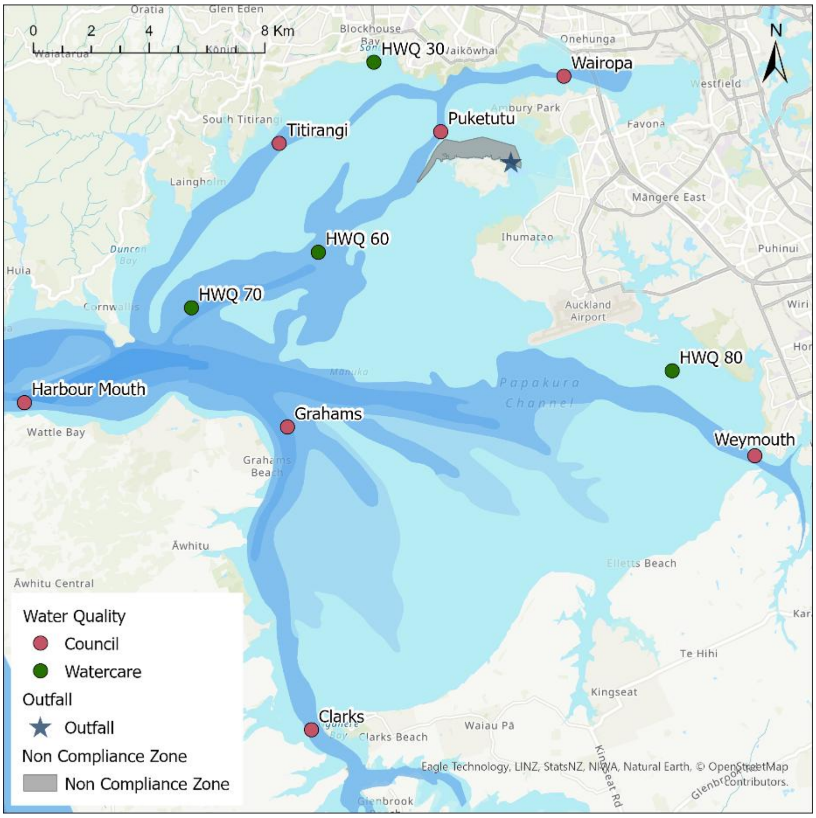


Figure 3: Benthic ecology monitoring sites by Watercare and Auckland Council.

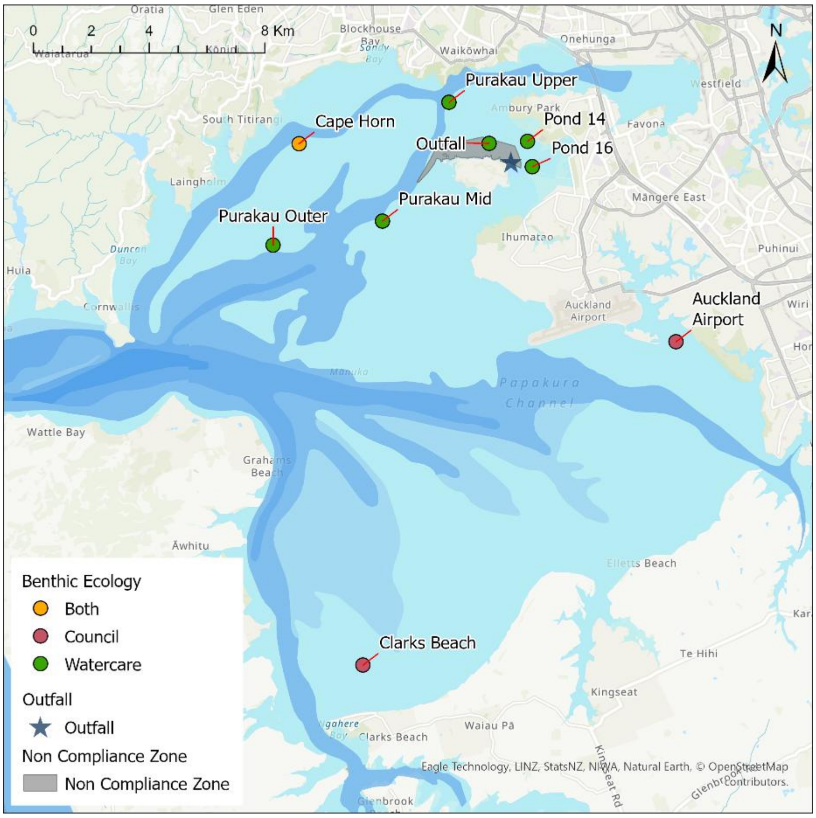


Figure 4: Required benthic macroalgae aerial assessment area. Note that the aerial photographs taken for this monitoring generally cover a broader area.

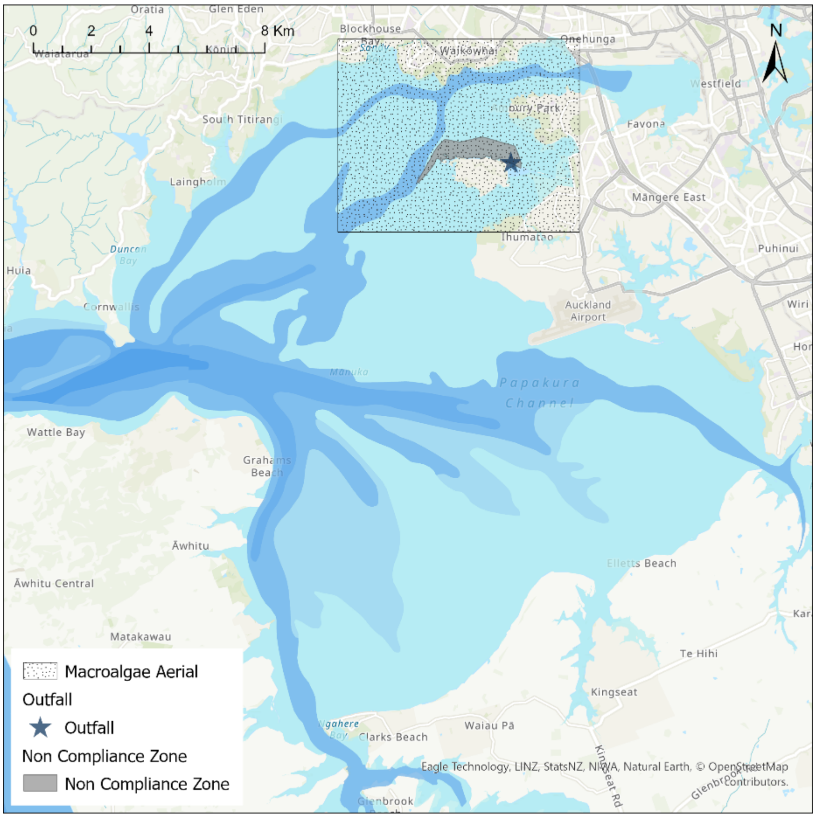


Figure 5: Sediment quality sites.

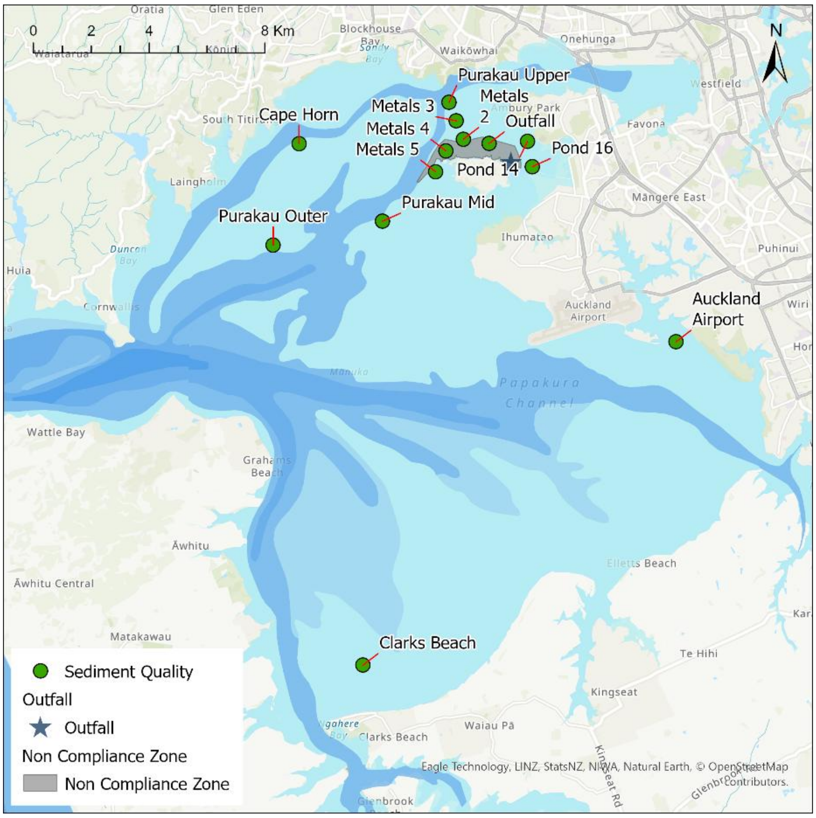
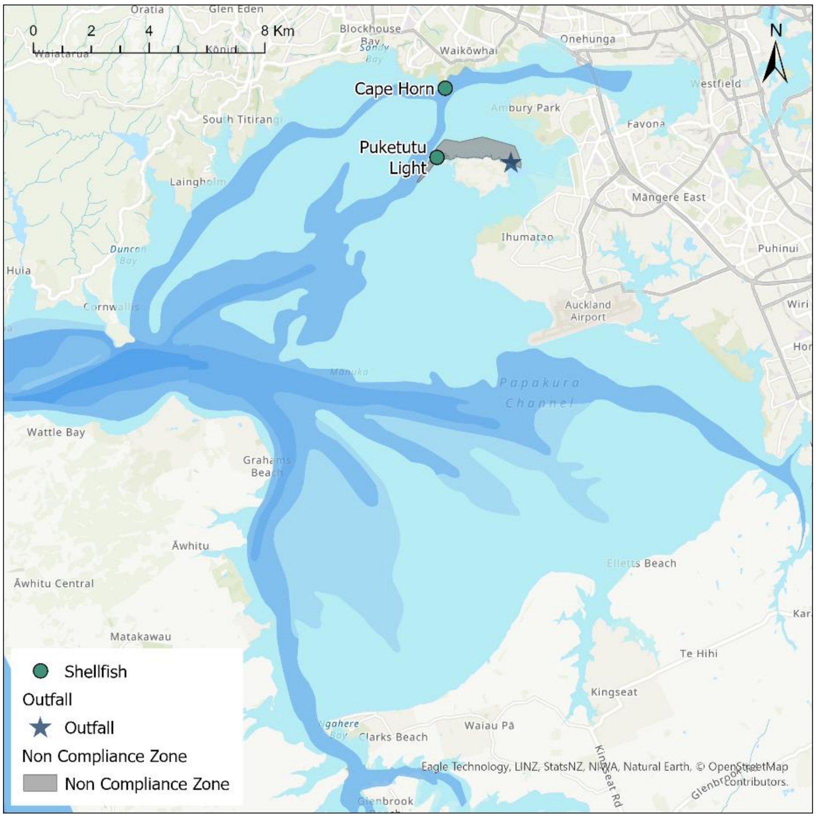


Figure 6: Shellfish (oyster) contaminant monitoring sites.



3 DISCHARGE VOLUMES AND LOADS

Discharge volumes, concentrations and loads of nutrients, total suspended solids (TSS) and five-day biochemical oxygen demand (BOD_5) were provided by Watercare Services[2]. Details of the sampling methods and frequency are provided in Watercare Services Ltd (2011). Briefly, nitrate-nitrite-nitrogen (NNN) and TN loads were based on concentrations obtained from seven-day composite samples, while estimates for the other parameters were based on average concentrations of multiple samples obtained during each seven-day sampling period. Discharge volumes were totaled over the seven days. Ammonia and BOD_5 samples were typically sourced from the ultraviolet (UV)-treated effluent at M15 (immediately upstream of discharge), but occasionally were taken from secondary effluent at M10 (between the reactor clarifiers and UV disinfection) when data from the discharge pump station were unavailable due to equipment or sampling failure. The results from M15 are directly comparable with those of M10, but have been shown to be slightly lower (Tan 2013; McBride & Zeldis 2012). Note that discharge loads include bypass contributions of secondary treated wastewater, but bypass volumes and durations are also presented separately.

Estimates of total monthly discharge volumes and loads were plotted using R Studio and analysed using the Time Trends (version 11.1) seasonal Kendall trend test (see Jowett (2009) for more details). This analysis effectively combines two separate tests:

- Seasonal Kendall test, which involves running separate Mann-Kendall trend tests on individual months over the time series, whereby interannual data are only compared with

[2] Discharge loads include bypass loads.

data from the same month, e.g., January data are only compared with other January data. Mann-Kendall trend tests compare consecutive data points in a time series to determine if changes are positive or negative. Large numbers of positive changes are regarded as evidence of an increasing trend. Large numbers of negative changes are regarded as evidence of a decreasing trend. The results for each month are then combined, and the significance of the overall result is determined.

- Sen slope estimation over the time series, which involves calculating individual slopes between consecutive data points in a time series and then taking the median annual slope from those values.

Both methods are insensitive to outliers, but trends derived from short-term data sets are not considered to be reliable because anomalies can have an undue influence on the results. Ten years of data is generally considered to be a reasonable timeframe for assessing trends in water quality data. It is long enough to counter the influence of short-term anomalies, and short enough to minimise the potential for historic data to "dampen" the detection of emerging trends. In this report, locally estimated scatterplot smoothing (LOESS) lines (± 95% CI) have also been fitted to each plot to assist with the visualisation of shorter-term fluctuations.

Monthly variation in total discharge volumes and total contaminant loads are shown in Figure 7, with Sen slopes and LOESS smoothing lines fitted. Between July 2015 and June 2025, significant declining trends of 3.8–4.2% per annum were detected in ammoniacal-N, SRP, TP and BOD_5 loads (Table 2). None of the parameters monitored displayed statistically significant increasing 10-year trends.

However, LOESS smoothing lines show that while discharge volumes were relatively stable over the 10-year period, discharge loads of NNN, SRP and TP were declining for most of the 10-year period, but have recently started increasing. The NNN minimum was centred around 2021, and the phosphorus minimum was centred around 2022. Since then, loads of NNN, DRP and TP have increased rapidly, and in 2025 were comparable to those at the start of the 10-year period (2015). In contrast, only slight fluctuations occurred in ammoniacal-N, TSS, and BOD_5 loads over the same period.

Seasonal and interannual variation was apparent in the occurrence, volume and durations of bypass events occurring between July 2015 and June 2025, but there did not appear to be any consistent long-term trends in the occurrence of those events (Figure 8). In the latest year (July 2024 to June 2025), 12 bypass events occurred.

Table 2: Seasonal Kendall test results and Sen slope estimates derived from total monthly discharge volumes and loads between July 2015 and June 2025. Statistically significant trends (i.e., those with p values of ≤0.05) are shown in red.

Variable	Significance (p value)	Median Sen slope (annual)	Annual change (% of median)
Discharge Volume	0.314	0.06	0.6
Nitrate-Nitrite-Nitrogen	0.128	-1.073	-1.9
Total Nitrogen	0.084	-1.352	-1.7
Ammoniacal-N	0.028	-0.336	-3.9
Soluble Reactive Phosphorus	0.002	-0.616	-4.2
Total Phosphorus	0.004	-0.764	-3.9
BOD_5	0.002	-1.108	-3.8
Total Suspended Solids	0.188	-0.81	-1.4

Figure 7: Total monthly discharge volumes, nutrient loads, biological oxygen demand and total suspended solids from the Mangere Wastewater Treatment Plant between July 2015 and June 2025. Sen slopes are fitted, with line colour indicating statistical significance. Dark blue lines are from LOESS smoothing (± 95% CI).

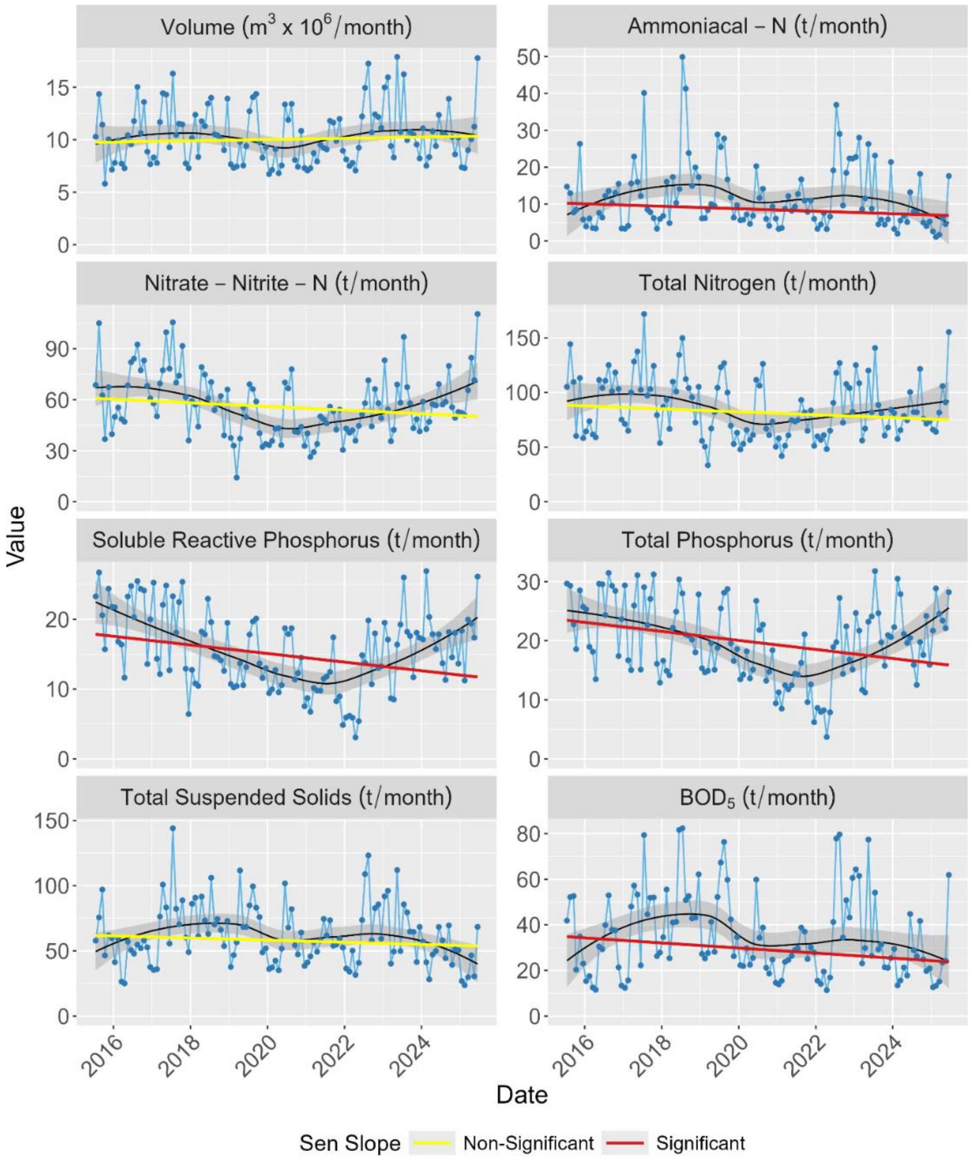
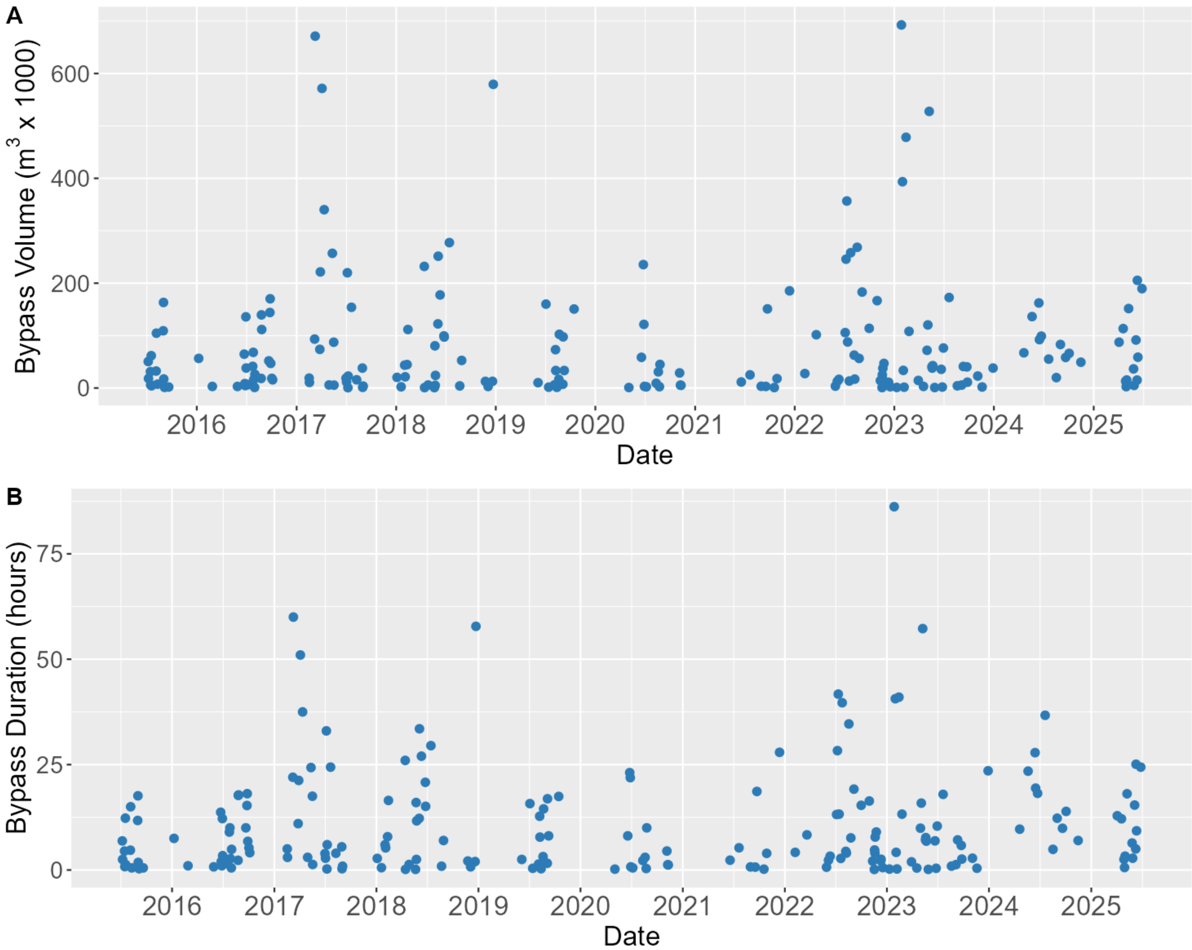


Figure 8: Volumes and duration of secondary-treated wastewater bypassed between July 2015 and June 2025.



4 HARBOUR WATER QUALITY

4.1 HARBOUR WATER QUALITY METHODS

4.1.1 SAMPLE COLLECTION AND ANALYSIS

Monthly water samples were collected by helicopter, with samples obtained 2.5 to 4 hours after high tide. On each occasion, *in situ* readings were also obtained for water temperature, salinity and dissolved oxygen (DO) concentrations. The use of a helicopter ensured that all samples were collected within a reliable and narrow timeframe, and at approximately the same tidal stage. Water samples from Watercare's sites were then delivered to Watercare Laboratories, and analysed in accordance with the methods specified in the Monitoring Management Plan (Watercare Services Ltd 2011), as outlined in Table 3.

Table 3: Analytical methods for water samples.

Parameter	Analytical Method	Units
Ammoniacal-N	APHA (2005) 4500-NH3 G (mod)	mg/L
Chlorophyll *a*	APHA (2005) 10200 H	g/m^3
Dissolved oxygen	APHA (2005) 4500 – O, G	mg/L
Dissolved oxygen	APHA (2005) 4500 – O, G	% saturation
Enterococci	APHA (2005) 9230C	MPN/100 mL
Faecal coliforms	APHA (2005) 9222D	cfu/100 mL
Nitrate and nitrite-nitrogen	APHA (2005) 4100 B	mg/L
Total Kjeldahl Nitrogen (TKN)	APHA (2005) 4500-org A, D (mod)	mg/L
pH	APHA (2005) –H, B	pH unit
Reactive phosphate (SRP)	APHA (2005) 4500-P, F (mod)	mg/L
Total phosphorus	APHA (2005) 4500-P, B, F (mod)	mg/L
Salinity	APHA (2005) 2520 B	ppt
Temperature	APHA (2005) 2550 B	°C
Turbidity	APHA (2005) 2130 B (mod)	NTU

4.1.2 QUALITY CONTROL, DATA STORAGE AND ANALYSIS

To ensure consistency across the monitoring programme, quality control was undertaken in accordance with Auckland Council's internal standards, including procedures for the collection, transport and storage of samples, and methods for data verification and quality assurance. All field and laboratory data are stored in the Council's water quality archiving database KiWQM.

Samples from the Watercare sites were analysed by Watercare Laboratory Services Ltd, an IANZ-accredited laboratory. Analytical methods follow the "Standard Methods for the Examination of Water and Wastewater" 18th Edition (APHA 1992). Auckland Council samples were also analysed by Watercare Laboratory Services Ltd until June 2017. From July 2017, Auckland Council samples were analysed by Hill Laboratories. Poor consistency in the results for several parameters, including ammoniacal-N, total Kjeldahl nitrogen (TKN), TN, chlorophyll *a* and TSS, were detected between the laboratories. Those changes have prevented 10-year trend analyses from being carried out on affected sites (see Section 4.2.3).

A slight step change in TN concentrations also occurred around the beginning of 2016 in samples analysed by Watercare Laboratory Services. The reasons for this have been provided by Dr Steve Money (Department Head – Inorganic Chemistry, pers. com.) and are summarised in Appendix H.

4.1.3 DATA ANALYSIS

The focus of this report is on characterising existing harbour water quality and detecting emerging trends. Water quality data from the preceding 1- and 10-year periods were analysed to:

1. Summarise water quality results obtained from the past year (July 2024 to June 2025) using spatial bubble plots.
2. Examine spatial patterns in water quality using box plots of data obtained over the 10-year period from July 2015 to June 2025.

3. Detect temporal trends in water quality over the 10-year period from July 2015 to June 2025 (note that information from earlier periods is presented in the annual monitoring reports produced since 2011, and in Scarsbrook (2008) and Kelly (2010)).

Spatial and temporal trends were assessed for the concentrations of key nutrients, chlorophyll *a* (as an indicator of primary productivity), dissolved oxygen, enterococci, faecal coliforms,[3] TSS, and turbidity. Salinity and temperature data are also presented for reference. Chlorophyll *a* concentrations were also compared against the reference value of 0.03 mg/L defined by the Harbour Water Quality Task Force (1994).

Trend analyses were carried out using Time Trends (version 11.1) seasonal Kendall test (see Section 3 for more details). Note that the trend analysis is not designed to assess seasonal variation. It is a non-parametric analysis that effectively "averages out" seasonal variability to unmask underlying trends. However, in this report, LOESS smoothing lines (± 95% CI) have also been fitted to each plot to assist with the visualisation of shorter-term fluctuations in water quality results.

Prior to 2024, all analyses used randomised, imputed values from regression on order statistics (ROS) (R statistical software) for results that were below detection limits (as previously used for national reporting of coastal water quality by MfE (Dudley et al. 2017, Dudley & Jones-Todd 2018)). However, the methods used for reporting national trends in coastal water quality have changed (Fraser et al. 2021)—the use of ROS values has been replaced with a "high-censor" filter for left-censored values for trend analyses. The filter applies the highest detection limit to all values below it, which minimises biases arising from changes in detection limits over the period being assessed. That method has been adopted for trend analyses in this report.

In addition, mean summer (December to April), TN and $\log_{10}$ chlorophyll *a* concentrations for data obtained between July 2015 and June 2025 were plotted, and relationships between mean summer (December to April) TN, and mean and maximum summer chlorophyll *a* concentrations were assessed in accordance with the recommendations of Kelly (2018). To avoid the influence of laboratory artefacts, only results from:

- Watercare sites during the summers of 2016 (Dec 2015–Apr 2016) to 2024 (Dec 2023–Apr 2024); and,
- Auckland Council sites during the summers of 2018 (Dec 2015–Apr 2016) to 2024 (Dec 2023–Apr 2024);

were used, and data below detection limits were omitted from the analysis of relationships between TN and chlorophyll *a*.

[3] Microbial data are not plotted or statistically analysed due to low and patchy numbers.

4.2 HARBOUR WATER QUALITY RESULTS

4.2.1 JULY 2024 TO JUNE 2025: GENERAL SPATIAL PATTERNS BY PARAMETER

4.2.1.1 AMMONIACAL-N

Monthly median ammoniacal-N (NH_3-NH_4-N) concentrations obtained during the 2024–25 monitoring period were elevated in the north-eastern part of Manukau Harbour and rapidly declined with increasing distance from the treatment plant (Figure 9). Median concentrations reached 'background' levels, similar to those in the outer Manukau Harbour, mid-way along Purakau Channel. Median ammoniacal-N concentrations were relatively low in the southern harbour, with the highest southern harbour concentrations recorded at the Weymouth site.

4.2.1.2 NITRATE- AND NITRITE-NITROGEN

Monthly median nitrate-N, nitrite-N, and nitrate-nitrite-N (NNN) concentrations obtained during the 2024–25 monitoring period were elevated in the north-eastern part of Manukau Harbour and rapidly declined west of the treatment plant (NNN concentrations are shown in Figure 10). Median concentrations of nitrite-N, nitrate-N and NNN reached 'background' levels, similar to those obtained at the entrance to the Manukau Harbour, in the mid to outer section of Purakau Channel. Median concentrations were relatively low in southern harbour sites.

4.2.1.3 TOTAL INORGANIC NITROGEN (TIN)

Total inorganic nitrogen is the sum of ammoniacal-N and NNN. Median monthly TIN concentrations obtained during the 2024–25 monitoring period were elevated in the north-eastern part of Manukau Harbour and rapidly declined west of the treatment plant (Figure 11). Median concentrations reached 'background' levels, similar to those obtained at the entrance to Manukau Harbour, in the mid to outer section of Purakau Channel. Median concentrations were low in southern harbour sites.

4.2.1.4 TOTAL KJELDAHL NITROGEN (TKN)

Total Kjeldahl nitrogen is the sum of ammoniacal-N and nitrogen in organic substances. Highest median monthly TKN concentrations were obtained from the Wairopa and Puketutu sites (Figure 12). The HWQ 30, Titirangi, and Weymouth harbour sites had moderately elevated TKN concentrations. Lower concentrations were recorded at the Waiuku Channel and HWQ 80 sites, and the lowest concentrations were obtained from the harbour mouth.

4.2.1.5 TOTAL NITROGEN

Highest median monthly TN concentrations were obtained from the Puketutu site (Figure 13). Concentrations were moderately elevated at the Wairopa, HWQ 30, and Titirangi sites, and low elsewhere.

4.2.1.6 SOLUBLE REACTIVE PHOSPHORUS (SRP)

Monthly median SRP concentrations obtained during the 2024–25 monitoring period were elevated in the north-eastern part of Manukau Harbour and rapidly declined west of the treatment plant (Figure 14). Concentrations reached 'background' levels, similar to those obtained in the southern harbour and the harbour entrance, in the mid-section of Purakau Channel. All sites in the southern Manukau Harbour had low SRP concentrations.

4.2.1.7 TOTAL PHOSPHORUS

Monthly median total phosphorus concentrations obtained during the 2024–25 monitoring period were elevated in the north-eastern part of Manukau Harbour and declined west of the treatment plant (Figure 15). Median concentrations reached 'background' levels, similar to those obtained at the harbour entrance, in the mid to outer section of Purakau Channel. Sites in the southern Manukau Harbour had low total phosphorus concentrations.

4.2.1.8 CHLOROPHYLL *A*

Median monthly chlorophyll *a* concentrations obtained during the 2024–25 monitoring period ranged from 0.0007 mg/L to 0.0028 mg/L (Figure 16). Concentrations never exceeded the Harbour Water Quality Task Force's reference value for chlorophyll *a* of 0.03 mg/L.

4.2.1.9 DISSOLVED OXYGEN

Median saturation levels of dissolved oxygen were close to 100%, with saturation levels and concentrations ranging from 95.6% to 102.9%, and 7.58 to 8.06 mg/L, respectively. Lowest saturation levels were obtained from the southern harbour sites, while highest levels and greatest variability occurred at the northern harbour sites (Figure 17 to Figure 18).

4.2.1.10 pH

Variation in median pH values ranged from 8.08 to 8.18 in the 2024–25 year (Figure 19). Lowest values were recorded at sites with lowest salinity levels (i.e., in channels at the entrance to harbour tributaries).

4.2.1.11 SALINITY

Median salinity levels ranged from 31.1 ppt at the Wairopa site to 34.3 ppt at the Harbour Mouth site. The variation in salinity reflects the influence of freshwater inputs.

4.2.1.12 TEMPERATURE

Seasonal water temperatures ranged from 12.3 °C in winter to 22.6 °C in summer.

4.2.1.13 TURBIDITY AND TOTAL SUSPENDED SOLIDS

Median turbidity ranged from 1 to 6.3 NTU, while median TSS concentrations ranged from 4 to 16 mg/L. Median values for both parameters were highest in the Wairopa, HWQ 30, Weymouth, HWQ 80 and Clarks sites and declined towards the Harbour Mouth (Figure 21 and Figure 22).

4.2.1.14 ENTEROCOCCI AND FAECAL COLIFORMS

Monthly enterococci and faecal coliforms concentrations are only obtained from the four Watercare monitoring sites (HWQ 30, HWQ 60, HWQ 70 and HWQ 80). Enterococci concentrations were at the detection limit of 10 MPN/100 ml in all 48 samples analysed during the year. Faecal coliform concentrations were also low (<10 CFU/100 ml) in 44 of the 48 samples analysed. The highest concentration obtained was 38 CFU/100 ml obtained from the HWQ 80 (Auckland Airport) sites on 1 August 2024.

Figure 9: Bubble plot of median ammoniacal-N concentrations obtained in the July 2024 to June 2025 monitoring period.

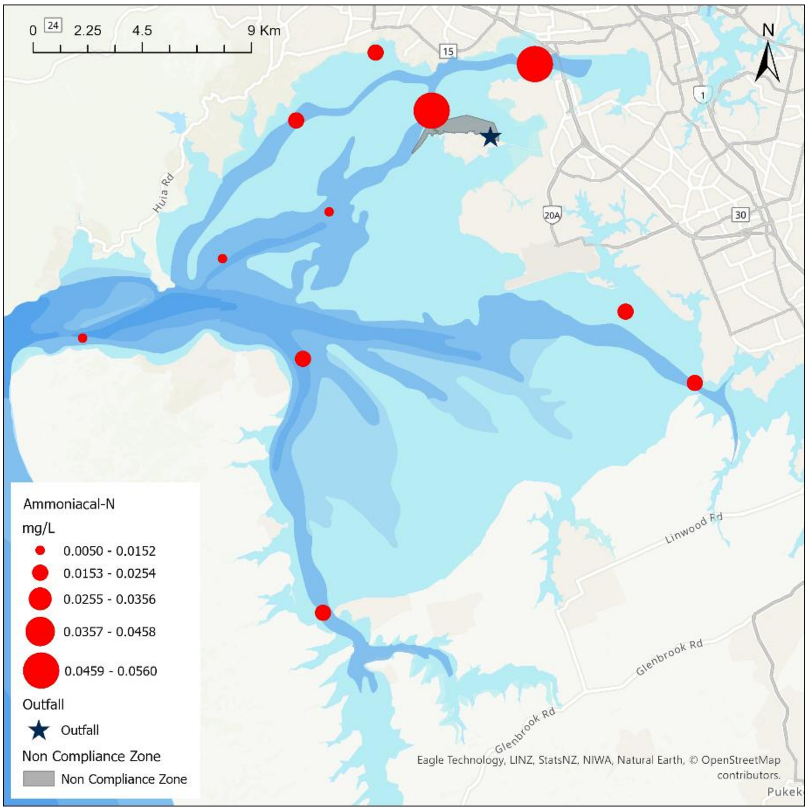


Figure 10: Bubble plot of median nitrate-nitrite-N concentrations obtained in the July 2024 to June 2025 monitoring period.

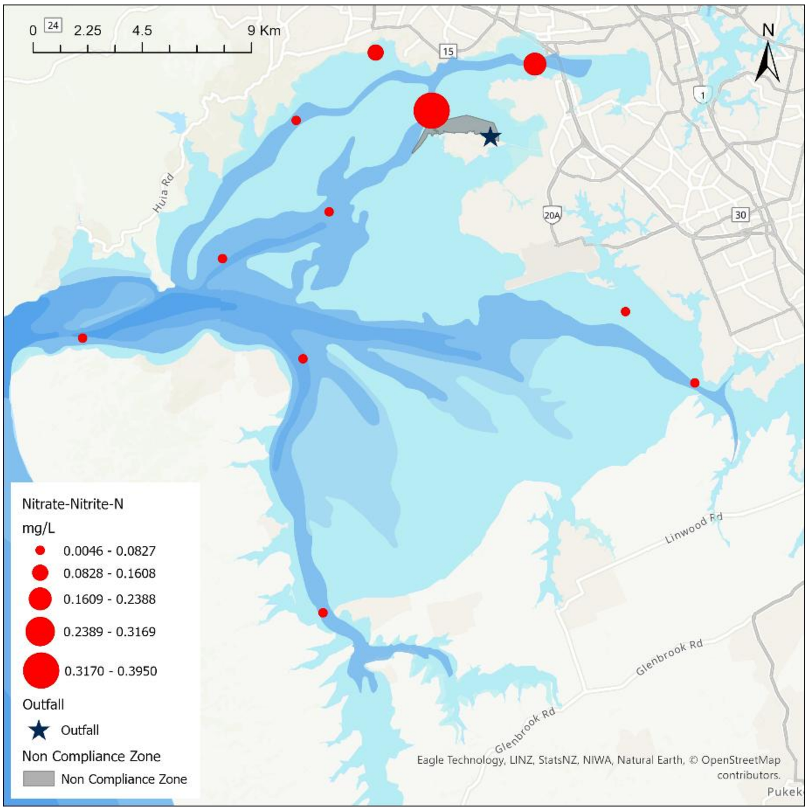


Figure 11: Bubble plot of median total inorganic nitrogen concentrations obtained in the July 2024 to June 2025 monitoring period.

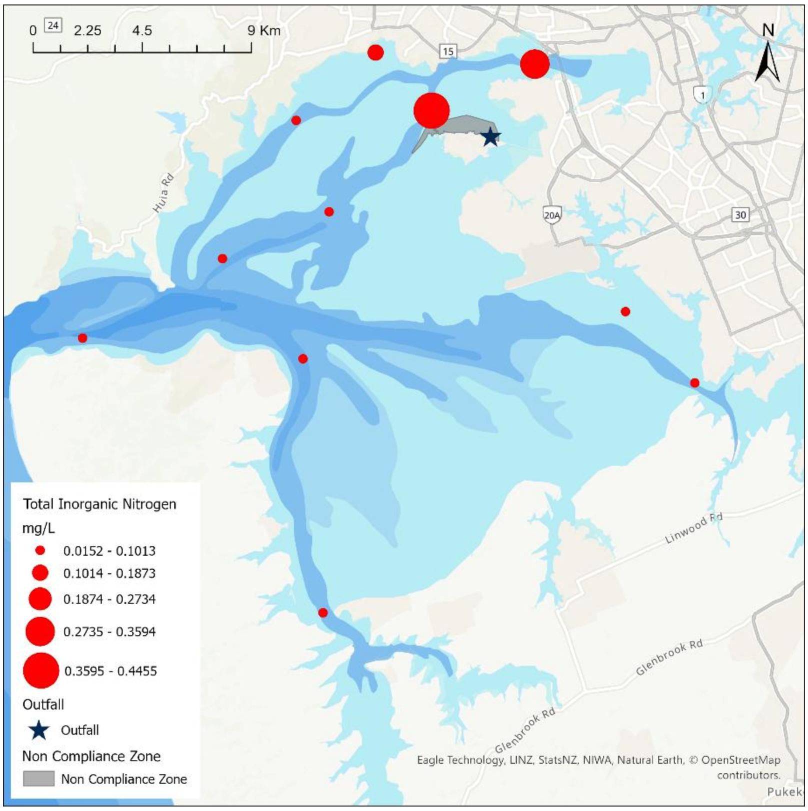


Figure 12: Bubble plot of median total Kjeldahl nitrogen (TKN) concentrations obtained in the July 2024 to June 2025 monitoring period.

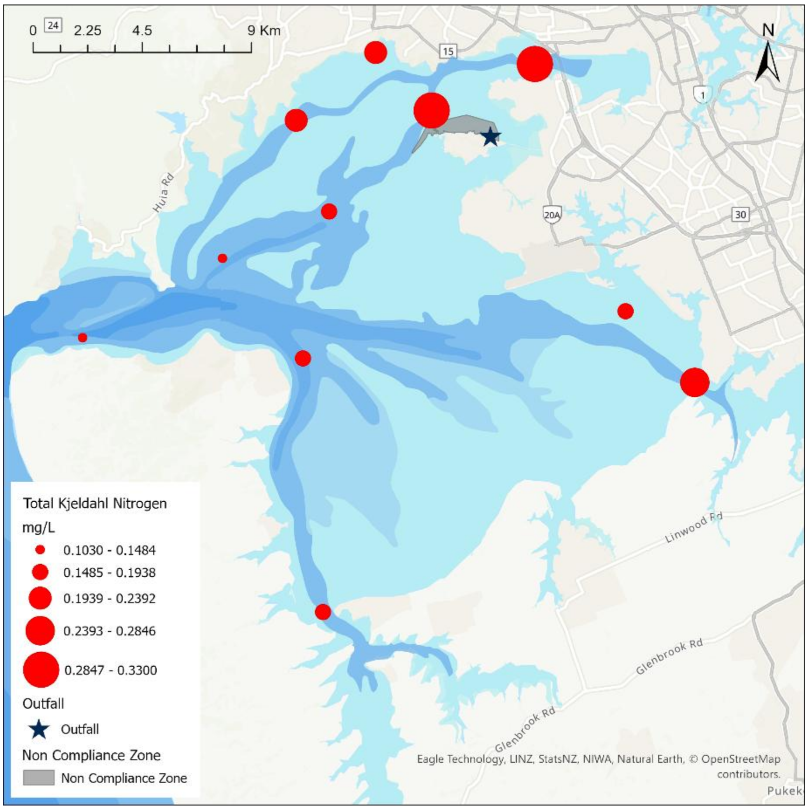


Figure 13: Bubble plot of median total nitrogen concentrations obtained in the July 2024 to June 2025 monitoring period.

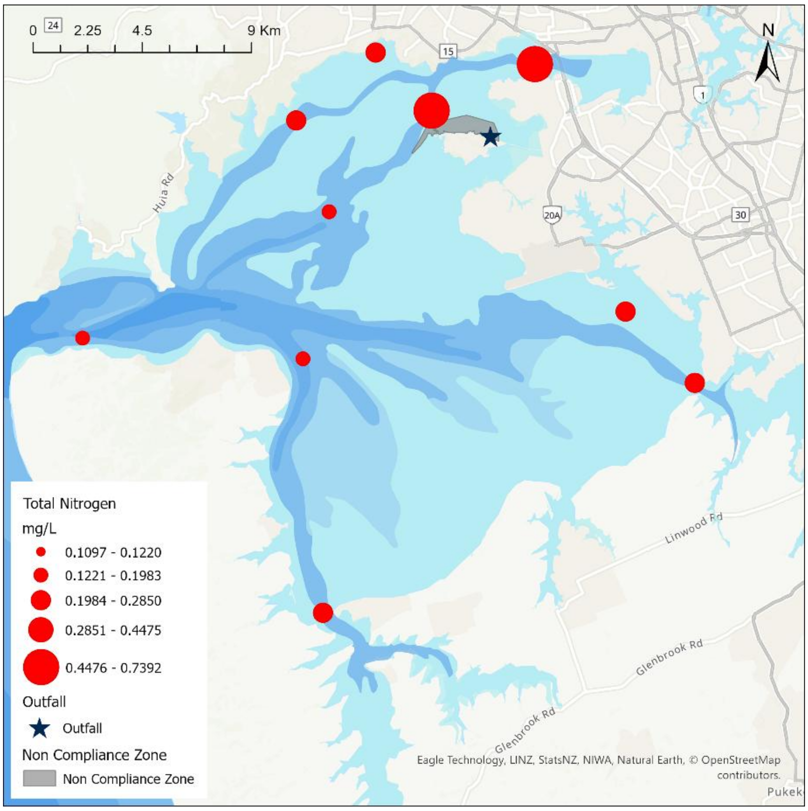


Figure 14: Bubble plot of median soluble reactive phosphorus concentrations obtained in the July 2024 to June 2025 monitoring period.

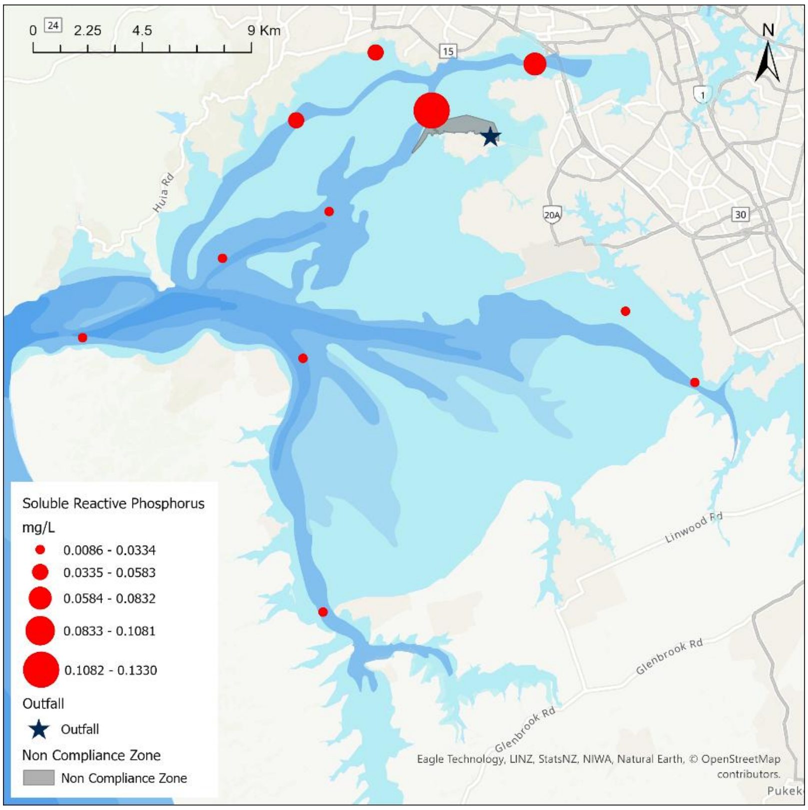


Figure 15: Bubble plot of median total phosphorus concentrations obtained in the July 2024 to June 2025 monitoring period.

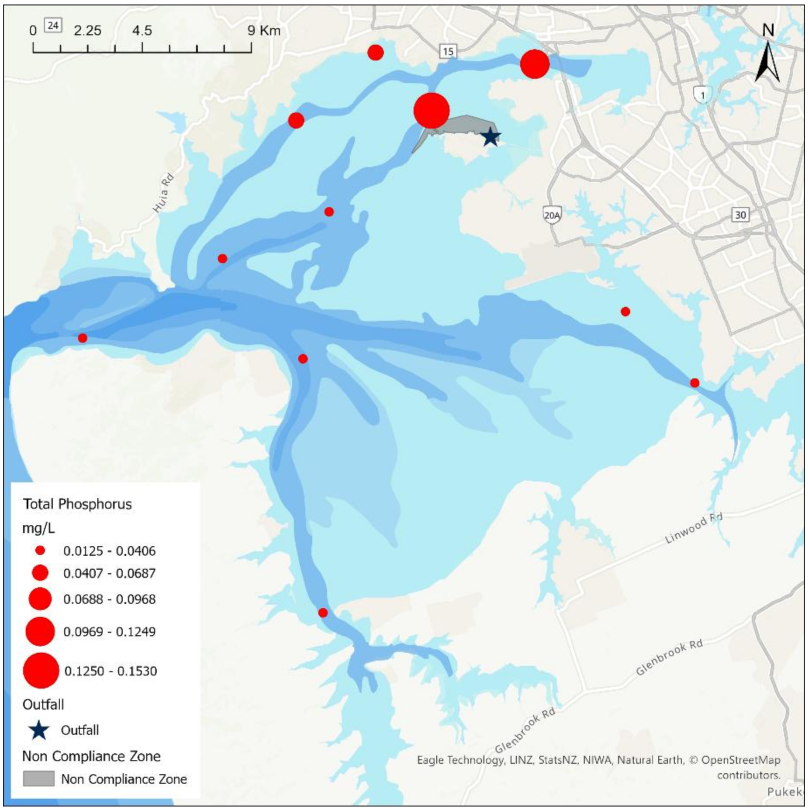


Figure 16: Bubble plot of median chlorophyll *a* concentrations obtained in the July 2024 to June 2025 monitoring period.

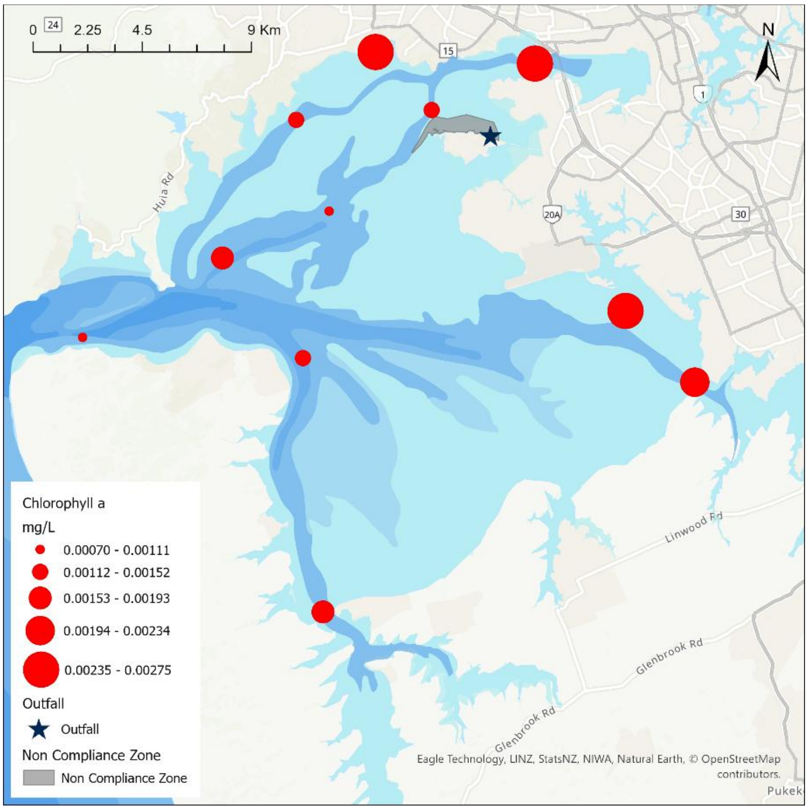


Figure 17: Bubble plot of median dissolved oxygen concentrations (mg/L) obtained in the July 2024 to June 2025 monitoring period.

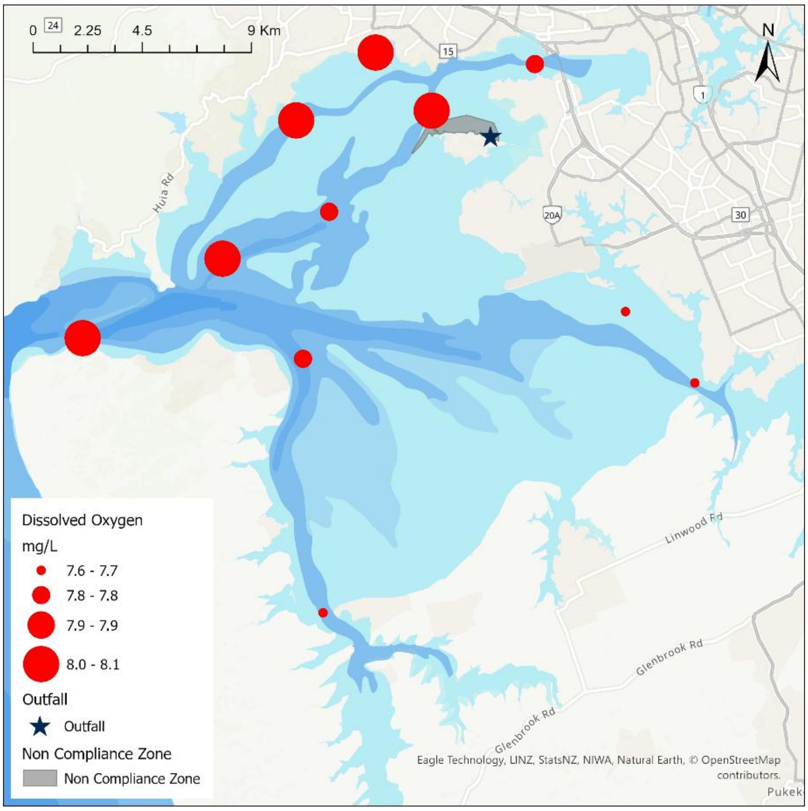


Figure 18: Bubble plot of dissolved oxygen saturation (%) obtained in the July 2024 to June 2025 monitoring period.

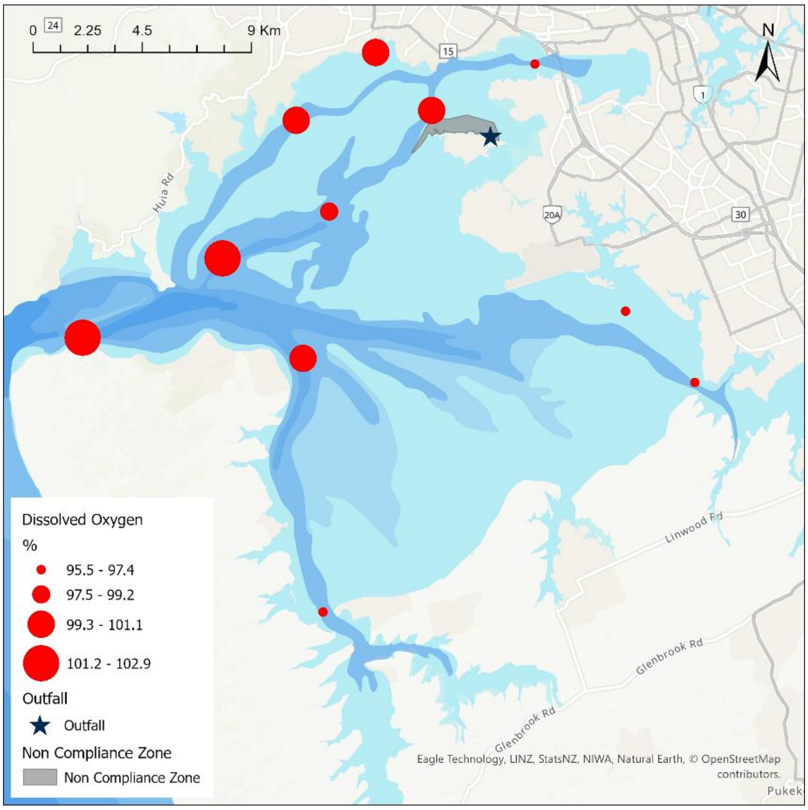


Figure 19: Bubble plot of median pH levels obtained in the July 2024 to June 2025 monitoring period.

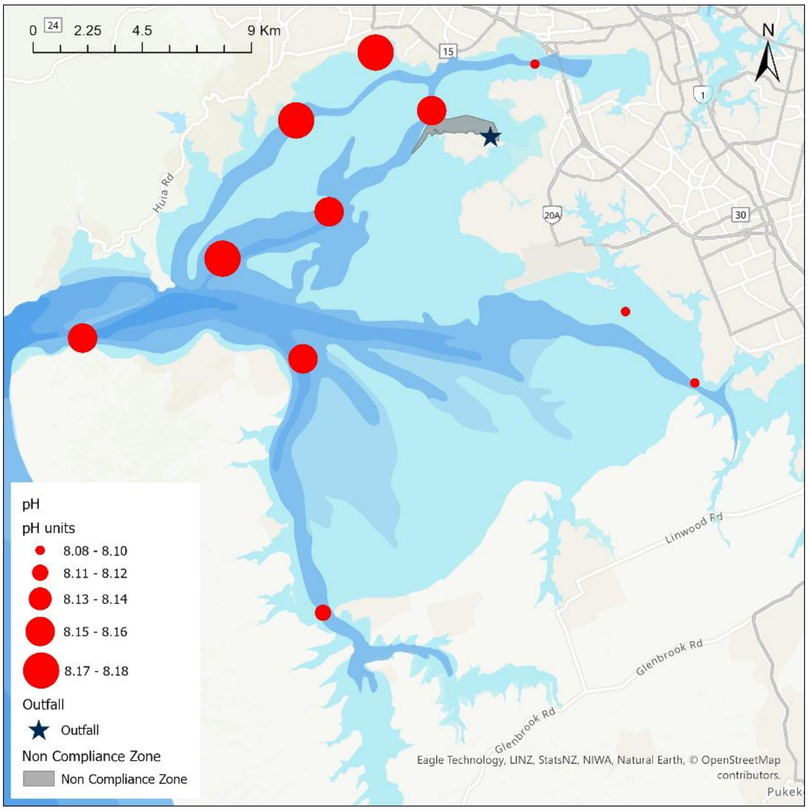


Figure 20: Bubble plot of median salinity (ppt) obtained in the July 2024 to June 2025 monitoring period.

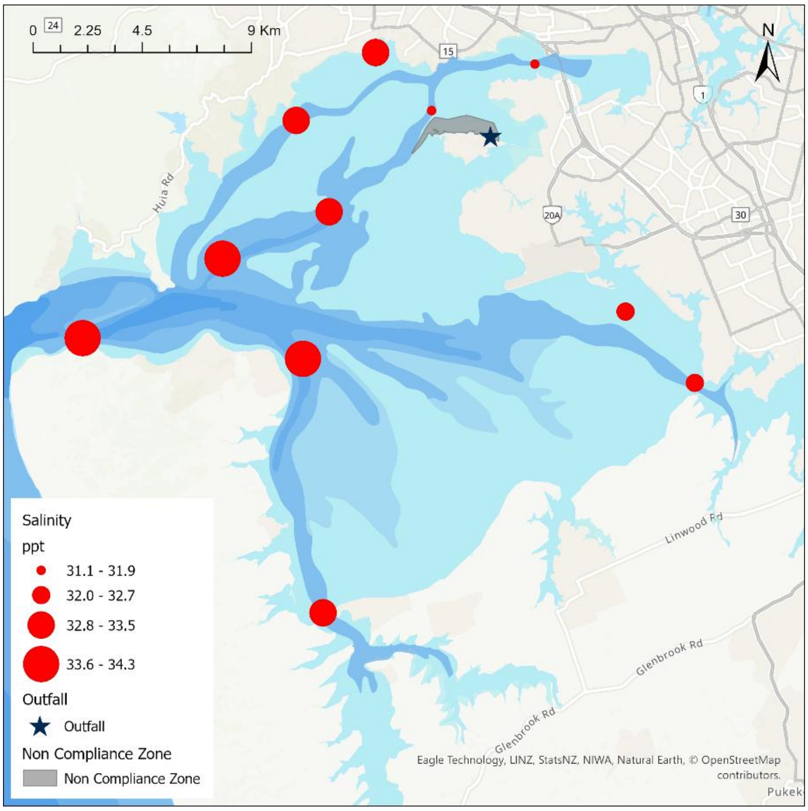


Figure 21: Bubble plot of median turbidity (NTU) obtained in the July 2024 to June 2025 monitoring period.

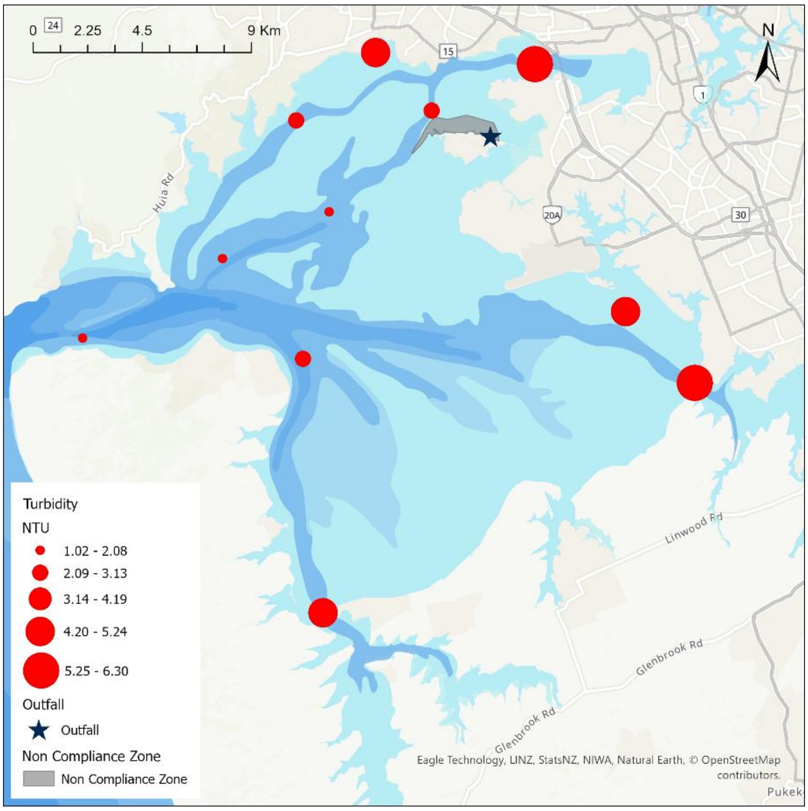
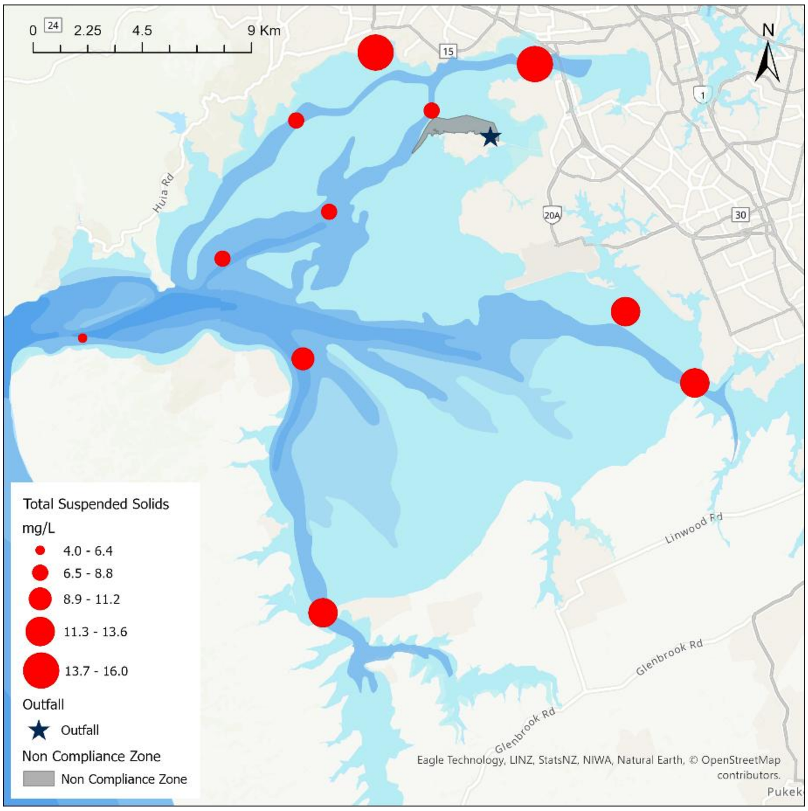


Figure 22: Bubble plot of median total suspended solids concentrations obtained in the July 2024 to June 2025 monitoring period.



4.2.2 SPATIAL PATTERNS IN WATER QUALITY

Boxplots of nutrient data pooled from monitoring carried out between July 2015 and June 2025 show spatial gradients in nitrogen concentrations down the main channels of the northern and southern harbour. Pooled ammoniacal-N, NNN, and TN data from the previous 10 years (Figure 23) shows:

- Highest concentrations occur at sites nearest to the treatment plant (Puketutu and Wairopa), with elevated levels extending approximately halfway down the Purakau and Wairopa Channels. Concentrations are close to 'background' levels, similar to those found at the Harbour Mouth, near the entrance to Purakau Channel (i.e., by site HWQ 70).
- Highest concentrations in the southern harbour occur in the upper channel sites (Clarks in the Waiuku Channel and Weymouth in Papakura Channel), with concentrations declining down those channels.

Pooled concentrations of SRP and total phosphorus were also highest in the northern harbour sites with similar gradients running down Purakau and Wairopa Channels (Figure 23). However, phosphorus concentrations in the southern harbour sites were generally low, with only slight gradients down Papakura and Waiuku Channels.

The gradients in nitrogen and phosphorus concentrations were reflected in the variation[4] of chlorophyll *a*, with sites toward the treatment plant and up Papakura Channel displaying greater variability (i.e., displaying stronger seasonal algal blooms) than the more remote sites (Figure 23 and Figure 27). The Harbour Water Quality Task Force (1994) trigger value for chlorophyll *a* was exceeded on three occasions between 2015 and 2025 (December 2015, October 2016 and November 2021 at the Wairopa site).

Total suspended solids, turbidity, salinity and pH also displayed spatial gradients, with TSS and turbidity decreasing, and salinity and pH increasing down both the northern and southern channels of the harbour[5]. Dissolved oxygen tended to be more variable at the northern harbour sites, while temperature was slightly more variable at the mid to inner harbour sites compared with the outer harbour sites (HWQ 70 and Harbour Mouth) (Figure 25).

[4] As indicated by the standard deviation of annual chlorophyll *a* concentrations.

[5] Abnormally low pH results were obtained from all sites in January and October 2016 (see outliers in Figure 25) are assumed to be related to an instrument error.

Figure 23: Monthly concentrations of ammoniacal-N, nitrate-nitrite-N and total nitrogen at monitoring sites in Manukau Harbour. Data were pooled from July 2015 to June 2025. Boxplots show median values with 25th to 75th percentiles (box), 5th and 95th percentiles (whiskers), and outliers (points).

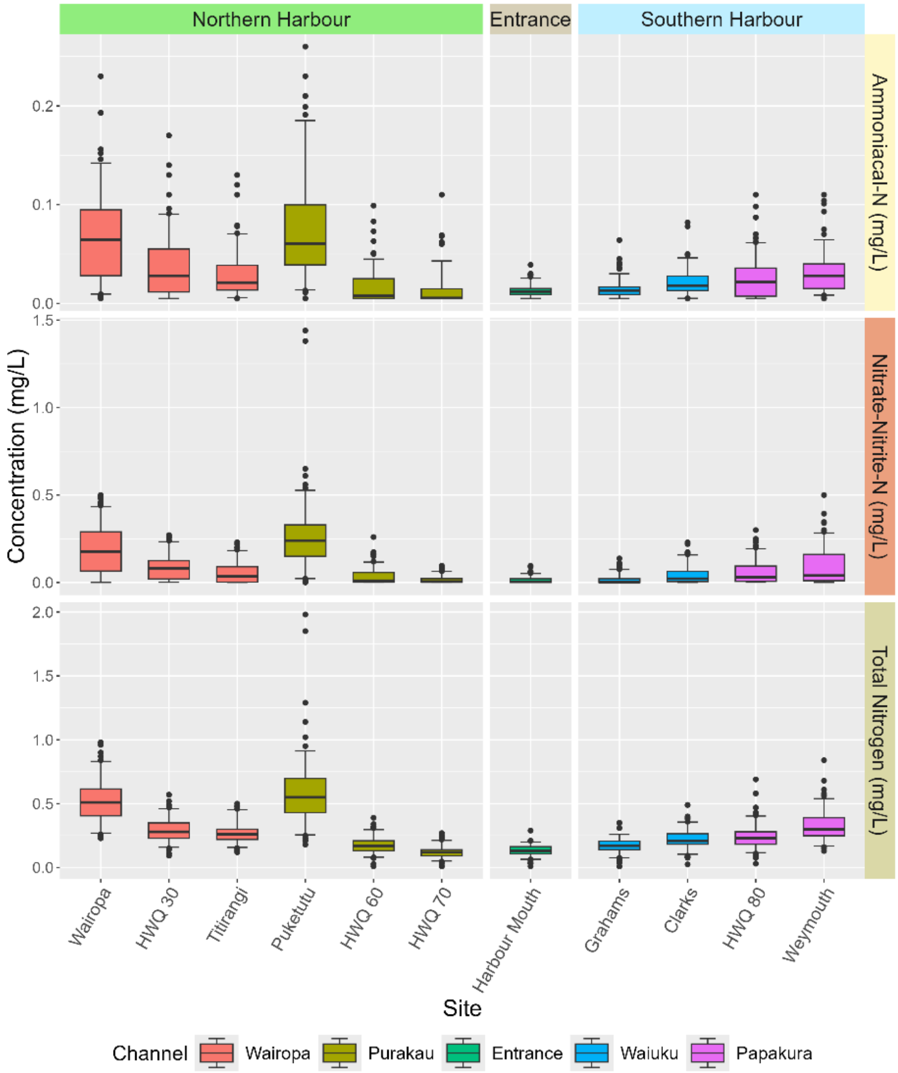


Figure 24: Monthly concentrations of soluble reactive phosphorus (SRP), total phosphorus, and chlorophyll *a* at monitoring sites in Manukau Harbour. Data were pooled from July 2015 to June 2025. The dashed red line shows the Harbour Water Quality Task Force's reference value for chlorophyll *a*. Boxplots show median values with 25th to 75th percentiles (box), 5th and 95th percentiles (whiskers), and outliers (points).

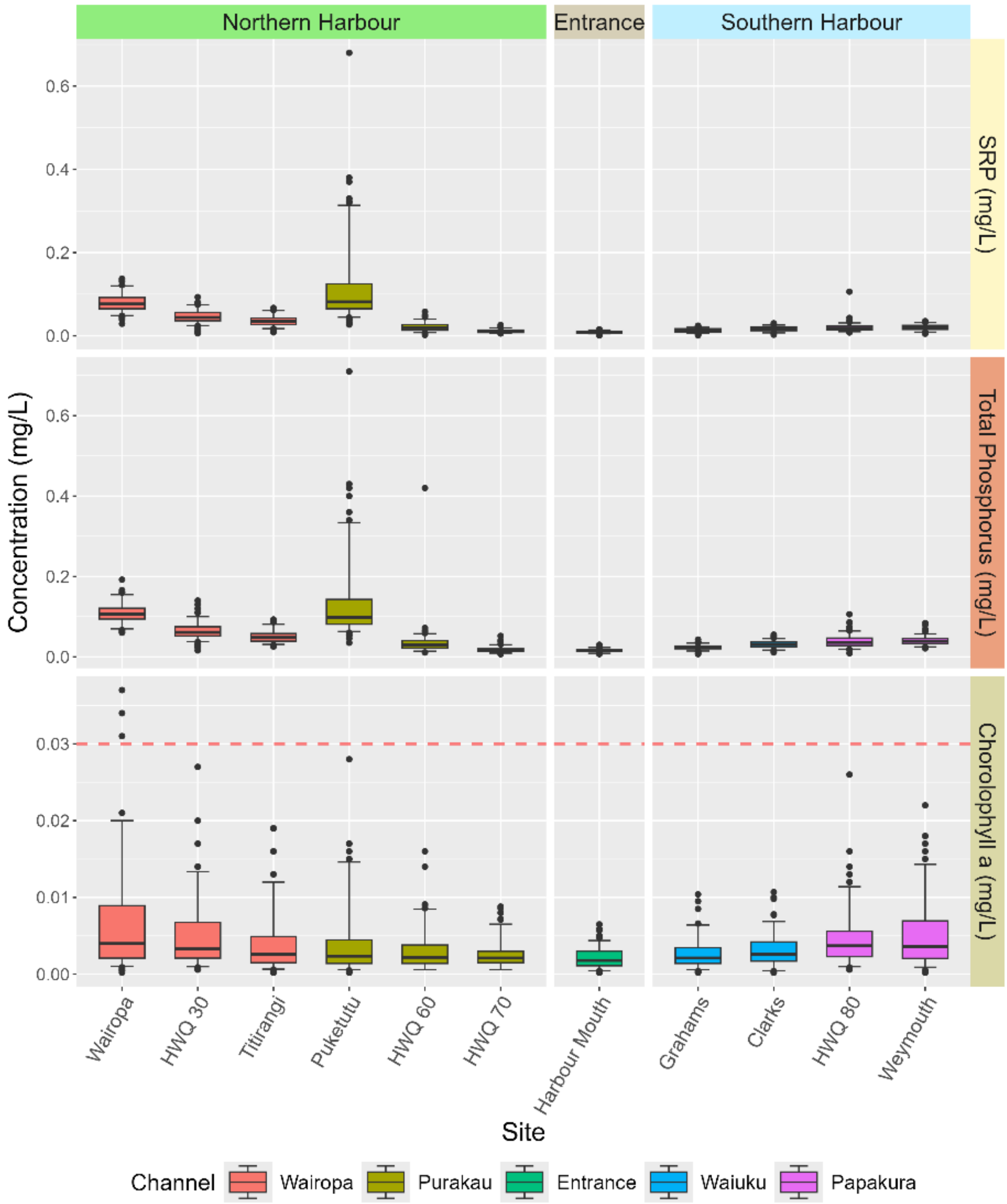


Figure 25: Monthly measurements of total suspended solids, turbidity and salinity at monitoring sites in Manukau Harbour. Data were pooled from July 2015 to June 2025. Boxplots show median values with 25th to 75th percentiles (box), 5th and 95th percentiles (whiskers), and outliers (points).

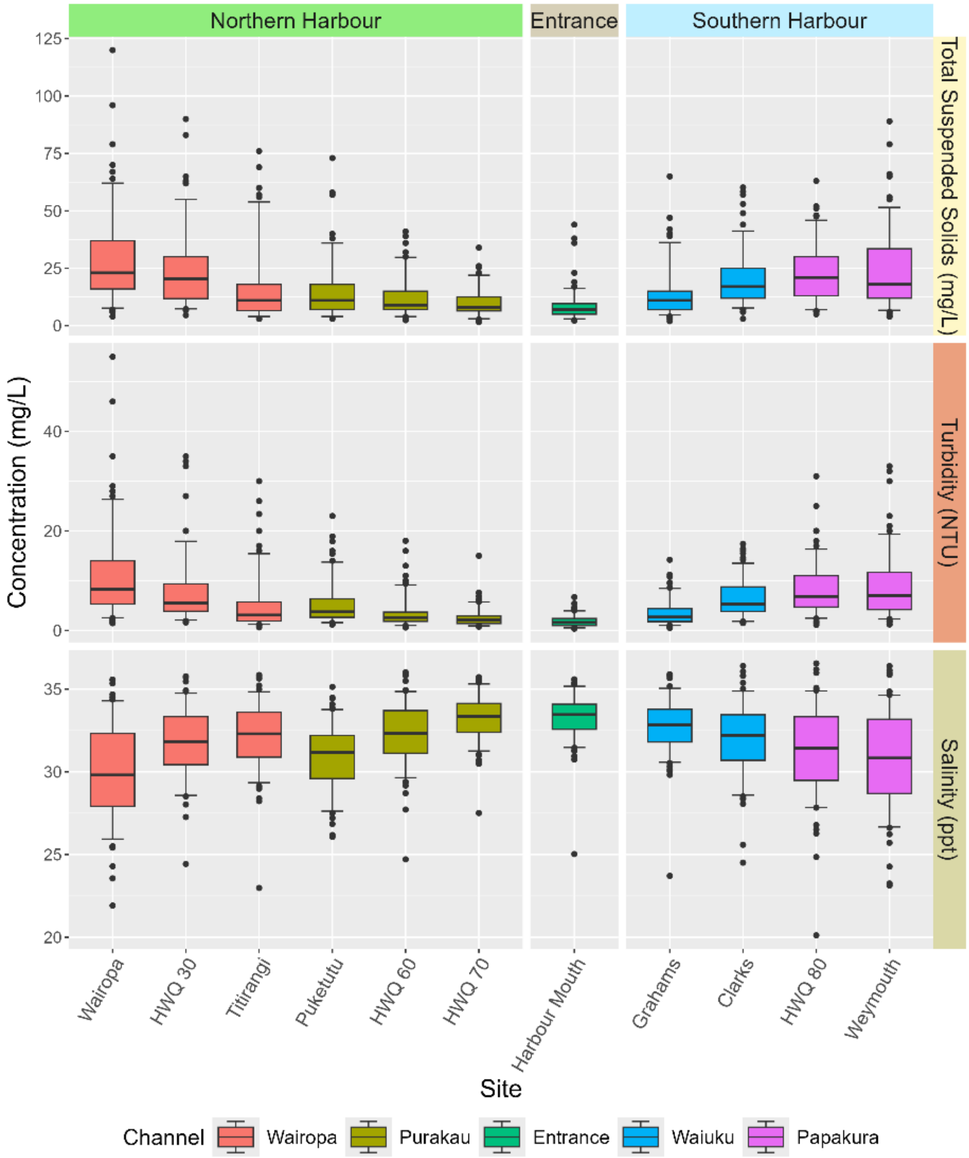


Figure 26: Monthly measurements of temperature, dissolved oxygen and pH at monitoring sites in Manukau Harbour. Data were pooled from July 2015 to June 2025. Boxplots show median values with 25th to 75th percentiles (box), 5th and 95th percentiles (whiskers), and outliers (points).

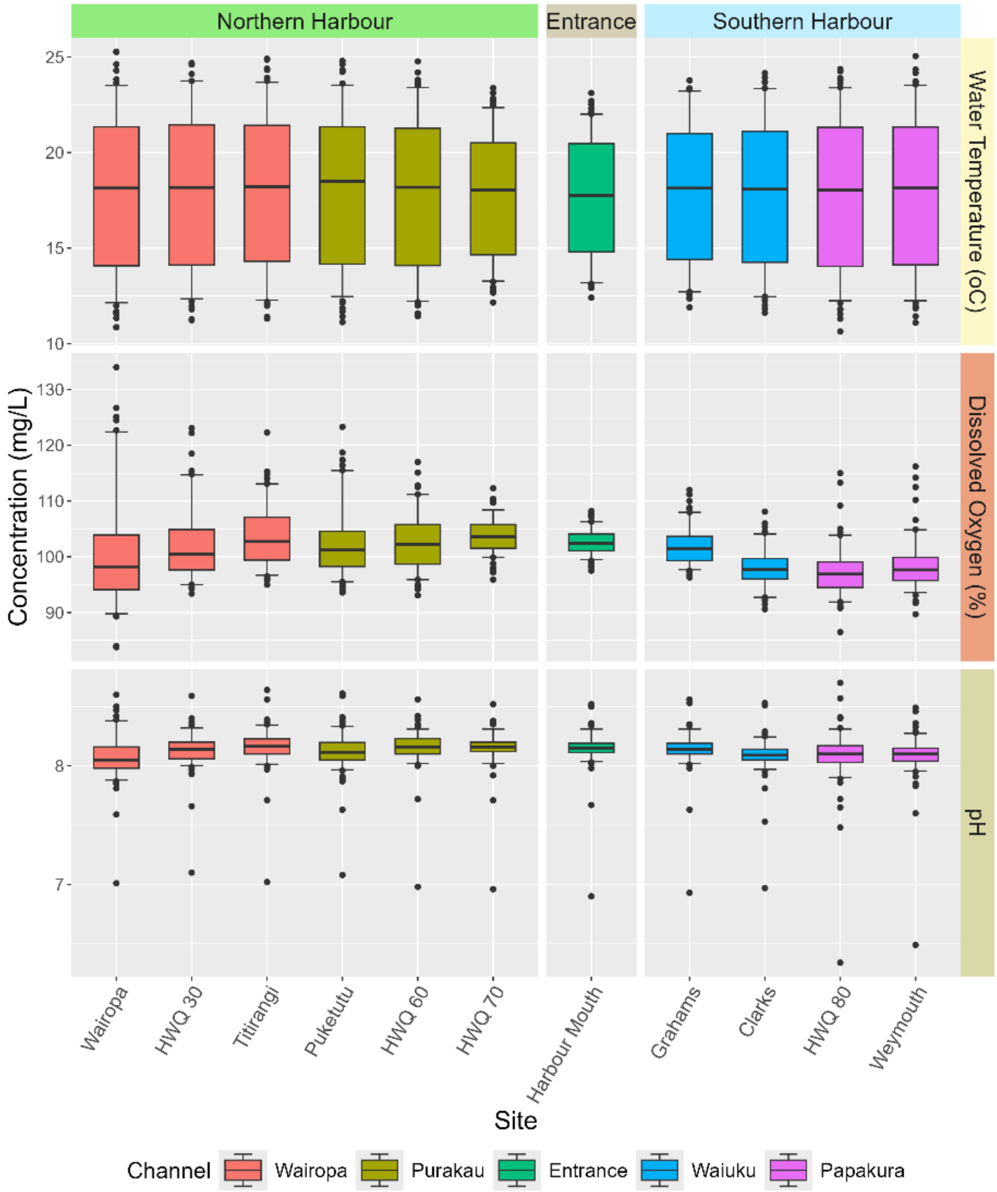
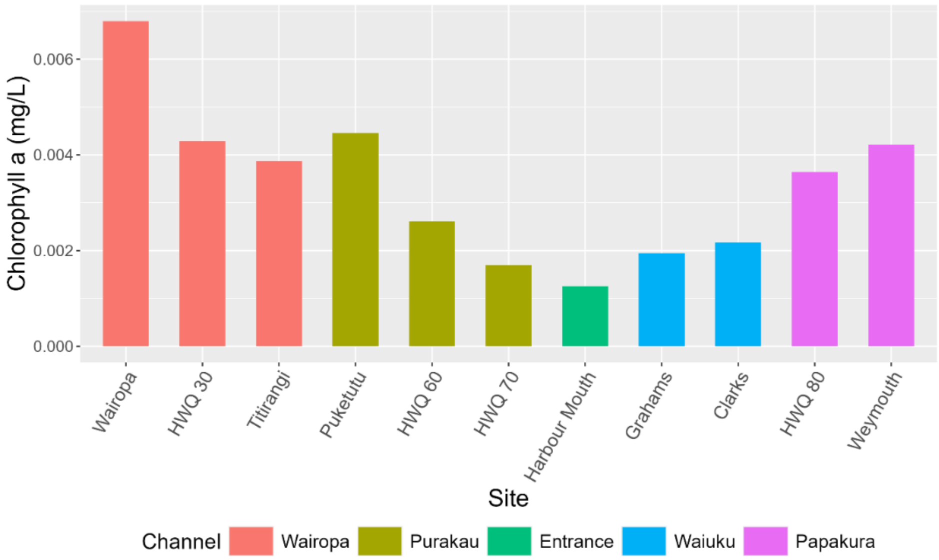


Figure 27: Standard deviations of monthly chlorophyll *a* concentrations obtained from monitoring sites between July 2015 to June 2025.



4.2.3 TEMPORAL TRENDS IN WATER QUALITY

Ammoniacal-N, TN, chlorophyll *a* and TSS at Auckland Council sites underwent step-changes in low-level concentrations that occurred from mid-2017 onwards. The timing of those changes coincided with the Auckland Council moving the testing of their samples from Watercare Laboratory Services to Hill Laboratories. Consequently, 2015–25 trend estimates are not provided for those variables at the Wairopa, Puketutu, Titirangi, Harbour Mouth, Grahams Beach, Clarks or Weymouth sites (as per previous annual monitoring reports).

Another slight step change in TN concentrations occurred at all sites around the beginning of 2016 (see Section 4.1.2). Because of changes highlighted above, formal trend analyses were not carried out on TN data from any site.

For the period between July 2015 and June 2025, seasonal Kendall tests (Table 4 and Table 5) detected, and LOESS smoothing showed:

- No significant 10-year trends in ammoniacal-N, TIN, SRP, water temperature or pH.
- LOESS smoothing shows:
  - Ammoniacal-N concentrations have fluctuated at all sites without displaying consistent patterns (Figure 28).
  - An upswing is apparent in TIN concentrations at the Puketutu site in 2022, with a subsequent increase in TIN variability since 2023 (this mirrors the patterns below for NNN). Concentrations at other sites have fluctuated over time without displaying consistent patterns (Figure 30).
  - An upswing in SRP concentrations and variability at the Puketutu site since 2022, which coincides with the similar upswing in discharge loads (Figure 7). LOESS smoothing of SRP concentrations at sites along Wairopa Channel also mirror recent patterns in discharge loads (Figure 32).

- Strong seasonality in temperature readings, but interannual patterns are not apparent over the 10-year period (Figure 37).
- Similar temporal fluctuations in pH at all sites, with no consistent trend (Figure 39).

- A significant increasing 10-year trend in NNN concentrations at the Puketutu site (8.2% per year). That trend appears to be related to an upswing in NNN concentrations at that site since 2022, and a subsequent increase in NNN variability since 2023. Those changes coincide with a similar upswing in discharge loads. LOESS smoothing shows that NNN concentrations at other sites have fluctuated over time without displaying consistent patterns or trends (Figure 29).
- Significant declining 10-year trends in TP of 2.9 to 5.4% per year at six of the 11 monitoring sites, and a significant increasing trend of 2.7% per year at the Puketutu site (Figure 33). The increasing trend is related to an upswing in TP concentrations and variability since 2022. The recent increases in TP (and SRP) at the Puketutu site coincide with upswings in discharge loads (Figure 7). LOESS smoothing curves of TP and SRP concentrations from sites along Wairopa Channel also mirror the patterns in discharge loads.
- Significant declining 10-year trends of 3.4 to 9.7% per year in turbidity at eight of the 11 monitoring sites (Puketutu, HWQ 30, Titirangi, Harbour Mouth, Grahams, Clarks, HWQ 80 and Weymouth) (Figure 35).
- Significant declining 10-year trends of 4.7 to 5.7% per year in TSS at two of the four sites with sufficient data for trend analyses (HWQ 30 and HWQ 80), and a significant increase of 4.9% at the HWQ 70 site (Figure 36).
- Significant declining 10-year trends of 4.4 to 10.2% per year in chlorophyll *a* concentrations at three of the four sites with sufficient data for trend analyses (HWQ 30, HWQ 60, HWQ 70).
- Seasonal fluctuations in DO concentrations, with a significant declining 10-year trend of 0.5% at the HWQ 60 site.

While formal trend analyses were not carried out on TN concentrations, plotted data from the period since the laboratory changes suggest that significant trends are unlikely to have occurred at all sites except Puketutu, where TN displayed an upswing in concentrations in 2022, and a subsequent increase in variability since 2023 (Figure 31).

4.2.4 RELATIONSHIPS BETWEEN NITROGEN AND CHLOROPHYLL *A*

Temporal trends and relationships between summer TN, and $\log_{10}$ chlorophyll *a* concentrations were examined using least squares regression. To avoid the influence of laboratory artefacts, results were pooled from:

- Watercare sites during the summers of 2016 (Dec 2015–Apr 2016) to 2024 (Dec 2023–Apr 2024);
- Auckland Council sites during the summers of 2018 (Dec 2015–Apr 2016) to 2024 (Dec 2023–Apr 2024).

Raw and mean summer TN and $\log_{10}$ chlorophyll *a* concentrations displayed high levels of variation within and between years. However, least squares linear regression did not detect consistent temporal trends in mean summer TN or $\log_{10}$ chlorophyll *a* concentrations at 10 of the 11 sites. The exception was the Puketutu, where a significant increasing trend in summer TN concentrations was detected between 2018 and 2024 (Figure 40). Conversely, a significant decreasing trend in summer chlorophyll *a* concentrations was detected at the Puketutu site over the same period (Figure 41).

For the analysis of relationships between TN and chlorophyll a, data from Auckland Council and Watercare sites were pooled separately, and values below detection limits were omitted. Pooling allowed a wider range of concentrations to be assessed in the analyses. However, the relationship between TN and chlorophyll *a* was markedly different at the Puketutu and Wairoa sites. Those sites were therefore analysed separately from the other Auckland Council sites.

Statistically significant relationships were detected between all combinations of data (Figure 42 and Figure 43). Apart from Puketutu and Wairoa, strong positive relationships were detected between mean TN concentrations and mean and maximum chlorophyll *a* concentrations at the Watercare and Auckland Council sites. Mean TN concentrations explained around 42% of the variation in mean ($p<0.0001$) and 30% of the of the variation in maximum ($p = 0.0006$) summer chlorophyll *a* concentrations in pooled results from the HWQ 30 to HWQ 80 Watercare sites, and 59% and 65% of the variation in mean ($p<0.0001$) and maximum ($p<0.0001$), respectively, of data pooled from five of the Auckland Council sites (Titirangi, Harbour Mouth, Grahams, Clarks and Weymouth).

Surprisingly, negative relationships were detected between mean summer concentrations of TN and mean and maximum concentrations of chlorophyll *a* in pooled data from the Puketutu and Wairoa sites. For those sites, pooled TN concentrations explained around 45% of the variation in mean ($p = 0.0044$), and 59% of the variation in maximum ($p = 0.0005$) chlorophyll *a* concentrations (Figure 42 and Figure 43).

Table 4: Sen slope estimates of annual change between July 2015 to June 2025, using monthly measurements of key water quality indicators. Statistically significant trends based on the Kendall statistic ($p < 0.05$) are shown in red. Northern harbour sites are highlighted in blue, while southern harbour sites are highlighted in green. Sites with less than 10 years of data and results from Council sites affected by a change in analytical laboratories have been omitted. Zero results indicate positive or negative trends of <0.0001 mg/L per year for nutrients and chlorophyll *a*, <0.001 NTU per year for turbidity, and <0.01 °C per year for temperature.

Site	Ammoniacal-N (mg/L/yr)	Nitrate-Nitrite N (mg/L/yr)	Total Inorganic Nitrogen (mg/L/yr)	Soluble Reactive Phosphorus (mg/L/yr)	Total Phosphorus (mg/L/yr)	Chlorophyll *a* (mg/L/yr)	Dissolved Oxygen (ppm/yr)	Turbidity (NTU/yr)	TSS (mg/L/yr)	Temperature (°C/yr)
Wairopa		-0.0013		-0.0007	-0.0009		-0.0251	-0.251		0.01
Puketutu		0.0181		0.0031	0.0027		-0.032	-0.271		0.02
HWQ 30	-0.001	-0.001	-0.0021	-0.0005	-0.0034	-0.0003	-0.0156	-0.287	-1.189	0.05
Titirangi		0		-0.0003	-0.0017		-0.0277	-0.301		0.02
HWQ 60	0.0004	0.001	0.0001	0.0005	-0.001	-0.0002	-0.0384	-0.075	0.099	0.05
HWQ 70	0.0011	0.0004	0.0002	0	-0.0006	-0.0001	-0.0322	0.033	0.401	0.07
Harbour Mouth		0.0009		-0.0001	-0.0006		-0.0187	-0.12		0.1
Grahams		0.001		0.0001	-0.0004		-0.0272	-0.103	0	0.06
Clarks		0.0001		0.0003	-0.0005		-0.0367	-0.391		0.08
HWQ 80	-0.0001	-0.001	-0.0017	0.0001	-0.0012	-0.0002	-0.0164	-0.507	-1.006	-0.01
Weymouth		-0.0014		0.0002	-0.0011		-0.0137	-0.68		0.04

Table 5: Sen slope estimates of annual trends as a percentage of median values between July 2015 to June 2025. Statistically significant trends based on the Kendall statistic (p < 0.05) are shown in red. Northern harbour sites are highlighted in blue, while southern harbour sites are highlighted in green. Sites with less than 10 years of data and results from Council sites affected by a change in analytical laboratories have been omitted. Zero results indicate positive or negative trends of <0.1 % per year.

Site	Ammoniacal-N (%/yr)	Nitrate-Nitrite N (%/yr)	Total Inorganic Nitrogen (%/yr)	Soluble Reactive Phosphorus (%/yr)	Total Phosphorus (%/yr)	Chlorophyll *a* (%/yr)	Dissolved Oxygen (%/yr)	Turbidity (%/yr)	TSS (%/yr)	Temperature (%/yr)
Wairopa		-0.7		-0.9	-0.9		-0.3	-2.8		0.1
Puketutu		8.2		3.9	2.7		-0.4	-7.1		0.1
HWQ 30	-3.1	-1.3	-1.8	-1.2	-5.4	-10.2	-0.2	-4.8	-5.7	0.3
Titirangi		0		-1	-3.5		-0.3	-8.8		0.1
HWQ 60	3.9	5.4	0.4	2.4	-3.5	-7.6	-0.5	-2.8	1	0.3
HWQ 70	20.3	6.4	1.2	0	-3.8	-4.4	-0.4	1.6	4.9	0.4
Harbour Mouth		13		-1.6	-3.6		-0.2	-6.7		0.6
Grahams		13.9		1.2	-1.8		-0.3	-3.4		0.4
Clarks		0.2		1.6	-1.6		-0.5	-7.1		0.5
HWQ 80	-0.3	-2.7	-2.7	0.8	-3.4	-5.8	-0.2	-7.3	-4.7	-0.1
Weymouth		-2.6		1.4	-2.9		-0.2	-9.7		0.3

Figure 28: Variation in ammoniacal-N (NH_3-NH_4-N) concentrations obtained from water quality monitoring between July 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Point colours indicate whether results were above or below detection limits. Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

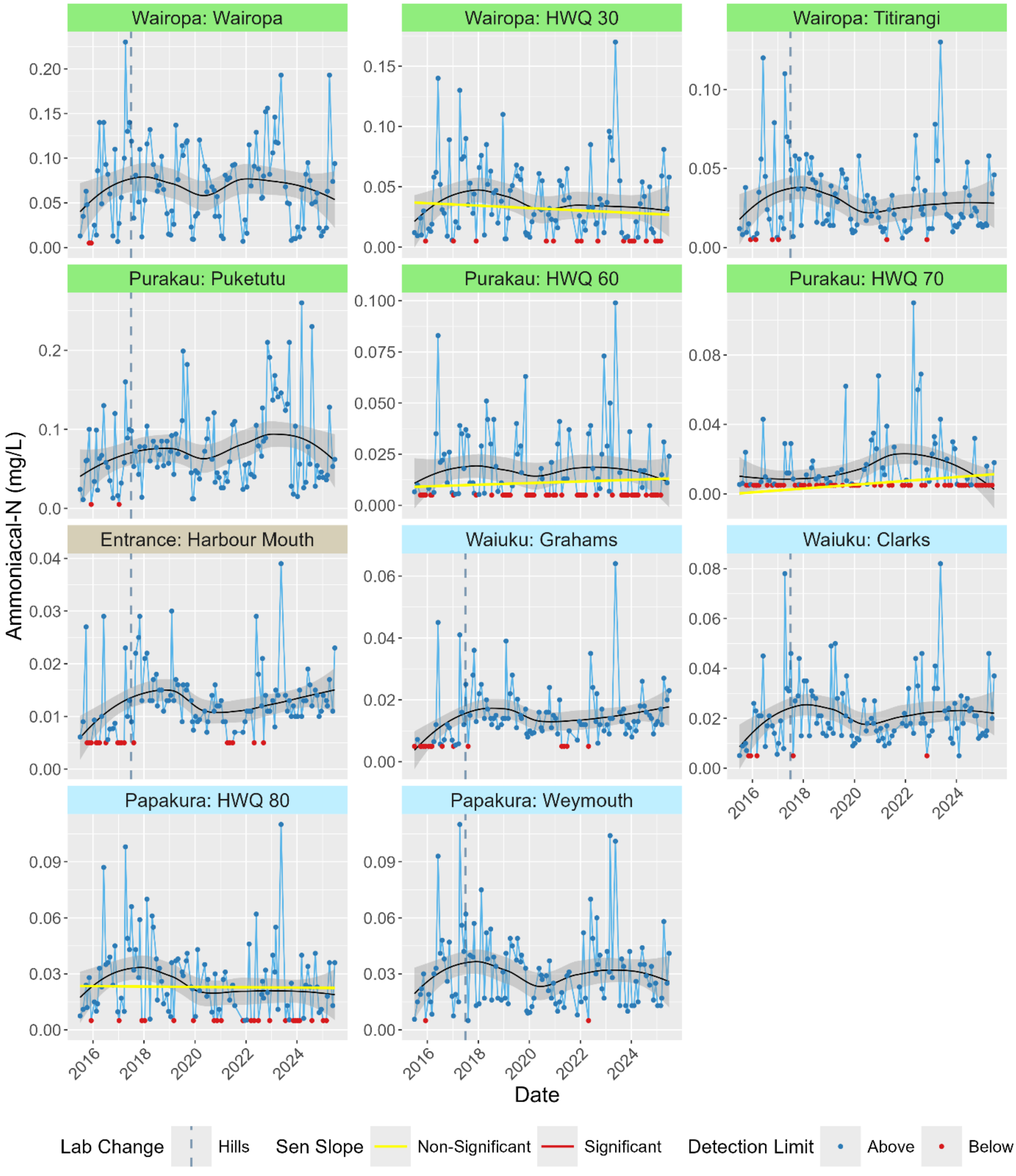


Figure 29: Variation in nitrate-nitrite-N concentrations obtained from water quality monitoring between July 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Point colours indicate whether results were above or below detection limits. Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

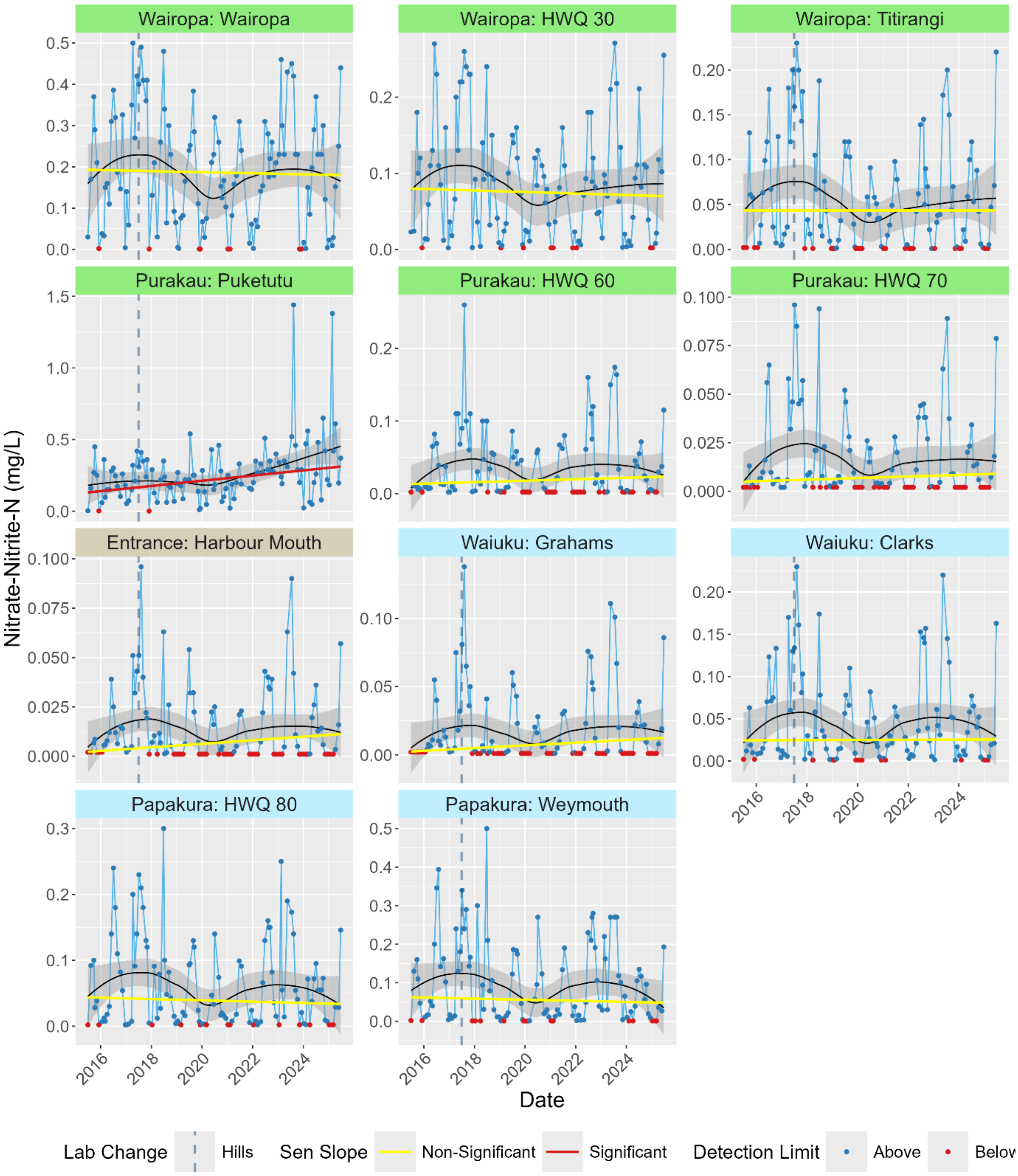


Figure 30: Variation in total inorganic nitrogen concentrations obtained from water quality monitoring between July 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Values associated with ammoniacal-N and/or nitrate-nitrite-N values below detection limits were derived using those detection limits. Note that the scale of the y-axis varies among graphs.

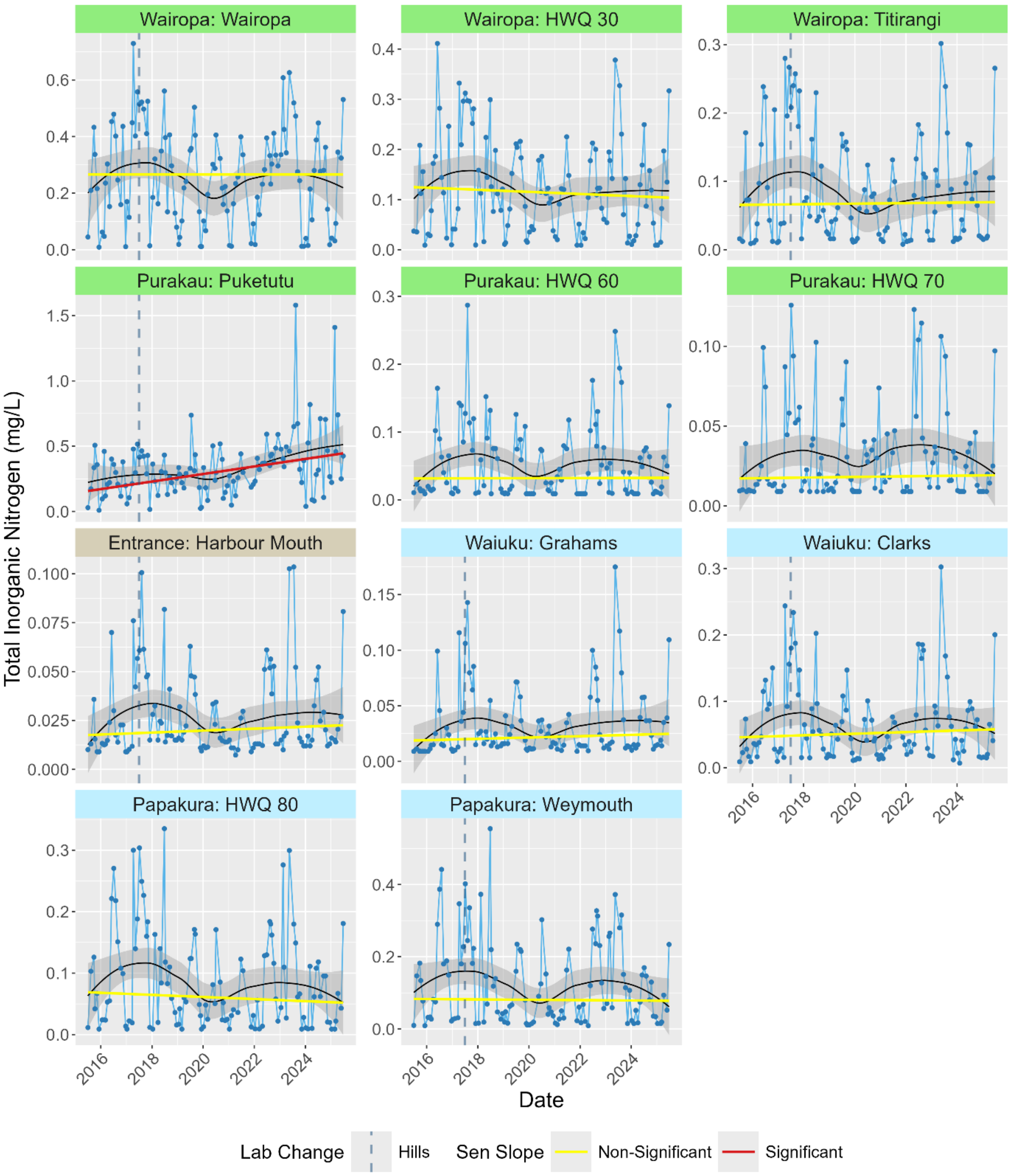


Figure 31: Variation in total nitrogen concentrations obtained from water quality monitoring between July 2015 and June 2025. Point colours indicate whether results were above or below detection limits. Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Trends have not been fitted because of laboratory-related step changes in concentrations that occurred partway through the time series (as indicated by the blue dashed lines). Note that the scale of the y-axis varies among graphs.

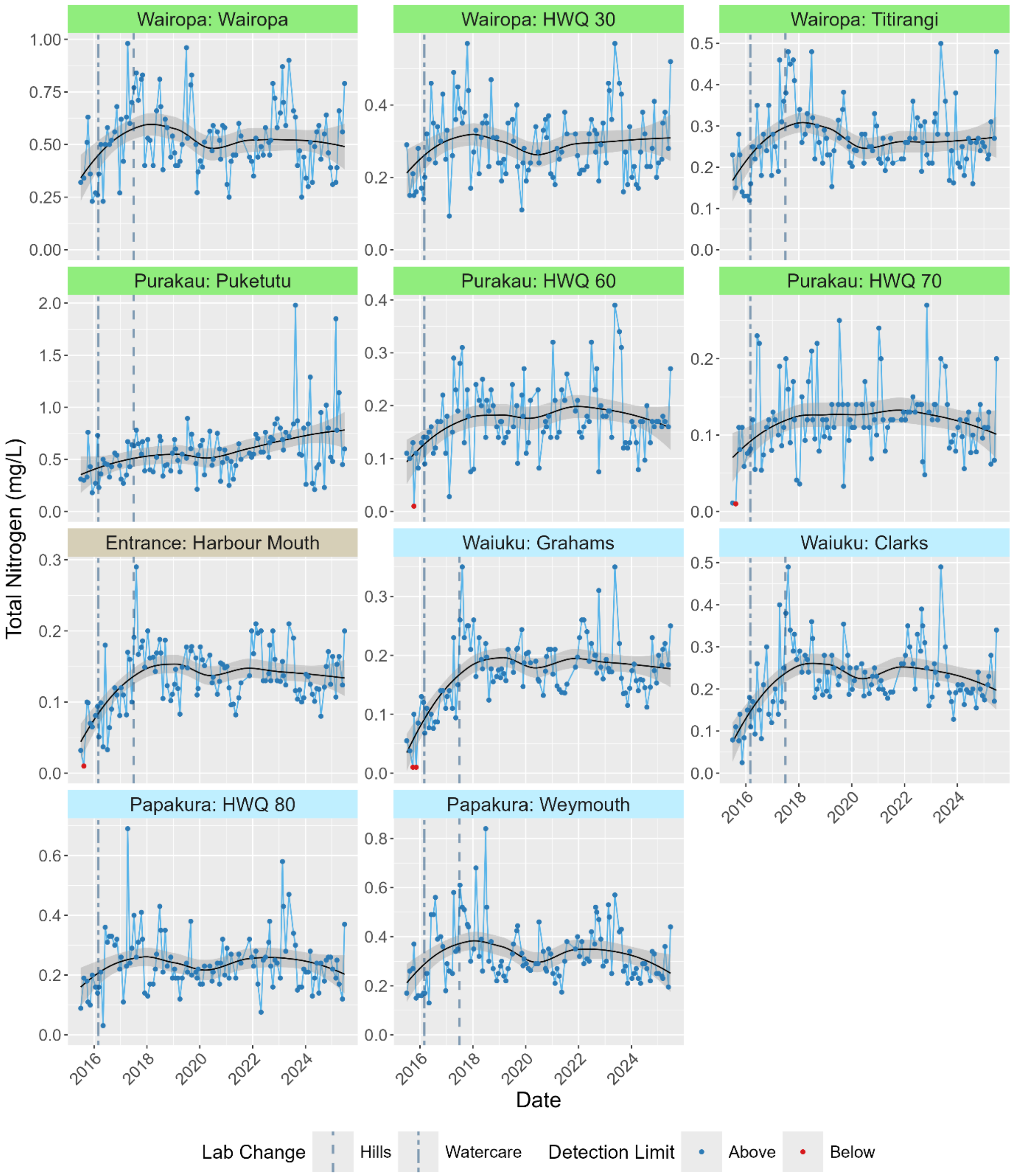


Figure 32: Variation in soluble reactive phosphorus concentrations obtained from water quality monitoring between 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Point colours indicate whether results were above or below detection limits. Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

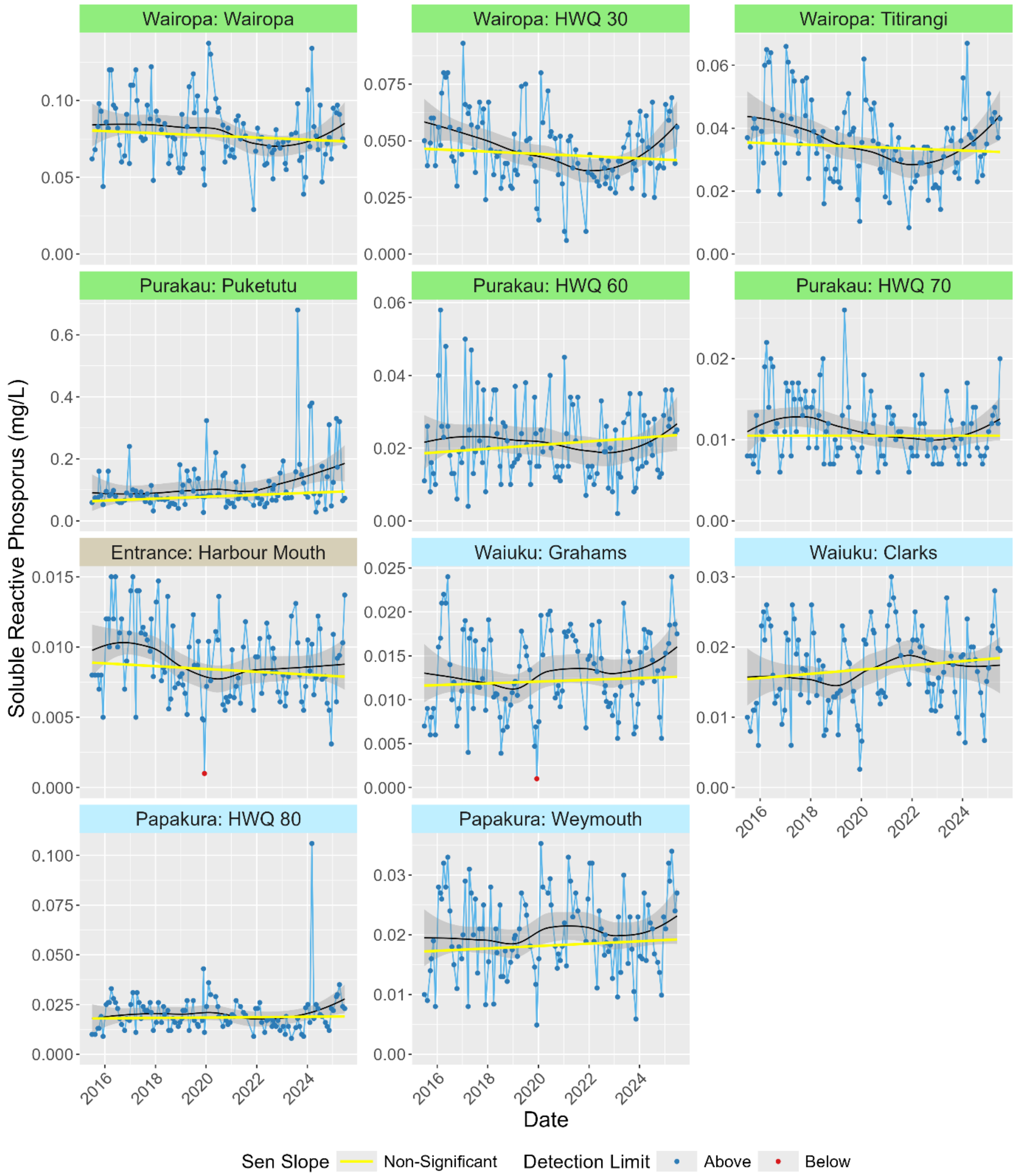


Figure 33: Variation in total phosphorus concentrations obtained from water quality monitoring between 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

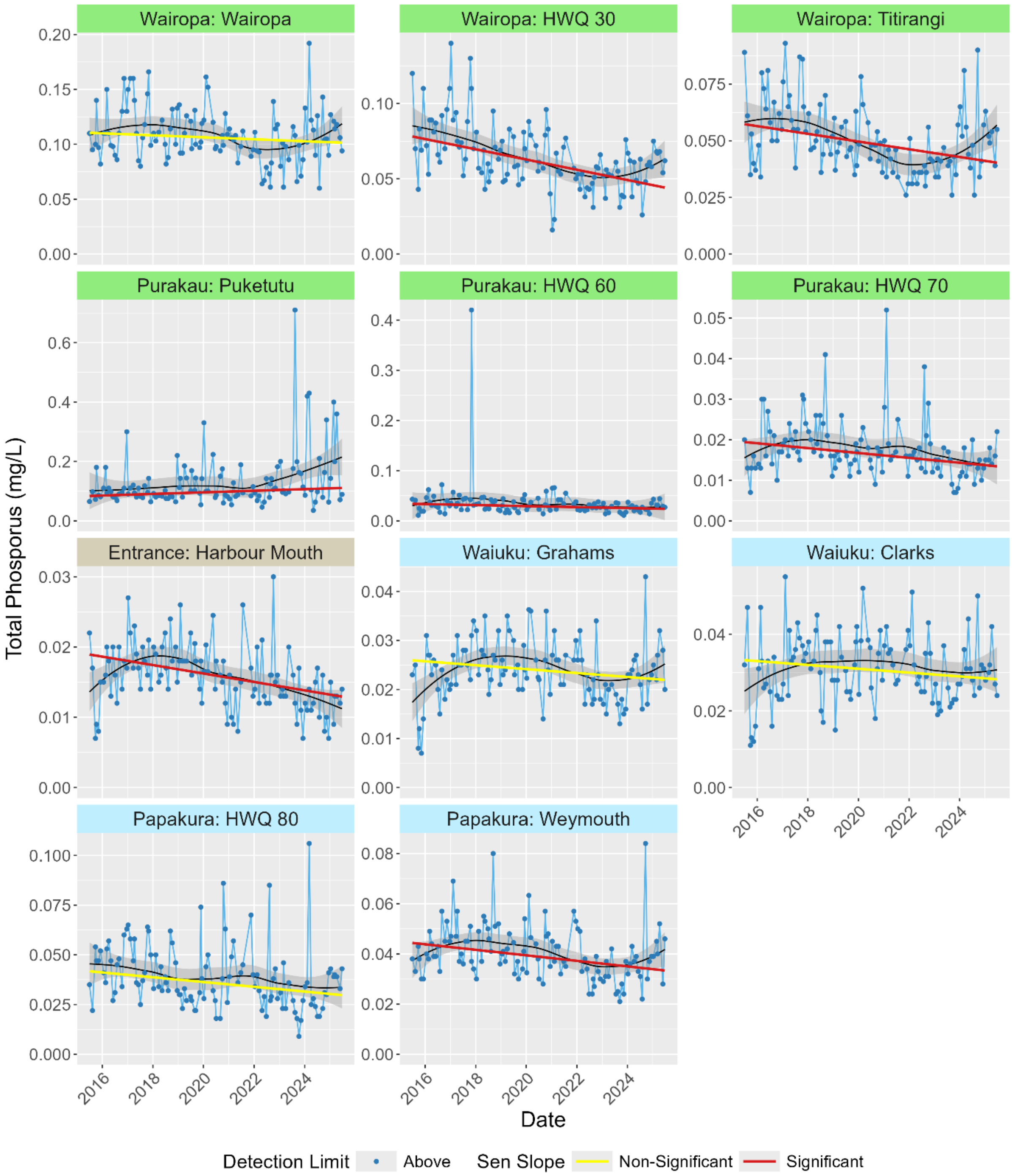


Figure 34: Variation in chlorophyll *a* concentrations obtained from water quality monitoring between July 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Point colours indicate whether results were above or below detection limits. Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). The dashed orange line indicates the Harbour Water Quality Task Force (1994) reference value. Note that the scale of the y-axis varies among graphs.

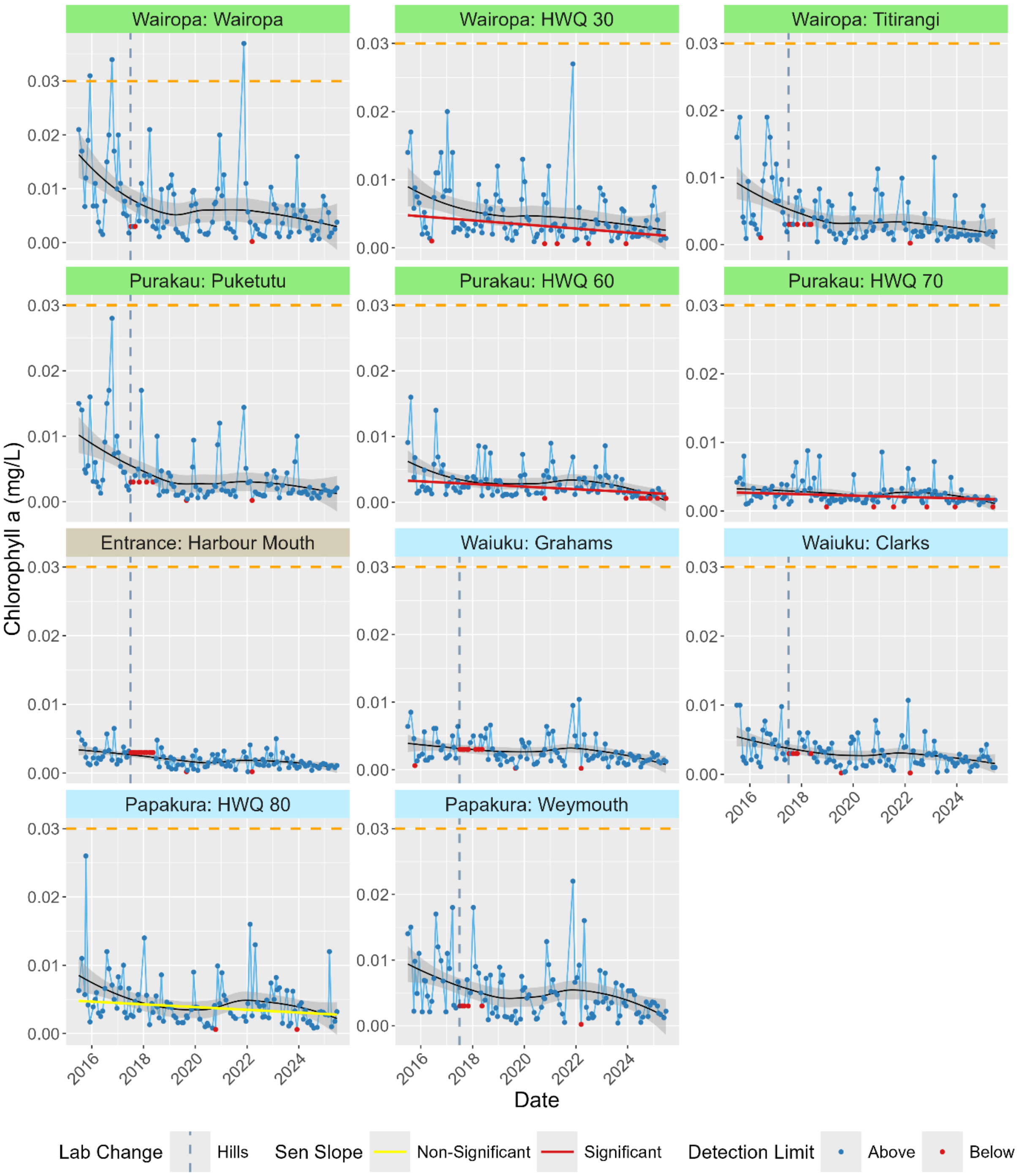


Figure 35: Variation in turbidity obtained from water quality monitoring between 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

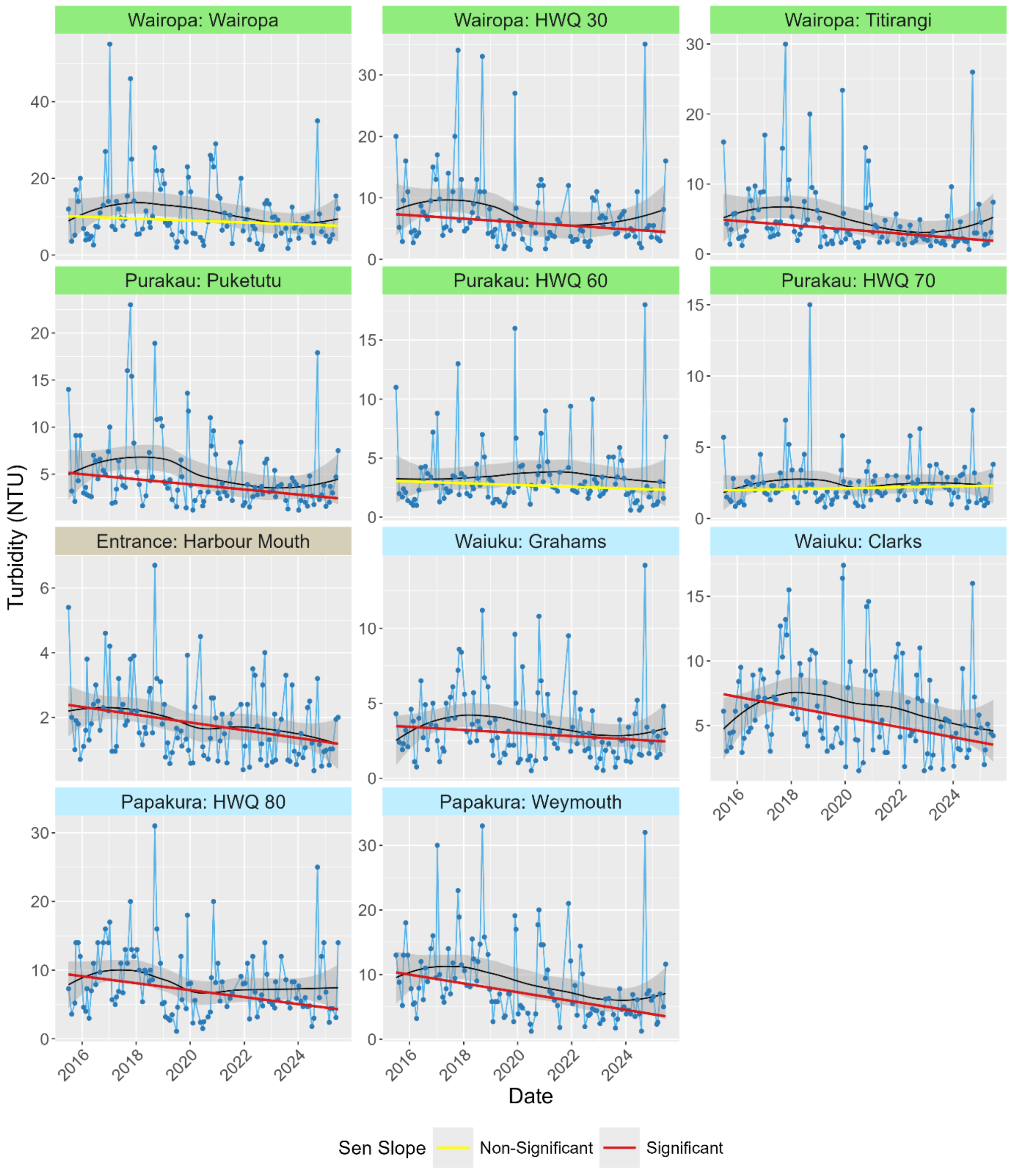


Figure 36: Variation in total suspended solids concentrations obtained from water quality monitoring between 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

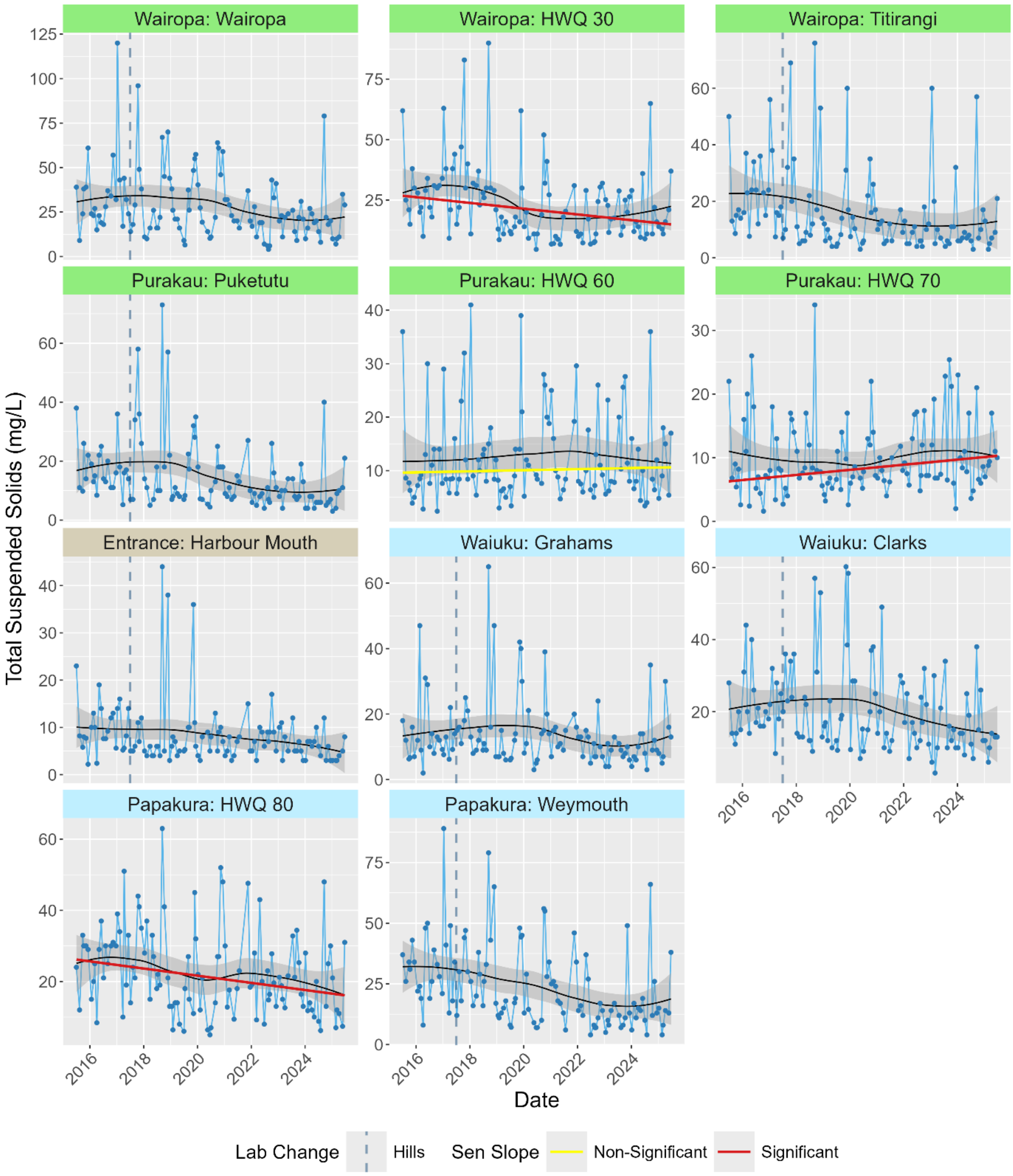


Figure 37: Variation in water temperature at water quality monitored between 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

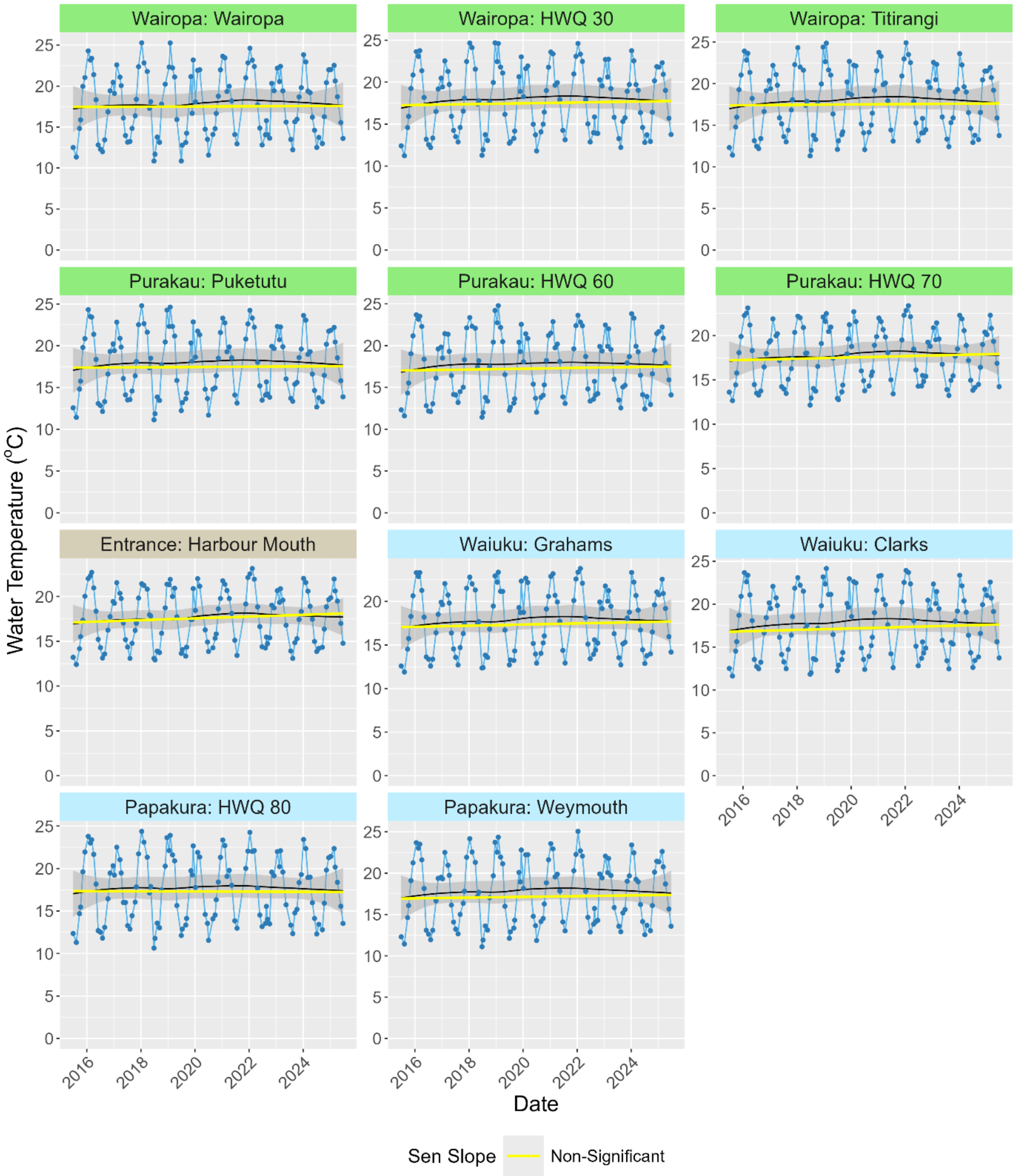


Figure 38: Variation in dissolved oxygen concentrations (mg/L) obtained from water quality monitoring between 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

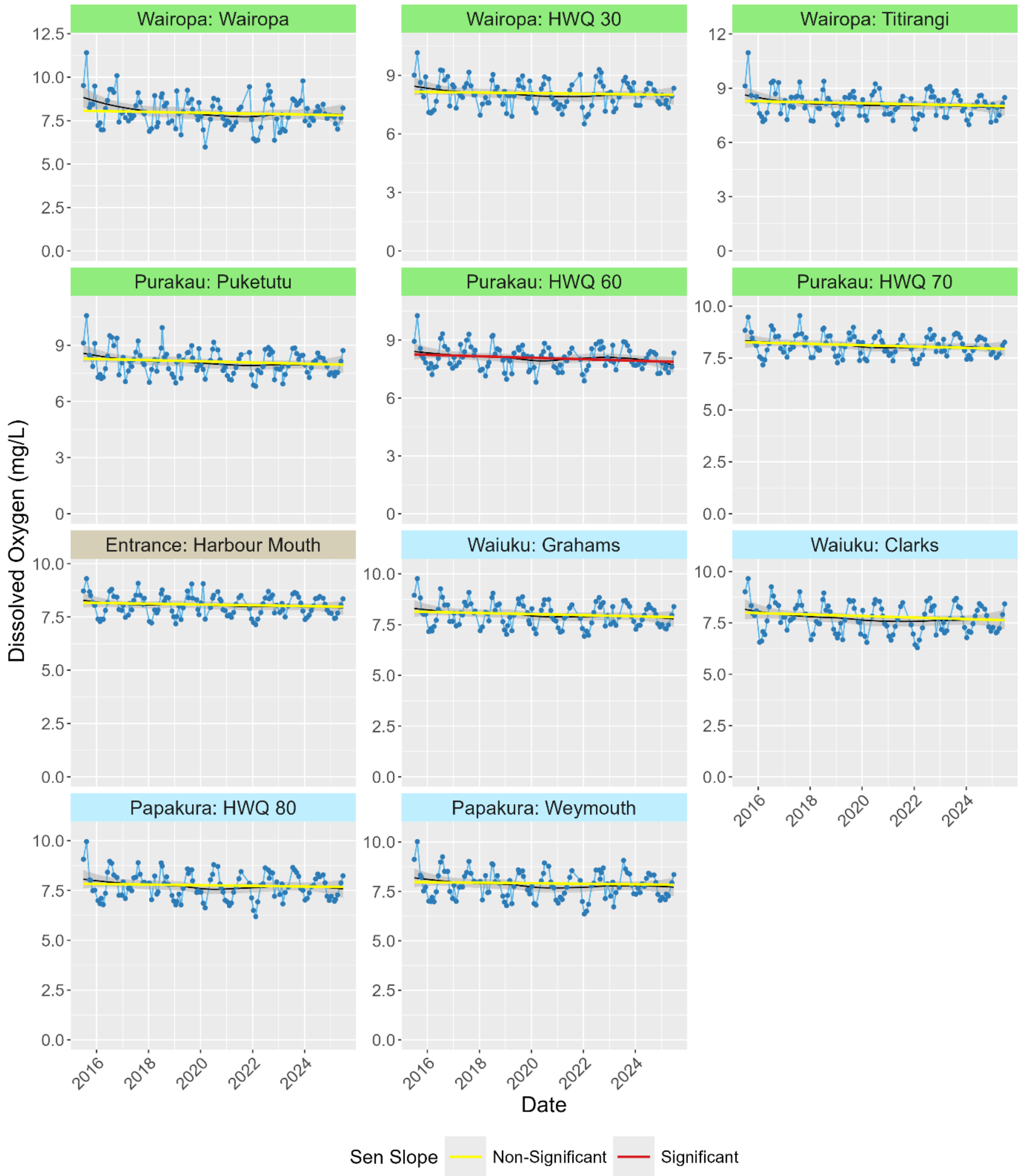


Figure 39: Variation in field measurements of pH obtained from water quality monitoring between July 2015 and June 2025. Sen slope lines are coloured by statistical significance, while dark blue lines are from LOESS smoothing (± 95% CI). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance). Note that the scale of the y-axis varies among graphs.

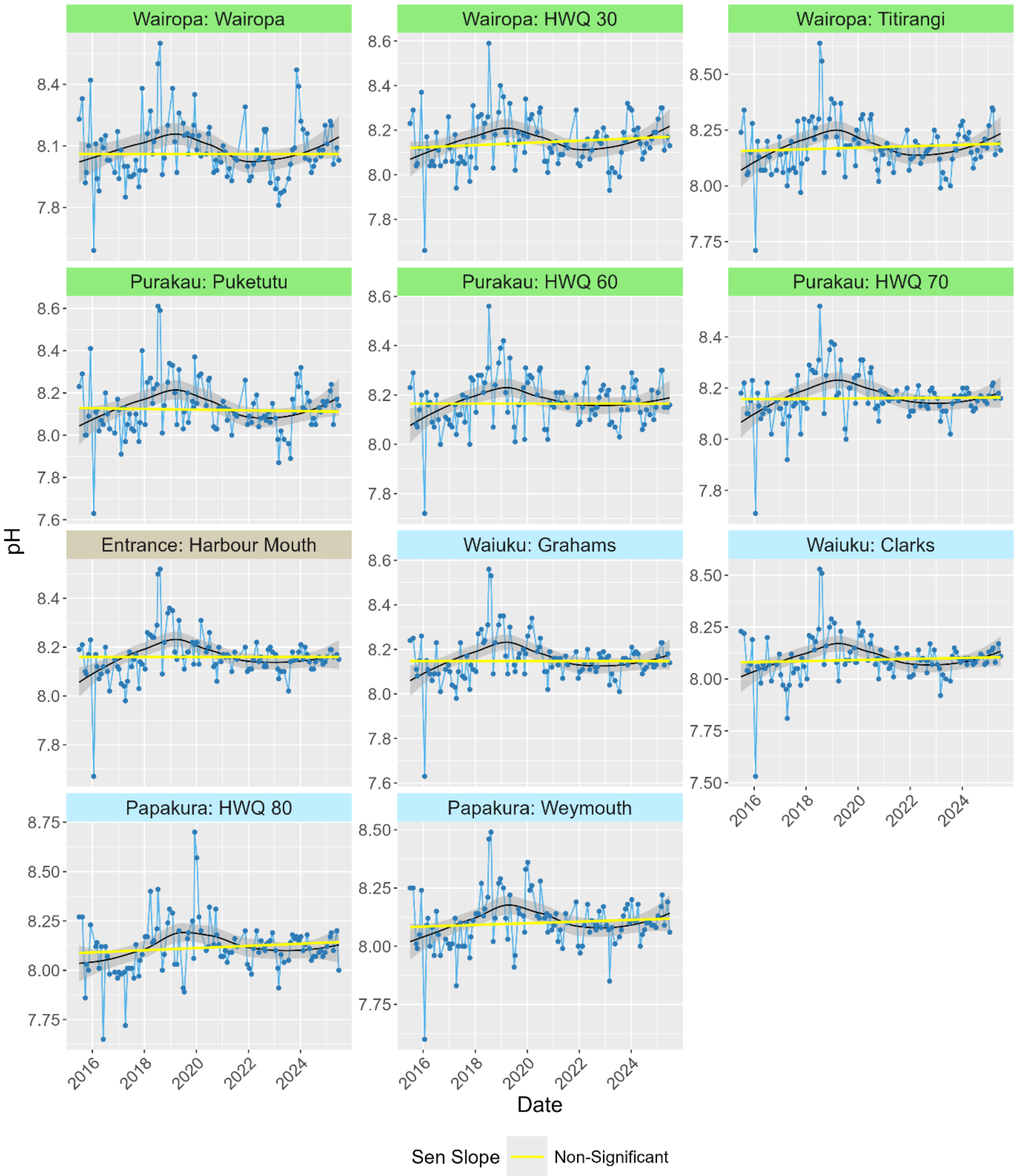


Figure 40: Variation in mean summer (December–April) total nitrogen concentrations obtained from water quality monitoring between December 2017 and April 2025. Least squares regression lines (± 95% CI fitted), with lines coloured by significance (p<0.05). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance).

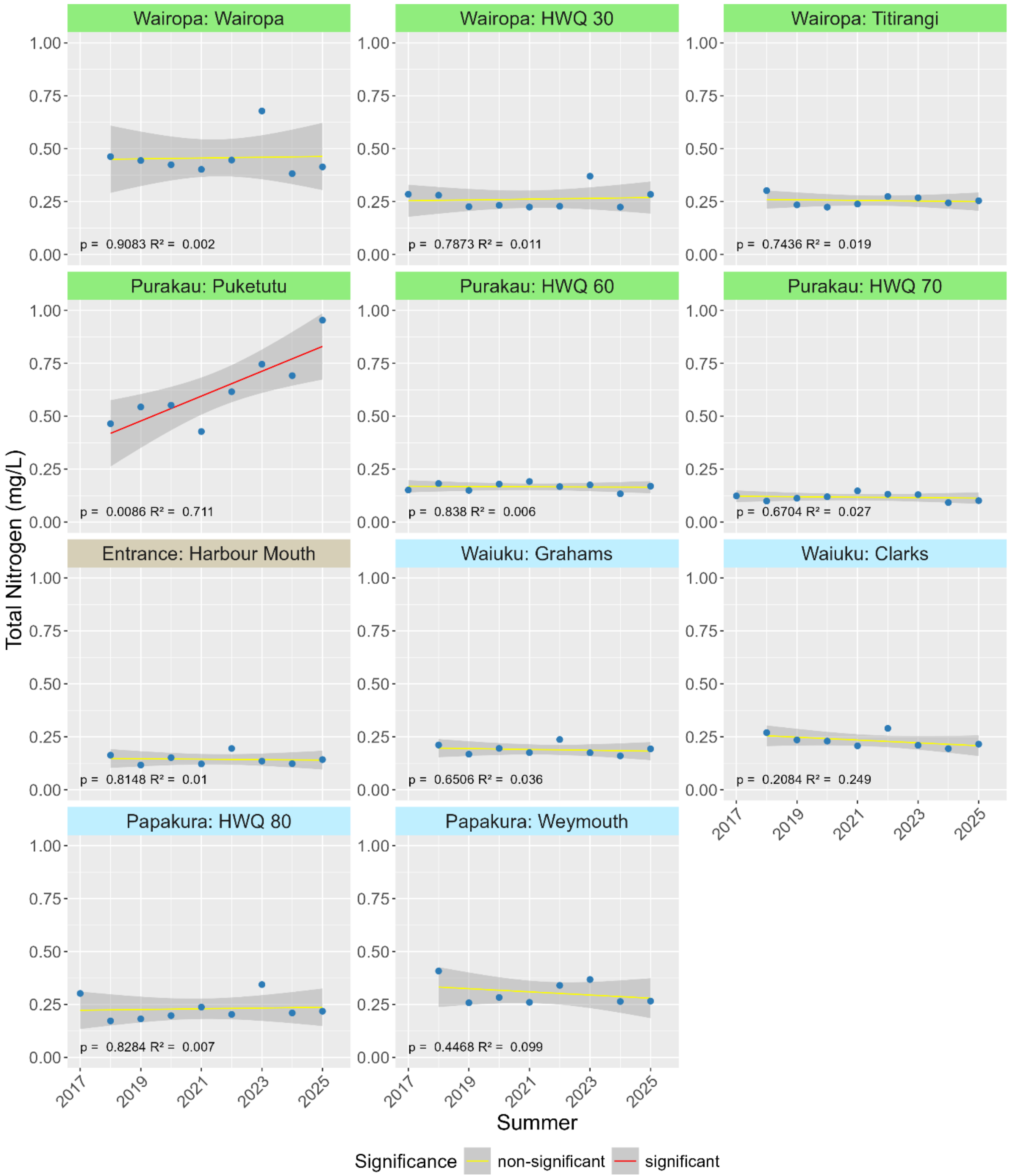


Figure 41: Variation in mean summer (December–April) $\log_{10}$ chlorophyll *a* concentrations obtained from water quality monitoring between December 2017 and April 2025. Least squares regression lines (± 95% CI fitted), with lines coloured by significance (p<0.05). Site labels provide channel and site names, coloured headings indicate harbour location (green = North, blue = South, khaki = Entrance).

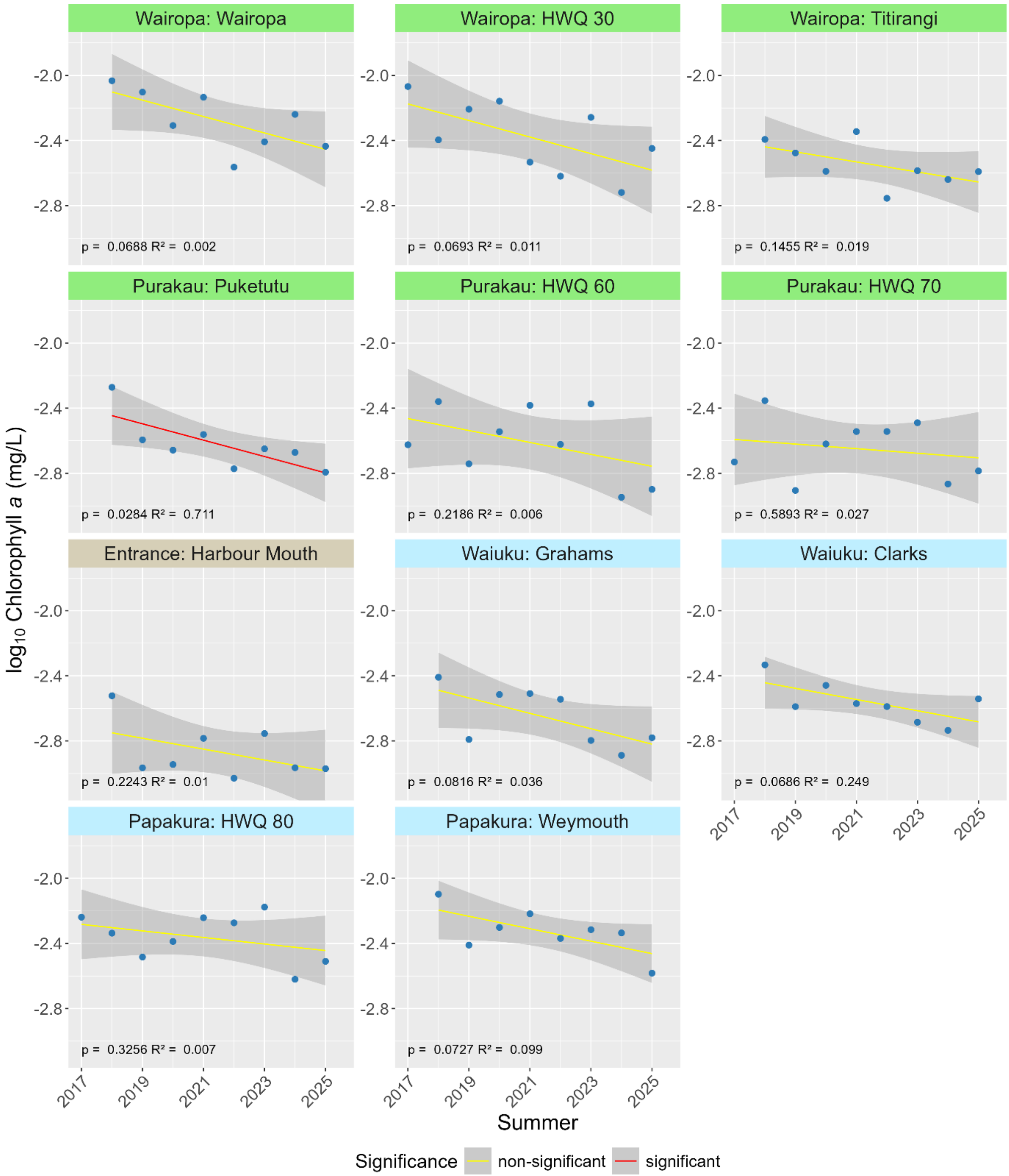


Figure 42: Relationships between pooled mean summer (December–April) total nitrogen concentrations and mean log_{10} chlorophyll *a* concentrations. Sites are separated by collector (Auckland Council or Watercare) and whether the trend is positive or negative. Data were limited to Watercare sites sampled between December 2016 and April 2024, and Auckland Council sites sampled between December 2017 and April 2024. Least squares regression lines (± 95% CI) are fitted, with associated probability and r^2 values.

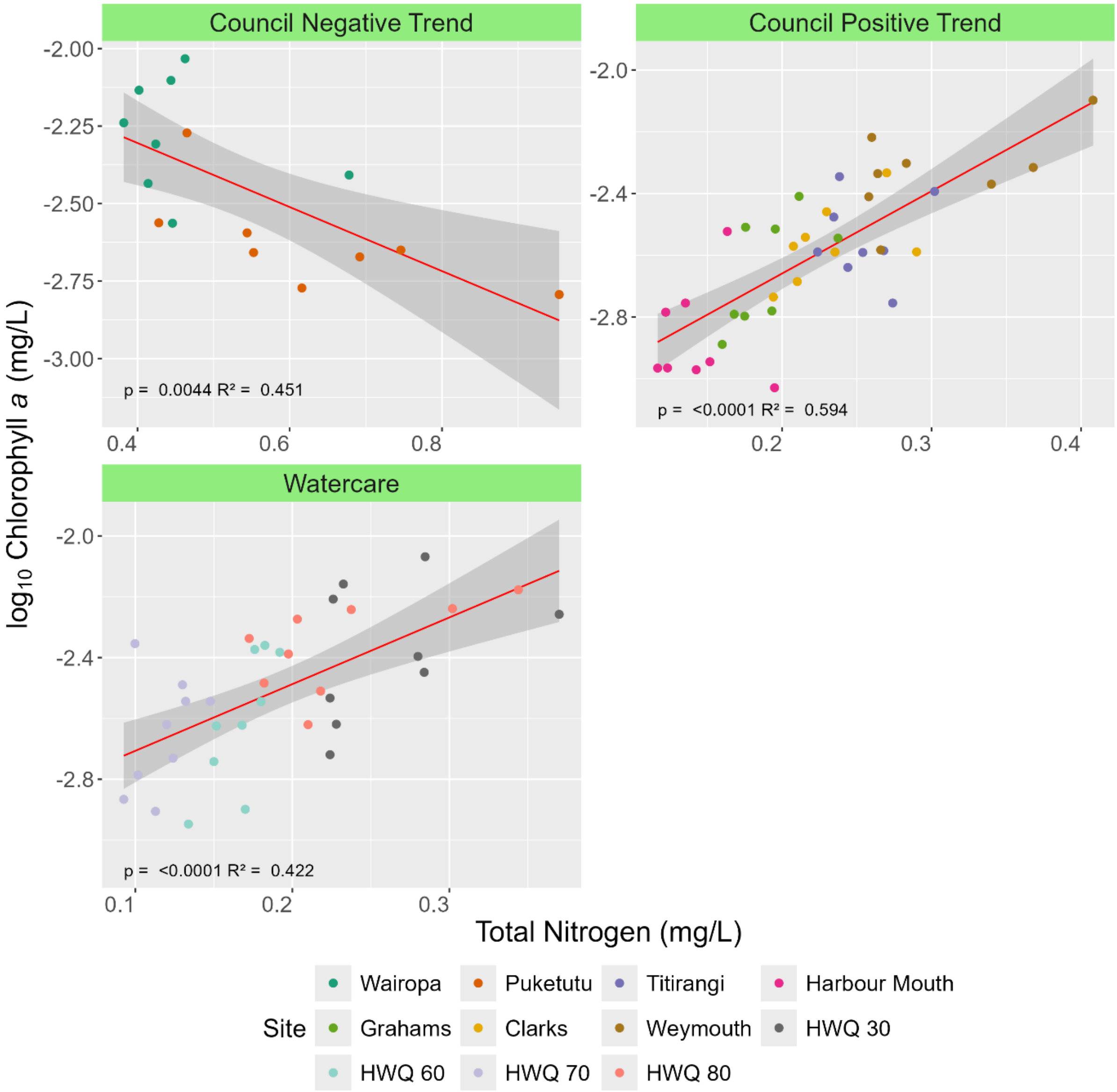
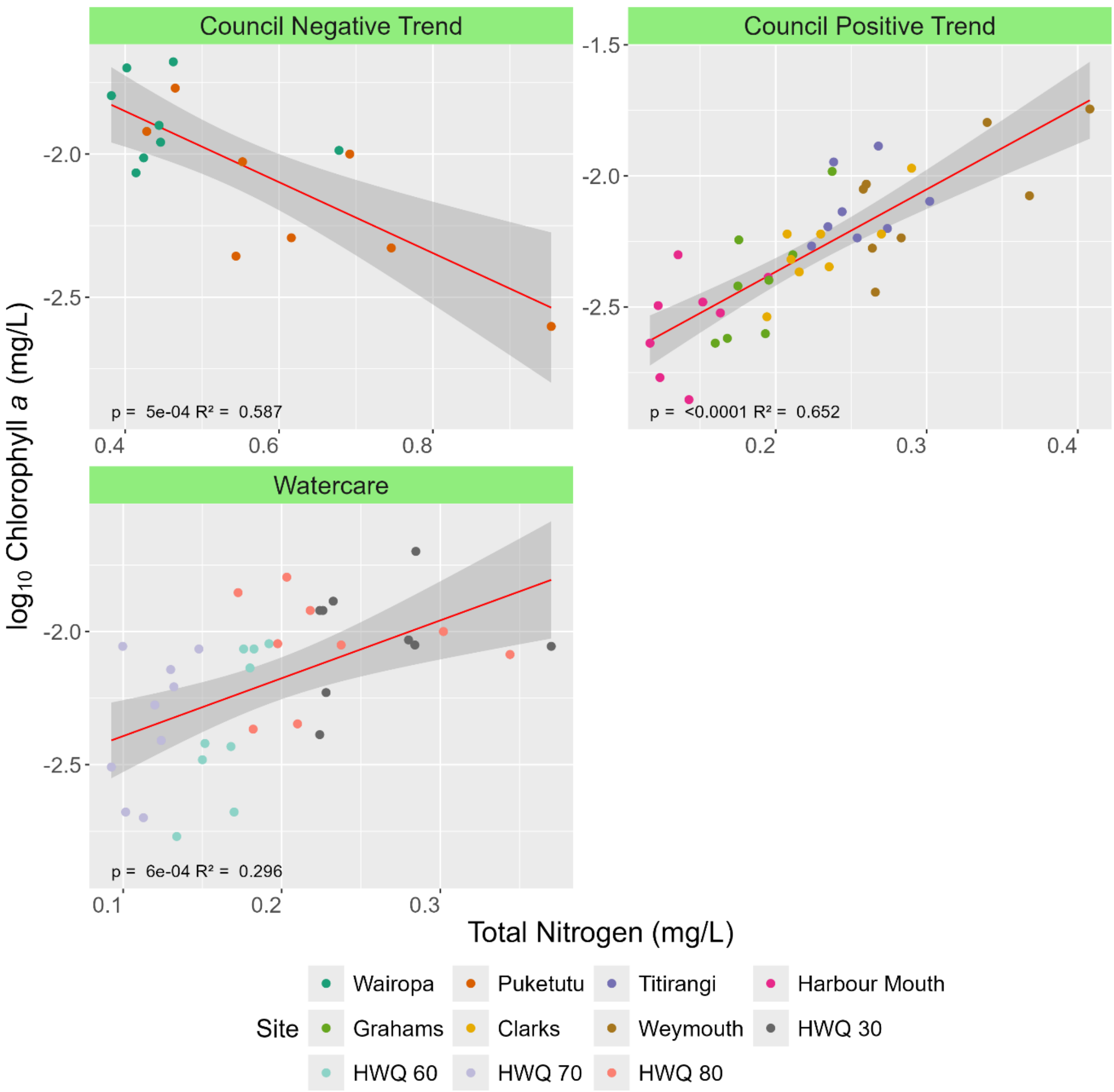


Figure 43: Relationships between pooled mean summer (December–April) total nitrogen concentrations and maximum log_{10} chlorophyll *a* concentrations. Sites are separated by collector (Auckland Council or Watercare) and whether the trend is positive or negative. Data were limited to Watercare sites sampled between December 2016 and April 2024, and Auckland Council sites sampled between December 2017 and April 2024. Least squares regression lines (± 95% CI) are fitted, with associated probability and r^2 values.



5 SEDIMENT QUALITY

5.1 SEDIMENT QUALITY METHODS

5.1.1 SAMPLE COLLECTION AND ANALYSIS

Sediment samples were obtained in October 2024 from the eight sites that are to be sampled biennially (Figure 5, Table 6).

Table 6: Sediment quality sampling sites and frequencies.

Site Name	Alternative Site Name	Sampling Frequency (years)
Outfall	Metals 1	2
Metals 2	Metals 2	2
Metals 3	Metals 3	2
Metals 4	Metals 4	2
Metals 5	Metals 5	2
Purakau Upper	Metals 6	2
Purakau Mid	Metals 7	4
Purakau Outer	Metals 8	4
Cape Horn	Metals 9	4
Pond 14	Pond 14	2
Pond 16	Pond 16	2
Auckland Airport	Metals 10	4
Clarks Beach	Metals 11	4

The protocols used to collect sediment samples have followed Auckland Council's methodology since 2012. This allows Watercare Services' sediment quality data to be directly compared with other data collected from throughout the Auckland Region. The Council's sampling protocols are summarised below:

- For monitoring sites where both ecological and sediment quality samples are collected (i.e., sites Pond 14, Pond 16, Metals 1 (Outfall) and Metals 6 (Purakau Upper)), five 2 cm deep × 8 cm wide × 5 cm long surface sub-samples were collected next to each randomly located ecological sampling station. Each sub-sample was sequentially allocated to one of five composite samples.
- For sites where only sediment quality samples were collected (i.e., sites Metals 2–5), surface sub-samples (2 cm deep × 8 cm wide × 5 cm long) were collected at 2 m intervals along two parallel, 25 m runways and sequentially allocated to five composite samples.

Composite samples were stored in 'ziplock' bags, homogenised by thorough kneading, and frozen. Three samples from each site[6] were then provided to Watercare Laboratory Services for

[6] Two back-up samples are stored to allow for retesting should anomalous test results be obtained.

the analysis of metal concentrations. Sediment samples from each site were also sent to NIWA for the analysis of sediment grain size.

Table 7. Analytical methods for sediment quality.

Parameter	Analytical Method – Water Samples	Units
Cadmium	Extraction from the < 500 mm sediment fraction using strong acid digestion: USEPA 200.2 or 200.8 (modified)	mg/kg
Copper		mg/kg
Lead		mg/kg
Mercury		mg/kg
TOC	Acid pretreatment to remove carbonates present, followed by catalytic combustion (O_2), separation and thermal conductivity detector (Elementar Analyser).	%
DDT	Sonication extraction and GC-ECD analysis using in-house methods based on US EPA 8081.	mg/kg
Dieldrin		mg/kg

5.1.2 DATA ANALYSIS

Sediment quality data were tabulated, plotted, and compared with the sediment quality guidelines provided in ANZG (2018) and MacDonald *et al.* (1996) (see Table 8). Note that the MacDonald *et al.* (1996) guidelines are considerably more conservative (i.e., protective) than the ANZG (2018) guidelines.

Table 8. Sediment quality guideline values by ANZG (2018)[7] and MacDonald *et al.* (1996).

	ANZG (2018) Guidelines		MacDonald *et al.* (1996)		
Parameter	**DVG**	**GV-High**	**TEL**	**PEL**	**Units**
Cadmium	1.5	10.0	0.68	4.20	mg/kg
Copper	65	270	19	108	mg/kg
Lead	50	220	30	112	mg/kg
Mercury	0.15	1.00	0.13	0.15	mg/kg
Zinc	200	410	124	271	mg/kg

5.2 SEDIMENT QUALITY RESULTS

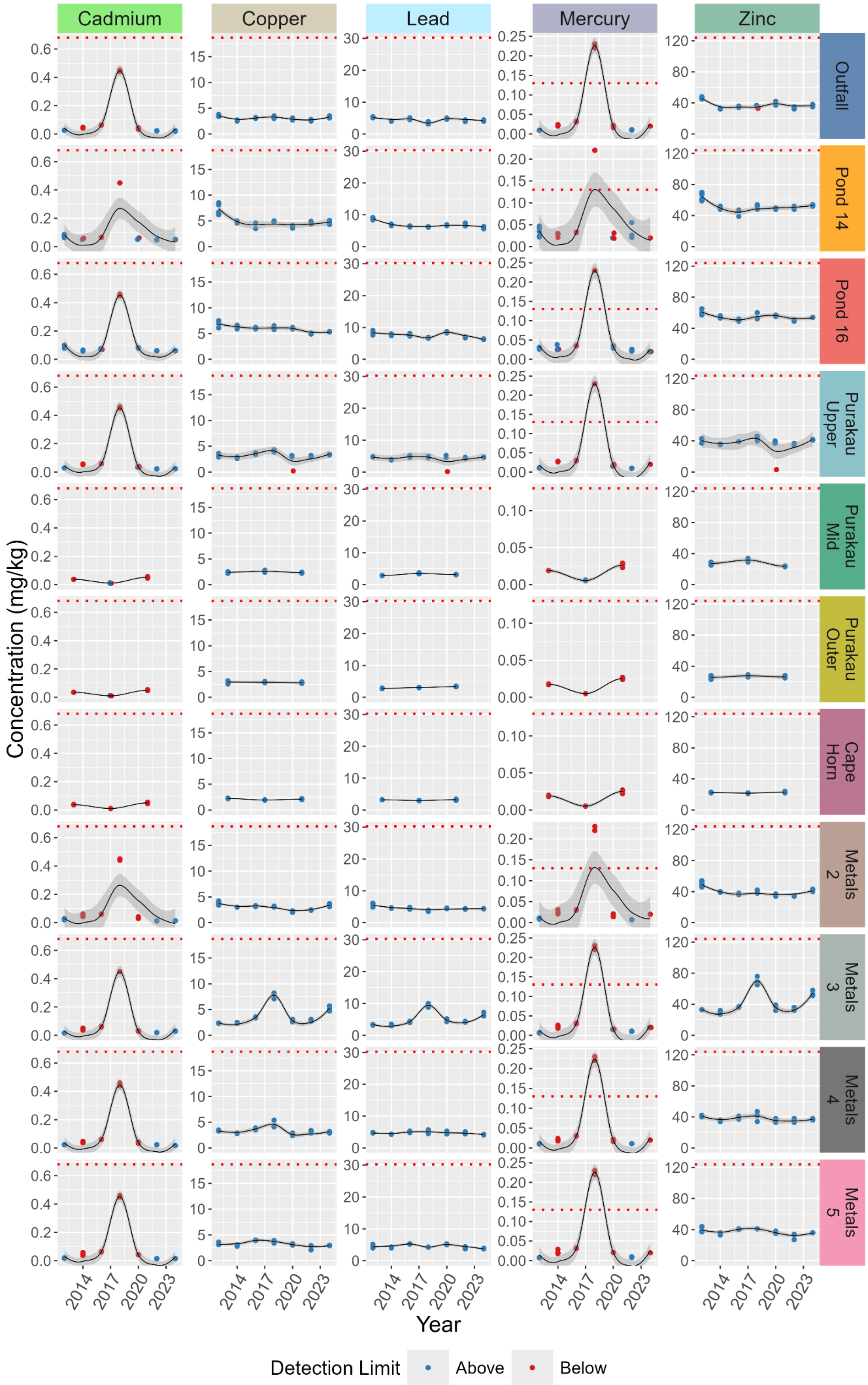
Sediment quality results since 2012 are summarised below:

- Cadmium and mercury concentrations were near or below detection limits in all samples obtained in 2024 (Figure 44). Apart from 2018, when detection limits for cadmium and mercury were anomalously high, concentrations have been relatively stable, and well below TEL guideline values (Figure 44).
- Copper, lead, and zinc concentrations at all sites remain around the nominal background concentrations for marine sediments in the Auckland Region identified by Williamson (2004). Concentrations have been relatively stable and well below TEL guideline values since 2012 (Figure 44).

[7] Note that ANZECC (2000) has been superseded by ANZG (2018). Naming conventions for sediment quality guideline values have changed (ISQG-L became DVG and ISQG-H became GV-high). Metal guideline values are unchanged, but values for total DDT and dieldrin have been amended.

- Total DDT and dieldrin concentrations in all samples obtained in 2024 were below detection limits.

Figure 44: Variation in sediment raw metal concentrations between 2012 and 2024. Loess smoothing lines (± 95% CI) are fitted, and threshold effects level (TEL) sediment guidelines (red dotted lines) are provided. Point colour indicates whether concentrations were above or below detection limits.



6 BENTHIC ECOLOGY

6.1 BENTHIC ECOLOGY METHODS

6.1.1 SAMPLE COLLECTION AND ANALYSIS

Twelve, random benthic cores (13 cm diameter × 15 cm deep) were collected from each ecological monitoring site in October 2023. In addition, 25 mm diameter × 20 mm deep core samples were collected adjacent to every second ecological core for the analysis of sediment grain size and benthic chlorophyll *a* concentrations. Previous years' benthic ecological samples were also collected in October, except for the first year of the revised monitoring programme (2011), when they were collected in November[8], and 2019 samples from the Pond 14 and 16, which were obtained on 1 November.

Total organic content is a useful indicator for interpreting ecological patterns and trends, but it is not required to be collected or reported under the monitoring plan. However, this parameter was determined and is reported here.

After collection, the ecological samples were sieved using a 500 µm mesh and the macrofauna preserved with 70% isopropyl alcohol. The macrofauna were then sorted in the laboratory by Bioresearches Ltd and/or Auckland Council, and taxa were identified and enumerated to the lowest practicable taxonomic level by Biolive[9] or NIWA[10].

Note that the Council have data from Cape Horn going back to 1987, but it does not monitor the site continuously. Watercare started monitoring the site in 2011, with the intention of providing a continuous dataset from that date forward. Between 2011 and 2017, the collection of ecological samples at that site was done under contract by Auckland Council (and its predecessor, Auckland Regional Council). Ecological samples were meant to be sent to both Bioresearches and NIWA in the years when sampling overlapped. However, in 2013 and 2017, samples were mistakenly only sent to NIWA. This appears to have been due to confusion arising from personnel changes at the Council. To avoid this, Bioresearches have now been commissioned to collect all of Watercare's ecological samples, while Auckland Council will continue doing their sampling separately.

6.1.2 REVIEW OF TAXONOMIC NOMCLEMENTURE AND PHYLOGENIC CONSOLIDATION

Changes in the taxonomists processing ecological samples, taxonomic nomenclature, and the taxonomic resolution of species identifications have occurred between 2011 and 2023. Checks are therefore carried out on an ongoing basis, with a more detailed review undertaken in 2024. This involved updating taxonomic names using the World Register of Marine Species[11] as a primary source, and consolidating taxa at appropriate levels of taxonomic resolution. The decision on whether to consolidate taxa sought to balance the potential risks of the number of taxa being overestimated (if a taxa that has been identified to a lower level is recorded separately from a higher level group that also contains records of that taxa) or underestimated (if a taxa that

[8] Delay was related to new sampling contracts being put in place.
[9] Bioresearches collected samples from the Watercare Services sites and use Biolive for taxonomic identification and enumeration services.
[10] Auckland Council collect their own samples and use NIWA for taxonomic identification and enumeration services.

[11] WoRMS - https://www.marinespecies.org/

has been identified to a lower level is consolidated with a higher level group that would not otherwise contain that taxa).

Generally:

- taxa were consolidated at a higher level if there one taxa was identified at that level, and one taxa was identified to a lower level;
- taxa were kept separate if one was identified at a higher level and two or more were identified to levels below it;
- taxa were consolidated at the highest consistent level if there were inconsistencies in their naming and/or taxonomic resolution over time;
- taxa identified using operational taxonomic units (OTU) (e.g., species A, species B) were consolidated at the level above the OTU;
- rarely encountered taxa that only occurred in low numbers (e.g., taxa that have occurred in a single year with total counts in single digits) were consolidated.

6.1.3 DATA ANALYSIS

In this report, the ecological analyses focused on samples collected since the revised monitoring was implemented in 2011[12]. All ecological count data obtained by Bioresearches were included in analyses[13]. However, Auckland Council limit the analysis of their ecological data to the 22 taxa used as indicator species in the Council's Manukau Harbour ecological monitoring programme prior to 2011 (Hewitt & Hailes 2007). That suite of species includes:

- potential keystone species (which have a substantial influence on overall community structure and function);
- species from a variety of ecological niches;
- prey species, which are utilised by humans and/or other animals;
- pollution-sensitive species, or species that respond to particular types of disturbance in a characteristic fashion;
- species whose distributions respond to environmental gradients; and,
- species that can be collected, identified, and counted at minimal cost.

Trends and patterns in annual results of sediment grain size, sediment mud, total organic content (TOC)[14] and chlorophyll *a* concentrations at the ecological monitoring sites were analysed by plotting mean (± 95% CI) values against time.

6.1.3.1 UNIVARIATE ECOLOGICAL ANALYSES

Ecological data were analysed by comparing measures of diversity, community structure, and taxa counts using a combination of univariate and multivariate plots. Indices of ecological

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[12] Longer term results for Auckland Council and the Watercare Outfall and Pond sites are presented in previous reports.

[13] Based on the consolidated taxa names used by Coast and Catchment (see Kelly 2024).

[14] Also referred to as total organic matter.

diversity included the number of taxa, number of individuals, Pielou's evenness and Shannon diversity.

Shannon diversity takes into account both the number of taxa and how evenly individuals are spread among those taxa. It is a measure of the uncertainty associated with correctly predicting which species a randomly selected specimen belongs to. That uncertainty decreases as the number of taxa and evenness decreases. If nearly all individuals belong to a single species, Shannon diversity approaches zero (it equals zero if there is only one species). Conversely, Shannon diversity increases as the number of taxa and evenness increases, with the maximum value achieved when each taxon has the same number of individuals (the maximum possible value equals the log of the number of species). Shannon diversity values are sensitive to sampling effort and the logarithm base used. Therefore, results should only be compared among studies with similar sampling designs, and for results using the same logarithm base (Clarke & Warwick 2001; Pla et al. 2012).

Pielou's evenness is a measure of how even (i.e., similar) the abundances of individual species are at a site. Low index values indicate that the site are dominated by a single, or a few, taxa that occur in high abundance(s). The remaining taxa occur in relatively low abundances. In contrast, high index values indicate that the abundances of all taxa are similar. Pielou's evenness is derived from the Shannon diversity value of a sample divided by the maximum possible Shannon diversity value of that sample (Clarke & Warwick 2001; Pla et al. 2012).

6.1.3.2 MULTIVARIATE ECOLOGICAL ANALYSES

Differences in community composition were investigated with multivariate analyses using Primer-E (v7). An initial analysis was carried out using non-metric multidimensional scaling (MDS) of square-root transformed count data using Bray Curtis similarity. This method provides an easily interpretable representation of community data. MDS plots provide a representation of overall community composition, with points plotted close together being more similar than those plotted further apart. MDS analysis was complemented with hierarchical clustering and similarity profile analysis. Those methods allow similarity (and dissimilarity) among samples to be estimated and presented in dendrograms, showing both statistically significant and non-significant clusters. The results of these analyses were plotted using Primer-E and R Studio.

The similarity percentage routine (SIMPER)[15] was then used to determine the contributions that individual taxa made to the average dissimilarity between the clusters identified above. Time series plots for the 24 taxa that made the greatest average contributions were then produced using R-Studio.

[15] Using Bray-Curtis dissimilarities.

Table 9: Species reported in the Council's monitoring programme and associated taxa reported by Bioresearches.

Type of Species	Common Name	NIWA Name	Bioresearches Name	Notes
Polychaete worm		*Aglaophamus macroura*	*Aglaophamus macroura*	
Anemone		*Anthopleura aureoradiata*	*Anthopleura aureoradiata*	
Polychaete worm		*Aonides oxycephala*	*Aonides oxycephala*	
Bivalve	Cockle	*Austrovenus stutchburyi*	*Austrovenus stutchburyi*	
Comma shrimp		*Colurostylis lemurum*	No match	Bioresearches only report to Cumacea family level
Isopod		*Exosphaeroma* spp.	*Exophaeroma planulum*	Consolidated into *Exosphaeroma* spp.
Polychaete worm		*Glycinde dorsalis*	*Goniada* sp.	Matched to *Goniada* sp. in Bioresearches dataset by Simon West from Bioresearches.
Bivalve	Wedge shell	*Macomona liliana*	*Macomona liliana*	Previously called *Tellina liliana.*
Polychaete worm		*Macroclymenella stewartensis*	Maldanidae	Bioresearches only report to Maldanidae family. This was matched to *Macroclymenella stewartensis* by Simon West.
Polychaete worm		*Magelona dakini*	*Magelona* sp.	Bioresearches only report to *Magelona* sp. This was matched to *Magelona dakini* by Simon West.
Amphipod		*Methalimedon* sp.	Atylidae	Bioresearches recorded two unnamed amphipods and one unidentified amphipod. Simon West indicated that this species probably matches with Atylidae, but there is some uncertainty.
Limpet		*Notoacmea scapha*	*Notoacmea scapha*	Previously *Notoacmea helmsi.*
Bivalve	Nut shell	*Linucula (Nucula) hartvigiana*	*Nucula hartvigiana*	Name changed from *Nucula hartvigiana* to *Linucula hartvigiana.*
Polychaete worm		*Orbinia papillosa*	*Orbinia papillosa*	
Polychaete worm		*Owenia petersenae*	*Owenia petersonae* (previously *O. fusiformis*)	Bioresearches previously identified this species as *Owenia fusiformis*.

Type of Species	Common Name	NIWA Name	Bioresearches Name	Notes
Amphipod		*Proharpinia* sp.	No match	
Amphipod		*Waitangi brevirostris*	No match	Bioresearches recorded three unnamed Phoxocephalidae but were unable to match any to this species.
Polychaete worm		*Prionospio aucklandica*	*Prionospio* spp.	Simon West recommended grouping and noted that the majority are *Prionospio* spp. in the HEMP samples, but because of the quality of some specimens, they are grouped under the genus in HEMP data.
Bivalve	Sunset shell	*Soletellina siliquens*	*Soletellina siliquens*	Now called *Hiatula siliquens*.
Amphipod		*Torridoharpinia hurleyi*	Phoxocephalidae A	Simon West indicated that this is likely to be Phoxocephalidae A in the HEMP data. Stated that it is definitely not Phoxocephalidae B or C.
Polychaete worm		*Travisia olens novaezealandiae*	*Travisia olens novaezealandiae*	Simon West indicated that this is a highly distinctive species, so if it is not listed, it is not present.
Sea cucumber		*Taeniogyrus dendyi*	No match	Previously called *Trochodota dendyi.*

6.2 BENTHIC ECOLOGY RESULTS

6.2.1 SEDIMENT CHARACTERISTICS

The composition of sediments, based on the proportions of mud, sand and gravel, varied among sites, with the Outfall site consisting of muddy, gravely sand, the Pond sites consisting of sandy mud/muddy sand, and the remaining sites consisting of sand or muddy sand. Since 2011, sediments at the Outfall, Pond and Upper Purakau sites have been relatively stable, but variability among within-year replicates taken since 2018 is high. Until recently, sediments at the Purakau Mid, Outer and Cape Horn site have displayed less within-year variation in mud content than sediments from the upper harbour sites. Since 2020, mud content has increased at the former sites, with much higher and variable levels recorded in 2024 (Figure 45 and Figure 46).

The TOM content of sediments also differs among sites, with the highest levels at the Pond and Outfall sites, intermediate concentrations at the Purakau Upper and Mid sites, and lowest levels at the Purakau Outer and Cape Horn sites. Temporal variation in organic content was very similar at all sites between 2011 and 2024, with a large spike occurring between 2019 and 2022 at all sites, and mean TOM decreasing at five of the seven monitoring sites thereafter. The similarity in temporal variation was confirmed through a correlation analysis, which detected statistically significant ($p<0.05$) TOM correlations between most combinations of paired sites (Figure 47). The exceptions were the lack of significant correlations between TOM at the Outfall and Pond sites, and TOM at the Cape Horn site.

In 2024, TOM content at five of the seven monitoring sites dropped to the lowest recorded since 2011. Mean TOM rose slightly between 2023 and 2024 at the Cape Horn site, and dropped only marginally at the Purakau Outer. Similar to mud content, within-site variability at both of those sites was unusually high in 2024 due to a single outlier among the six replicate samples collected from each site.

The highest sediment chlorophyll *a* concentrations have generally been obtained from the Outfall site. The only exception was the Purakau Outer site in 2011, when unusually high and variable chlorophyll *a* concentrations were obtained. Concentrations at that site declined over the following two years, and since 2014 they have been similar to those in the Purakau Mid and decommissioned Pond sites. However, within-site variability in chlorophyll *a* concentrations was unusually high at the Cape Horn and Purakau Outer sites in 2024, due to a single outlier among the six samples collected from each site. Lowest chlorophyll *a* concentrations have consistently been obtained from the Purakau Upper site (Figure 46).

Figure 45: Annual variation in sediment texture (average values) at the seven sites sampled by Watercare Services Ltd between 2011 and 2024.

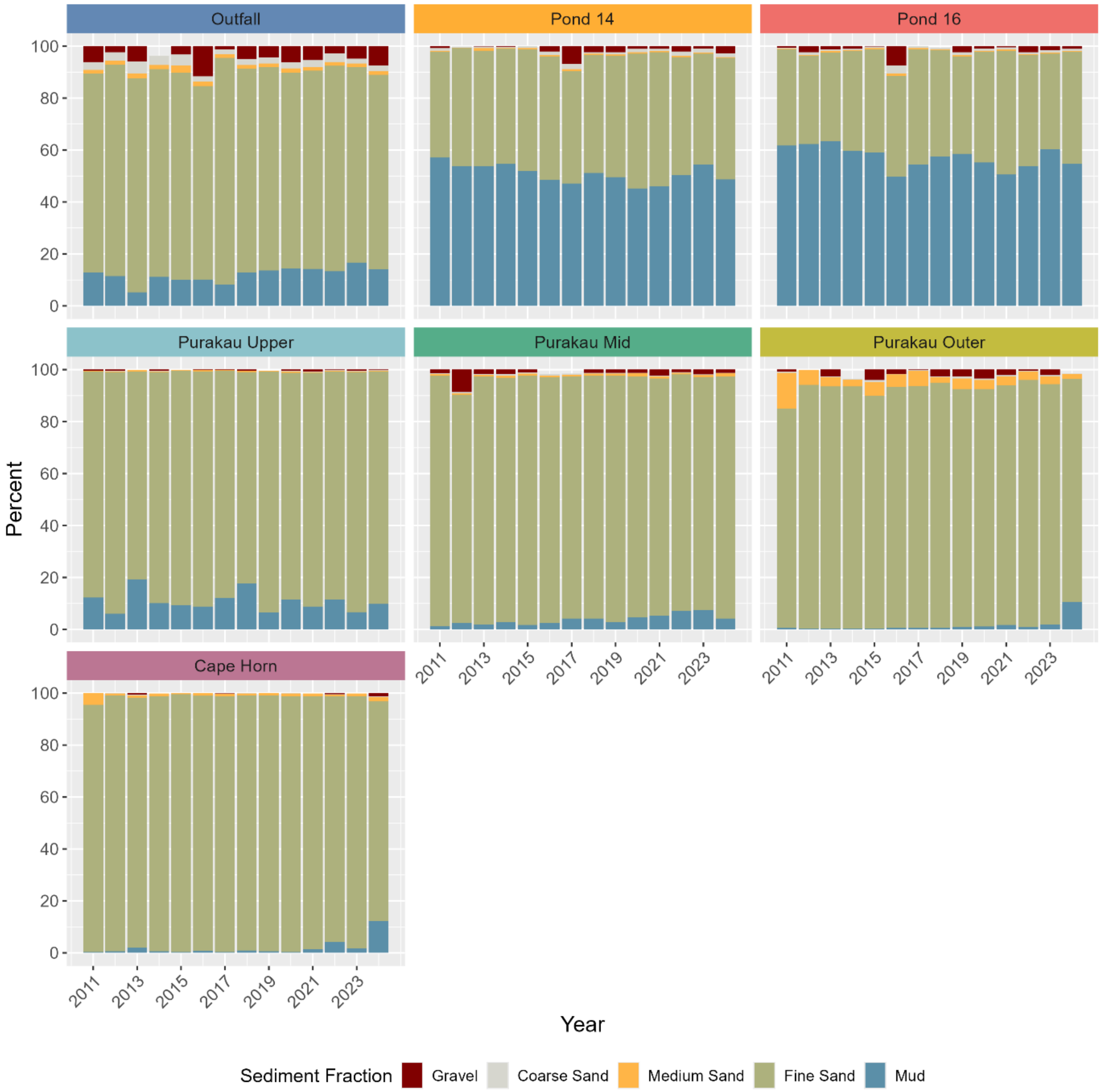


Figure 46: Sediment mud, total organic content (%), and chlorophyll *a* concentrations (µg/g) at the seven sites sampled by Watercare Services Ltd between 2011 and 2023. Mean (± 95% C.I.) values are shown when multiple samples were analysed, and raw values are shown when a single composite sample was collected.

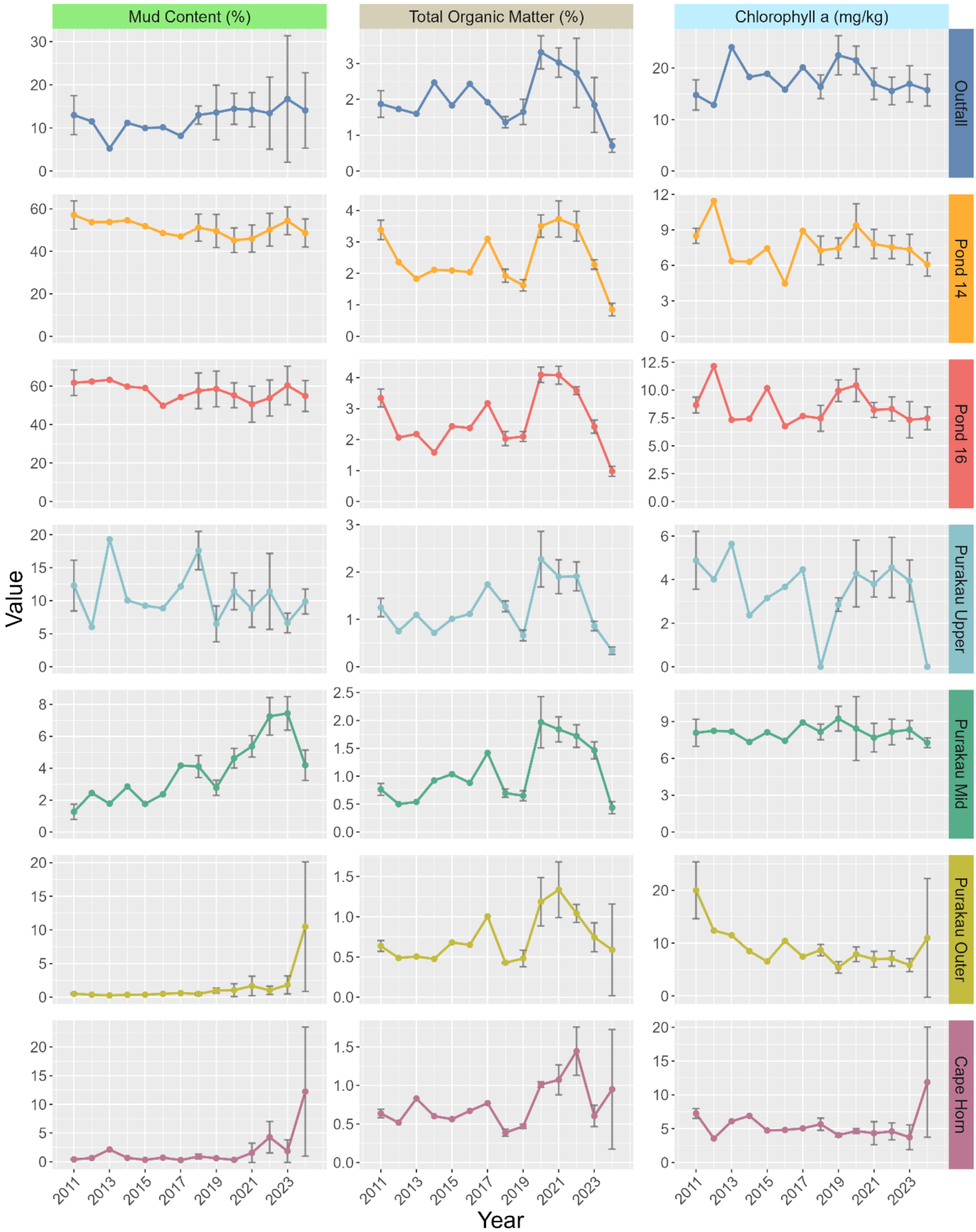
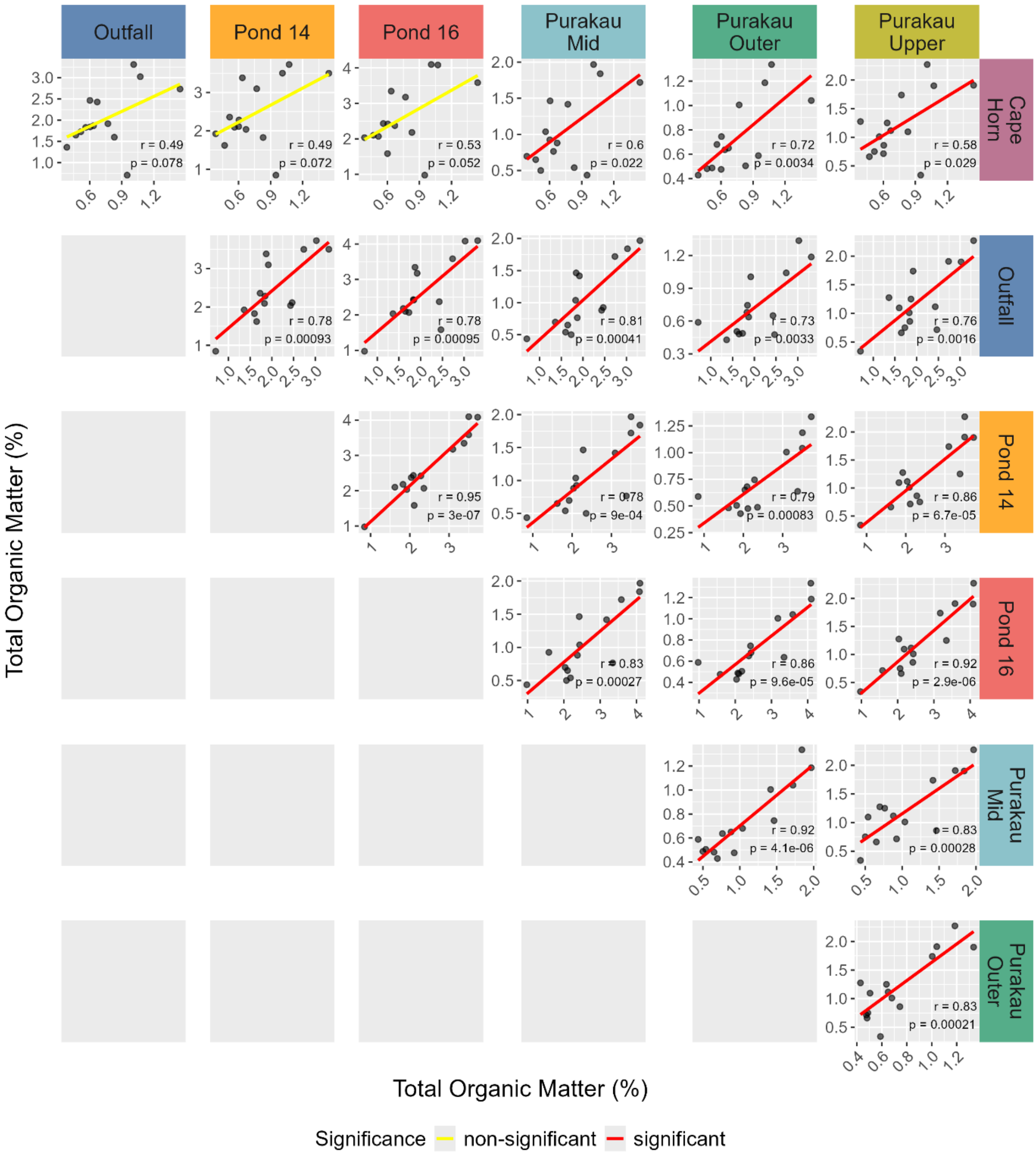


Figure 47: Scatter plot matrix showing correlations between mean percentages of total organic matter among Watercare Services' seven ecological monitoring sites. Linear regression lines are coloured by statistical significance, and correlation coefficients and p-values are provided for each comparison. Note that the ranges shown vary among sites.



6.2.2 BENTHIC DIVERSITY AND ABUNDANCE

Temporal plots of the numbers of taxa, numbers of individuals, Pielou's evenness and Shannon diversity show that counts of taxa and individuals have varied over time, but have not displayed consistent, progressive trends (Figure 49). Patterns of note since 2011 include:

- Boxplots of pooled ecological data from 2011 to 2024 (Figure 48) indicates that overall:
    - The highest and most variable numbers of taxa were obtained from the Purakau Mid site, while the pond sites tend to have the lowest numbers of taxa.
    - Pooled numbers of individuals were highest and most variable at the Outfall site, while the pond sites tended to have the lowest and least variable numbers. Numbers at Purakau and Cape Horn sites were similar.
    - Pielou's evenness was lowest and most variable at the Outfall site, and highest at the Pond 16 site. Pooled values at the other sites were similar.
    - Pooled Shannon diversity results indicate that the highest values were obtained from the Purakau Mid site, with little difference apparent among the remaining sites.
- Mean numbers of taxa at the monitoring sites displayed substantial interannual variation, without maintaining consistent directional trends between 2011 and 2024 (Figure 49). Taxa numbers at all sites, except Purakau Outer, underwent a substantial dip midway through the 2011–24 time series, but have since rebounded. The similarity in temporal patterns among sites, suggests that variation in taxa numbers was driven by the same, or similar, environmental factors. However, slight offsets in the timing of those dips (by one to two years) meant that significant correlations were only detected between the Outfall site and Pond 14 and Purakau Mid sites, and Pond 14 and Pond 16 sites (Figure 50). At the Purakau Outer site, mean numbers of taxa were low and relatively stable between 2011 and 2018. However, since 2018, taxa numbers at the Purakau Outer site have displayed an increasing trend, and in 2023–24 were amongst the highest recorded.
- A particularly large reduction in the total count of individuals occurred at the Outfall site between 2017 and 2018. This was mainly attributed to a substantial decline in the numbers of a single polychaete worm *Aonides trifida*, which prior to 2018 was the numerically dominant taxa at the Outfall site. Numbers of individuals at the Outfall site increased between 2018 and 2019, and subsequently stabilised.
- Numbers of individuals at the Pond 14 site have been trending up since 2017, while those in Pond 16 have been relatively stable since 2011.
- Variation in the number of individuals at the Purakau Upper and Mid, and Cape Horn sites have been similar to patterns in the number of taxa.
- Pielou's evenness and Shannon's diversity at the Outfall site increased in response to the declining numbers of *Aonides trifida*, while index values have been decreasing at the Pond 14 site as numbers of individuals increase.

Figure 48: Boxplots showing numbers of benthic taxa and individuals, Pielou's evenness and Shannon diversity from pooled 2011–2024 data.

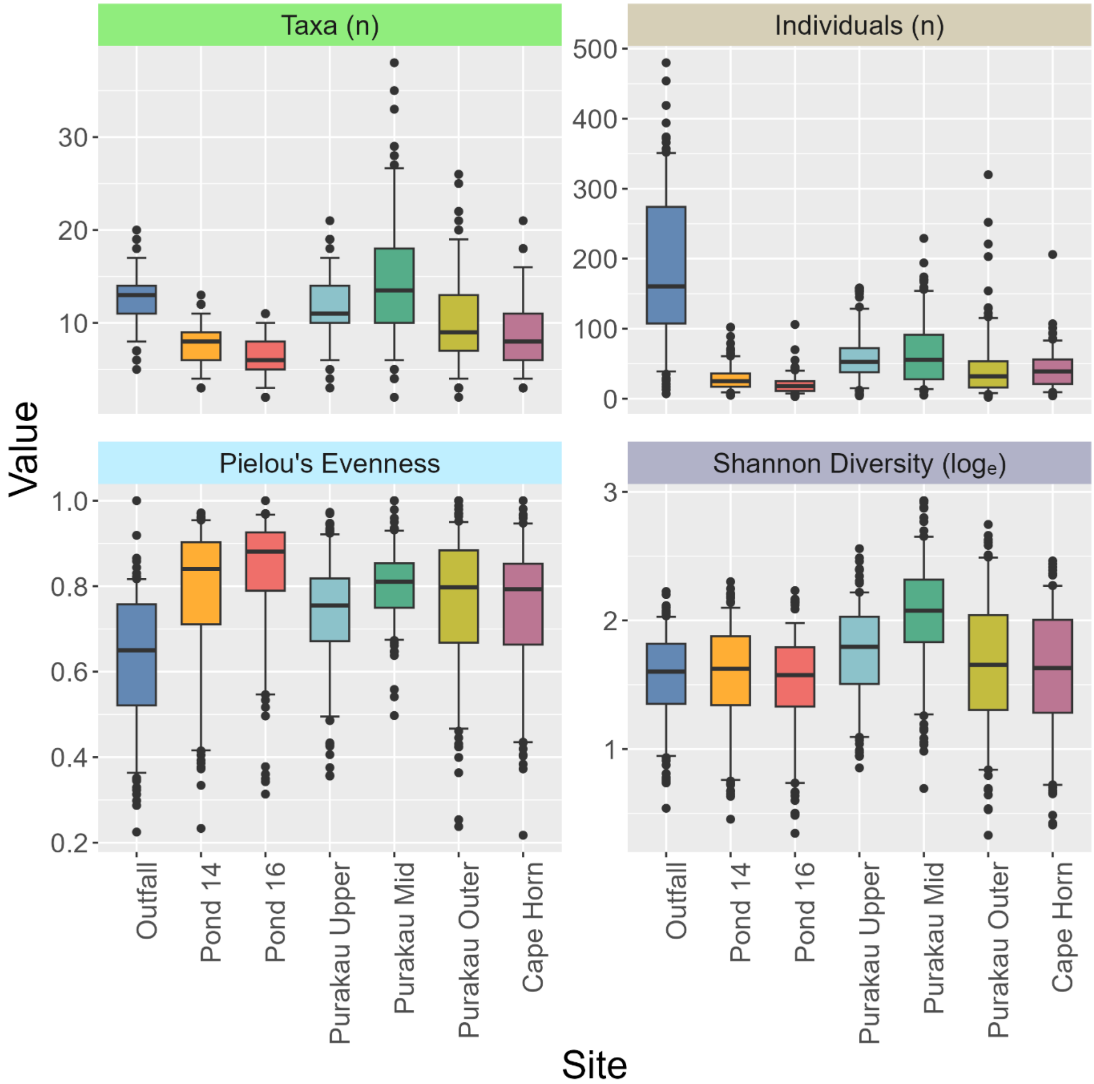


Figure 49: Changes in the mean (± 95% CI) number of taxa; total number of individuals; Pielou's evenness; and Shannon diversity at the seven ecological sites monitored by Watercare Services.

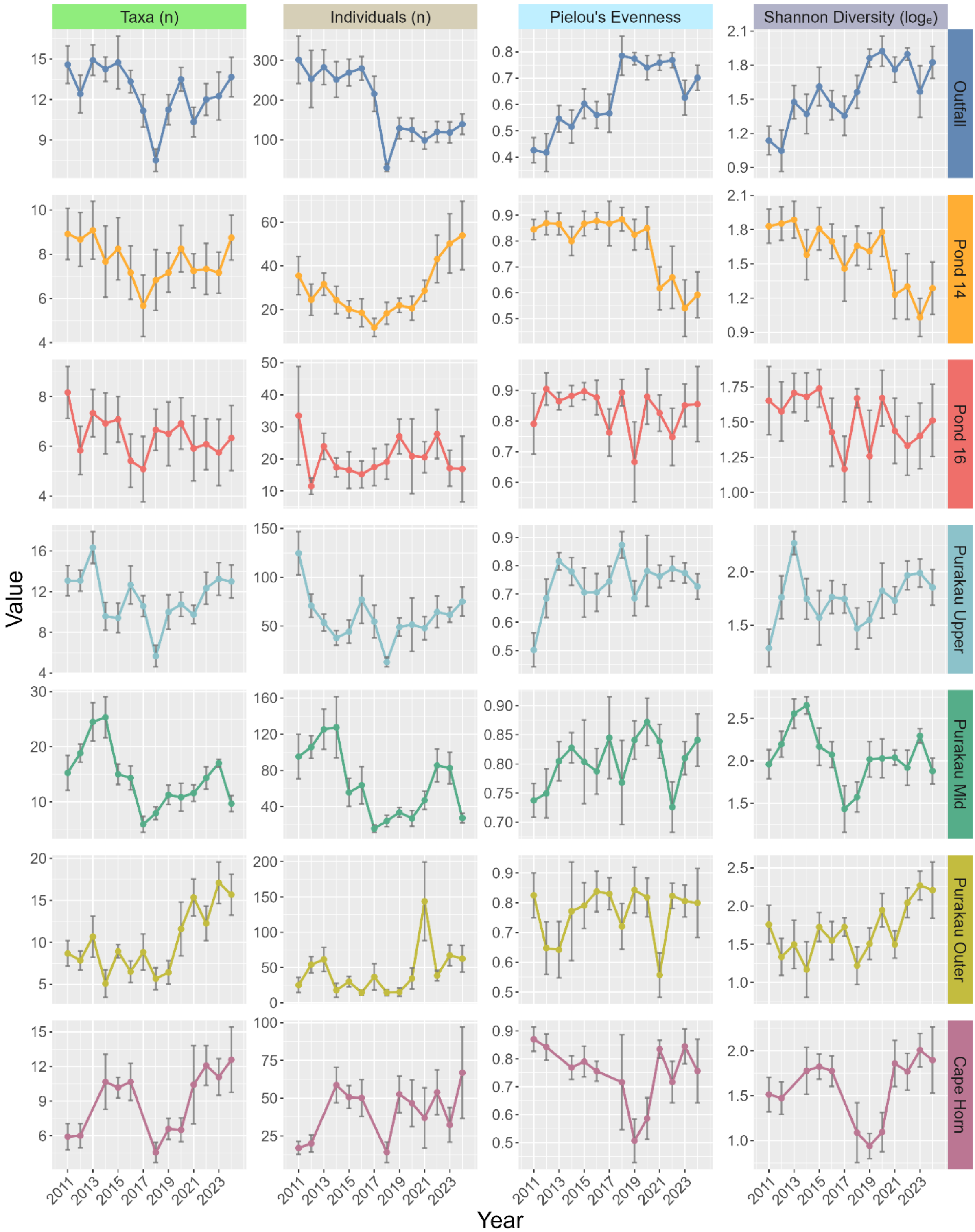
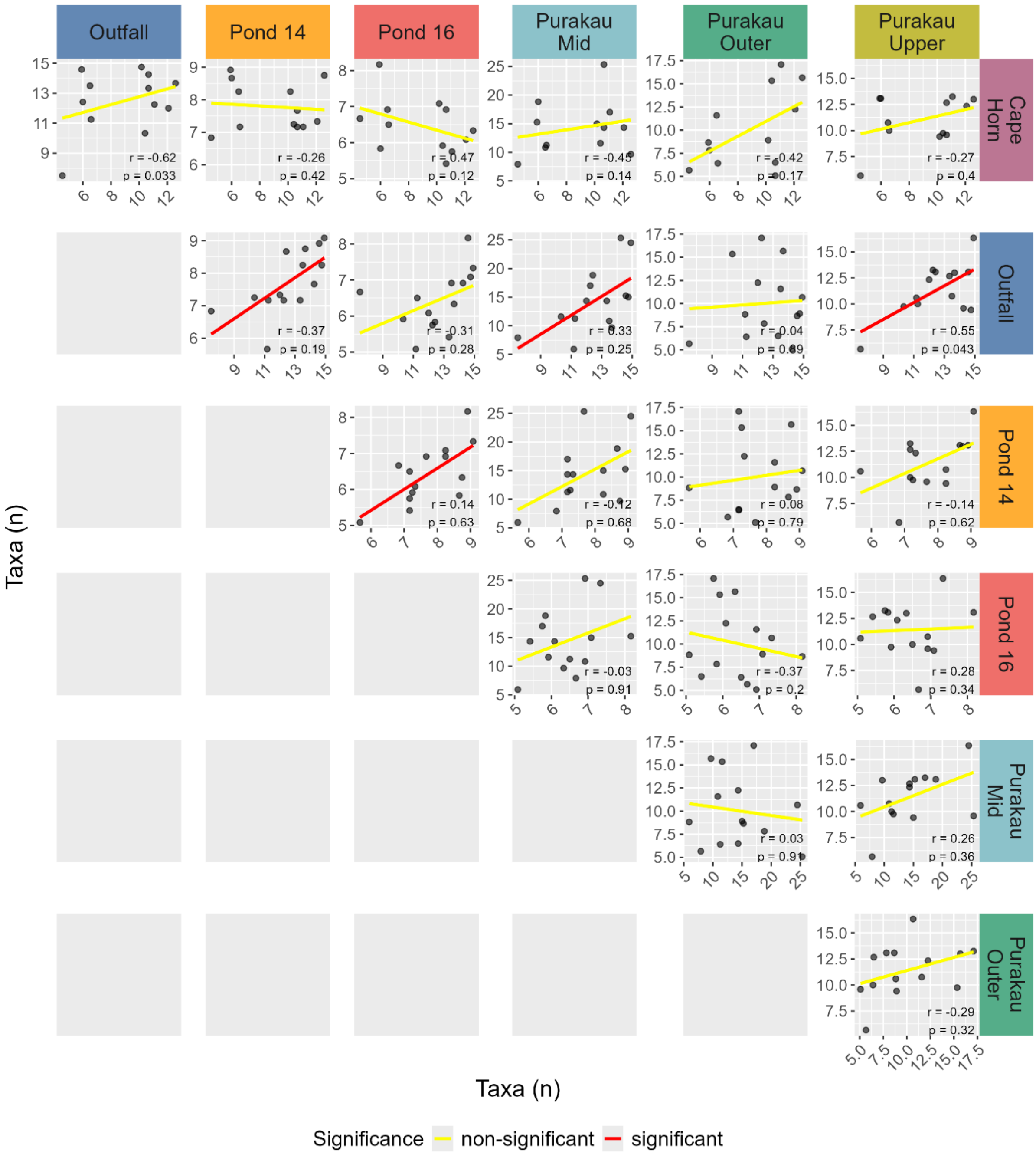


Figure 50: Scatter plot matrix showing correlations between mean numbers of taxa among Watercare Services' seven ecological monitoring sites. Linear regression lines are coloured by statistical significance and correlation coefficients and p-values are provided for each comparison. Note that the ranges shown vary among sites.



6.2.3 BENTHIC COMMUNITY COMPOSITION

Variation in benthic community composition was assessed using hierarchical clustering with similarity profile (SIMPROF) analysis (5% significance), and multidimensional scaling (MDS) using Bray-Curtis resemblance. The analyses were carried out on square-root transformed, total count data obtained between 2011 and 2024. Cluster analysis dendrograms and MDS plots showed that overall community composition[16] differed among monitoring sites (Figure 52). In summary:

- The MDS stress value was relatively high (0.17), indicating that while the plot provided a potentially useful representation of the data, cross-checking should be carried out (Clarke & Warwick 2001). SIMPROF clusters were therefore overlaid on the MDS plot to aid in its interpretation (Figure 51 and Figure 52).
- Benthic community composition at the two Pond sites were similar and distinct from all other sites.
- Community composition at the Outfall site was distinct from other sites and temporarily shifted between 2016 and 2017.
- There was a gradient in community composition from inner to outer harbour sites, and with distance from the outfall.
- The Cape Horn and Purakau Channel sites displayed much greater temporal variability than the Outfall and Pond sites, but there was little overlap between sites.
- High temporal variability at the Purakau and Cape Horn sites is reflected in those sites undergoing multiple shifts in community composition between 2011 and 2024.
- There was very little change in benthic community composition at all sites between 2021 and 2024, and there was little overlap among site clusters during those years. The exception was communities at the Purakau Mid and Cape Horn site, which were part of the same cluster (cluster “g” in Figure 52).

Hierarchical clustering and MDS of Auckland Council’s reduced set of indicator species corroborates the Watercare results, which show that community composition at the Cape Horn site has displayed a high level of temporal variation.[17] Two Cape Horn clusters contained most of the years sampled, with 2013 and 2019 forming their own single-year clusters. Community composition is much less variable at the Clarks Beach and Auckland Airport sites. Since 2011, community composition at the Auckland Airport has formed two multi-year clusters, with one containing results from 2011–2015, and the other containing all other years. Benthic community composition at the Clarks Beach site was grouped into a single cluster (Figure 53 & Figure 54).

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[16] Here, composition refers to the mix of taxa within a community i.e., the taxa present and their relative abundances.

[17] Community composition at the Cape Horn site is periodically monitored by Auckland Council.

Figure 51: Cluster analysis of community structure (using total taxa counts) in annual samples collected from the Outfall (OUT), Pond 14 (P14), Pond 16 (P16), Purakau Upper (PU), Mid (PM) and Outer (PO) and Cape Horn (CH) sites between 2011 and 2024. Sites are grouped by colour, with sampling year (abbreviated to the last two digits) provided beside each dot. Statistically significant clusters (5% probability) are separated by black lines.

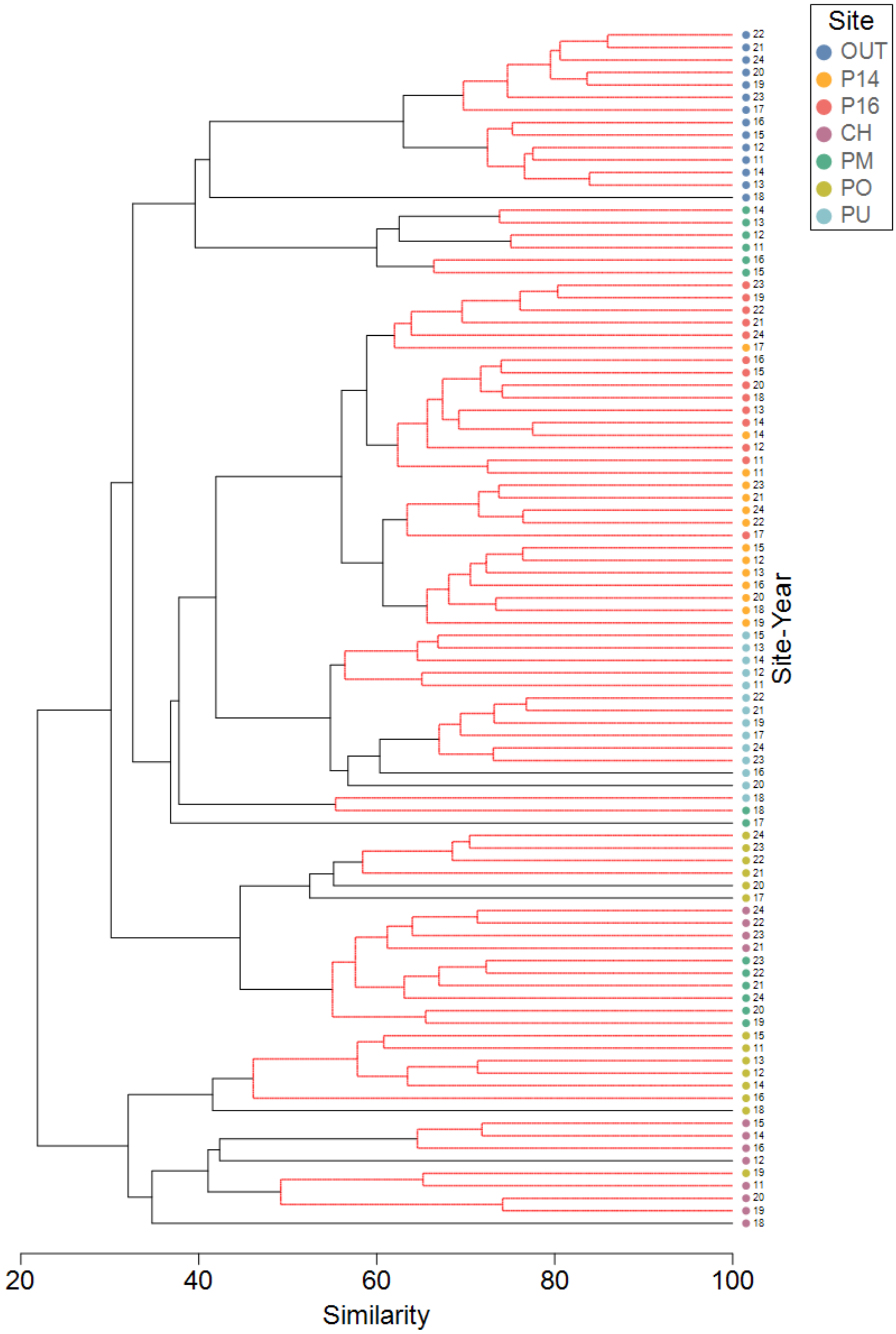


Figure 52: Multi-dimensional scaling plots of community structure (using total taxa counts) in annual samples collected from each Watercare site between 2011 and 2024, with: a) lines showing trajectories at each site through time (points labelled with the last two digits of the year), and b) points labelled and grouped into clusters, based on site, similarity profile results and temporal patterns.

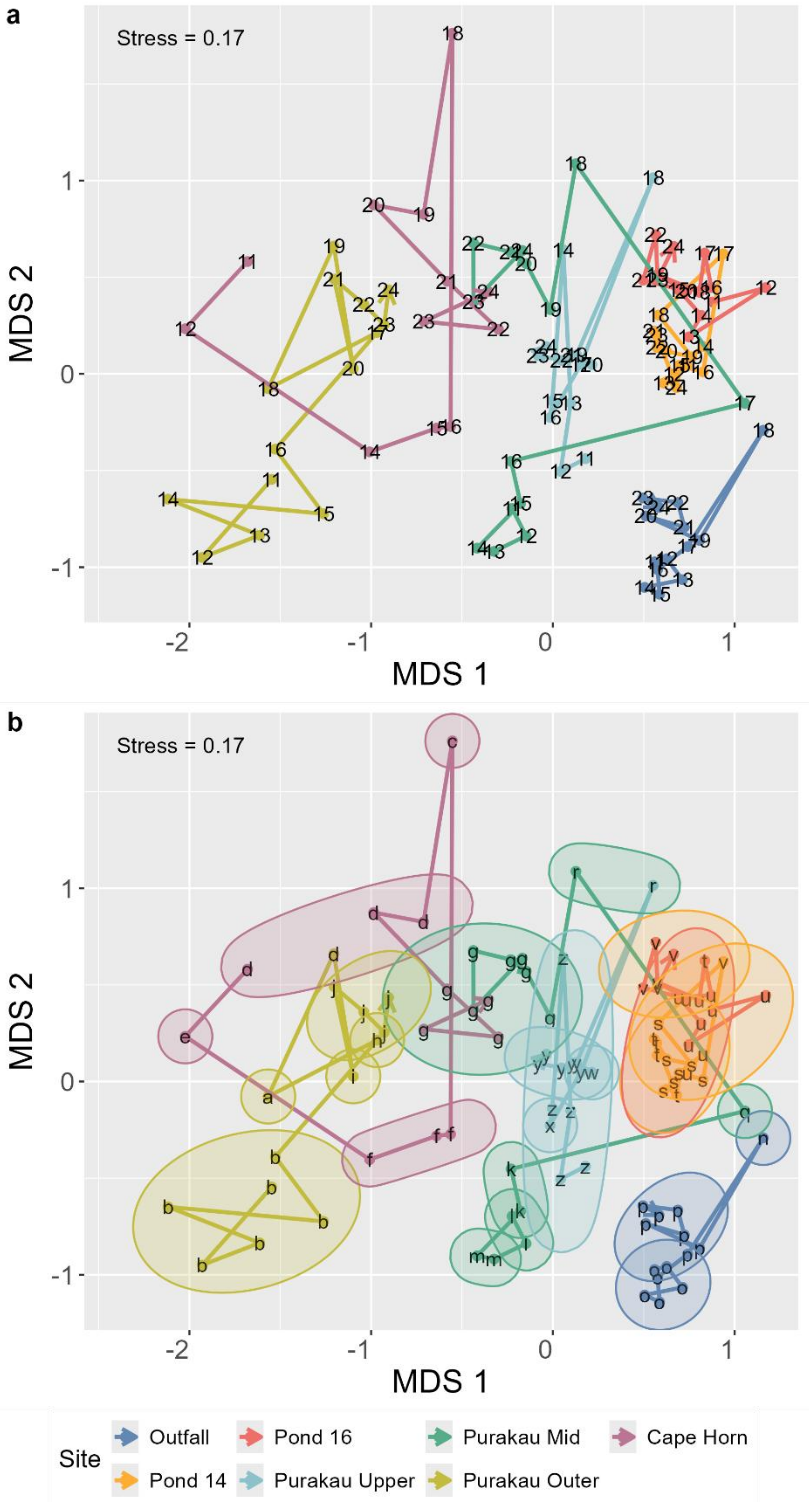


Figure 53: Cluster analysis of community structure (using total taxa counts) in annual samples collected from the Auckland Council sites (Clarks Beach (CB), Auckland Airport (AA), and Cape Horn (CH)) between 2011 and 2024. Sites are grouped by colour, with sampling year (abbreviated to the last two digits) provided beside each dot. Statistically significant clusters (5% probability) are separated by black lines.

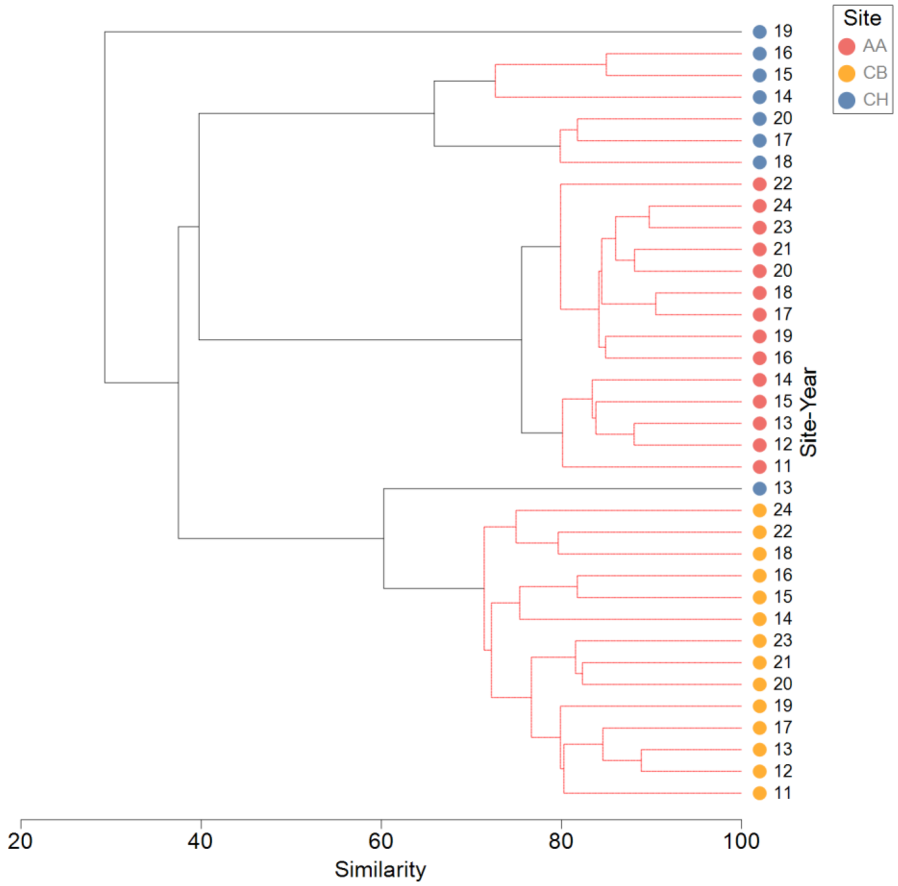
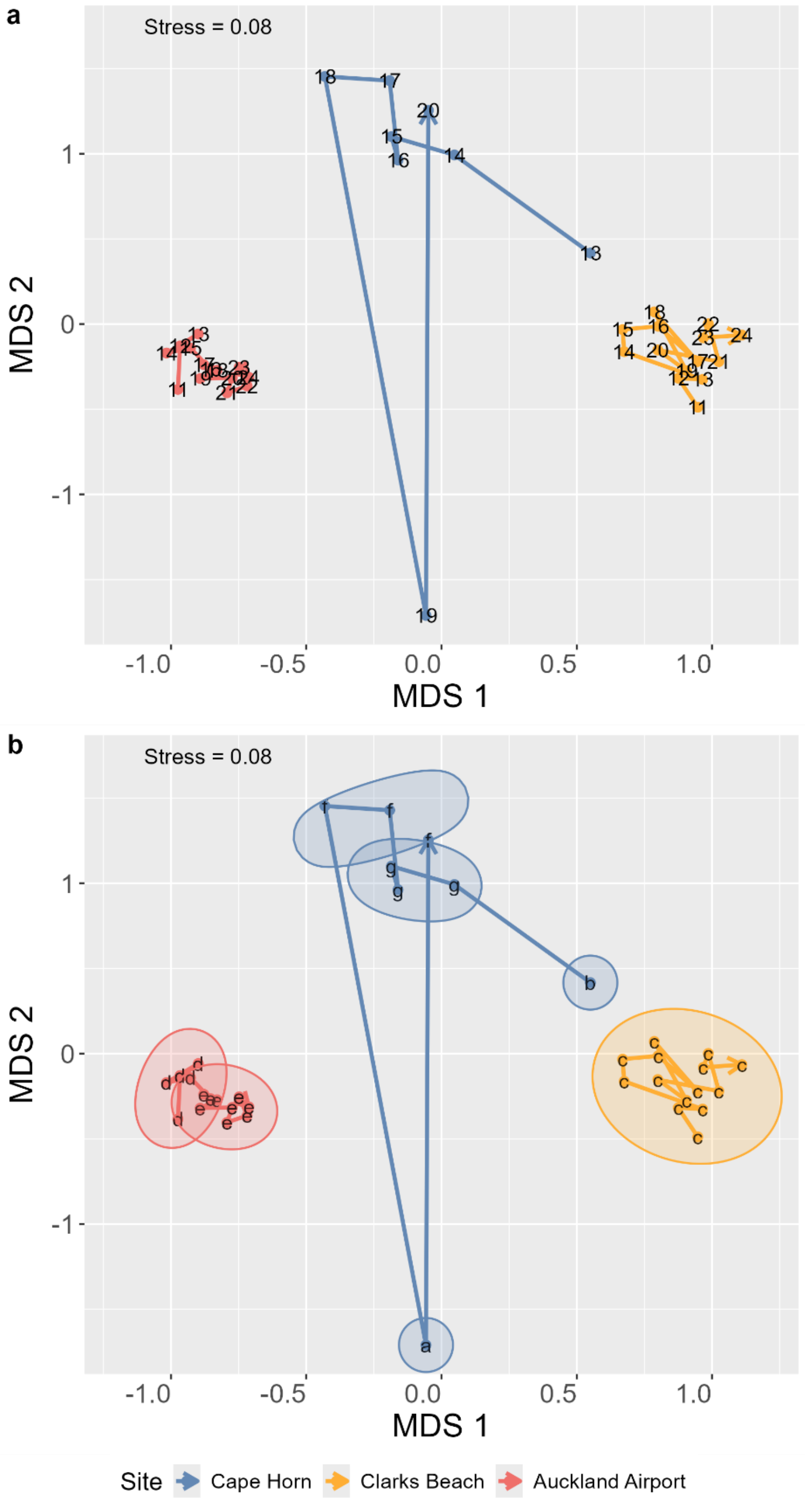


Figure 54: Multi-dimensional scaling plots of community structure (using total taxa counts) in annual samples collected from each Auckland Council site between 2011 and 2024, with: a) lines showing trajectories at each site through time (points labelled with the last two digits of the year), and b) points labelled and grouped into clusters, based on site, similarity profile results and temporal patterns.



6.2.3.1 VARIATION IN THE COUNTS OF KEY TAXA

Similarity percentages analysis (SIMPER)[18] was used to determine the contributions that individual taxa made to the dissimilarity between the clusters identified in Figure 51.[19] Taxa were then ranked according to their mean contribution. Overall, the eight taxa with the greatest influence on community shifts were: the polychaete worms *Heteromastus filiformis*, *Magelona dakini*, *Anoides trifida,* and *Prionospio aucklandica*; the small, introduced nut shell *Linucula hartvigiana*; cockles (*Austrovenus stutchburyi*) and a closely associated anemone *Anthopleura aureoradiata*; and phoxochephalid amphipods. Key patterns observed in the plots showing annual variation in the mean counts of the top 24 taxa (Figure 55) are summarised in Table 10.

Table 10: Summary of observed patterns in benthic macrofauna counts obtained from Watercare monitoring sites between 2011 and 2024.

Pattern	Taxa
Taxa common at all sites, with counts varying from absent to high. Variable temporal patterns, including sites with increasing, decreasing and fluctuating counts, and no clear spatial pattern in those trends.	Polychaete worm, *Heteromastus filiformis*
Taxa common at all sites, with counts varying from absent to high. Numbers have been consistently highest at the Outfall site. Variable temporal patterns include sites with decreasing and/or fluctuating counts. No clear spatial pattern in temporal trends.	Spionid worm *Prionospio aucklandica*
Taxa common at most sites, with counts varying from absent to moderate. Variable temporal patterns, including sites with decreasing trends, fluctuating counts, or only the occasional occurrence of a few individuals. No clear spatial pattern in temporal trends.	Nut shell, *Linucula hartvigiana*, Polychaete worm, *Magelona* cf. *dakini*, Cockle, *Austrovenus stutchburyi*, Amphipods from the family Phoxocephalidae
Taxa common at most sites except the Pond sites, with counts varying from absent to moderate. Variable temporal patterns, including sites with increasing, decreasing or fluctuating counts. No clear spatial pattern in temporal trends.	Anemone, *Anthopleura aureoradiata*, Polychaete worms, *Owenia petersenae* and Syllidae Bamboo worms from the family Maldanidae Shrimps from the order Cumacea
Boom or bust taxa, with periods of moderate to extreme numbers followed by periods of absence or the occasional occurrence of a few individuals.	Polychaete worm *Aonides trifida*, Asian date mussel *Arcuatula senhousia* Unidentified amphipods
Low-density taxa with minor fluctuations or cyclical numbers. May be consistently absent from one or more sites.	Polychaete worms *Nicon aestuariensis, Glycinde trifida, Clymenella stewartensis, Aricidea* spp., and Nereididae Shrimps from the orders Tanaidacea, Mysidacea, and Cumacea Wedge shell, *Macomona liliana*

[18] Using Bray-Curtis dissimilarities.

[19] Using hierarchical clustering with similarity profile (SIMPROF) analysis of data from Watercare sites.

Figure 55: Variation in the mean (± S.E.) counts of taxa ranked 1–4 for mean percentage contributions to dissimilarity between clusters. Note that the scale of the y-axes varies among plots.

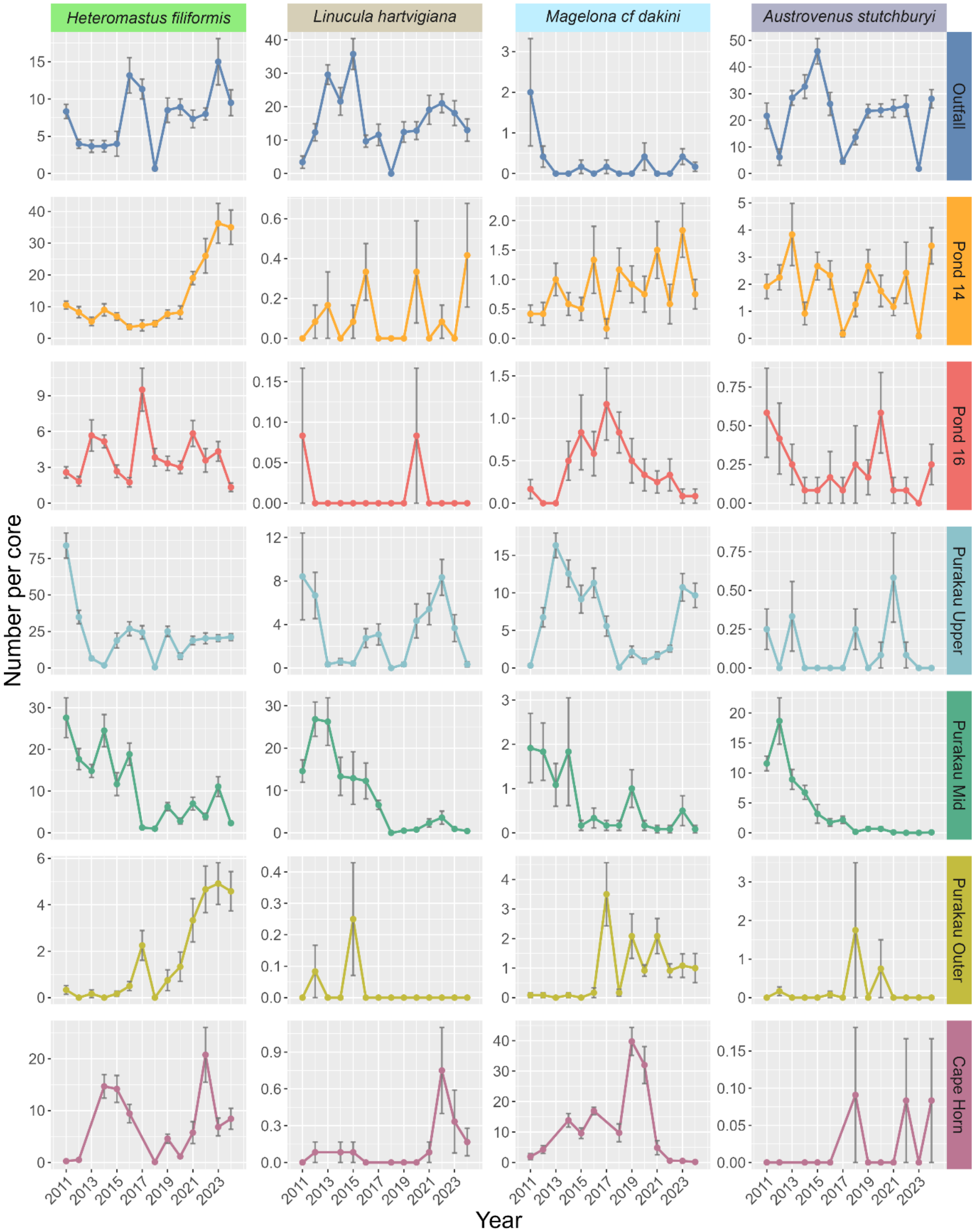


Figure 55 cont.: Variation in the mean (± S.E.) counts of taxa ranked 5–8 for mean percentage contributions to dissimilarity between clusters. Note that the scale of the y-axes varies among plots. Blank plots indicate the absence of that taxa.

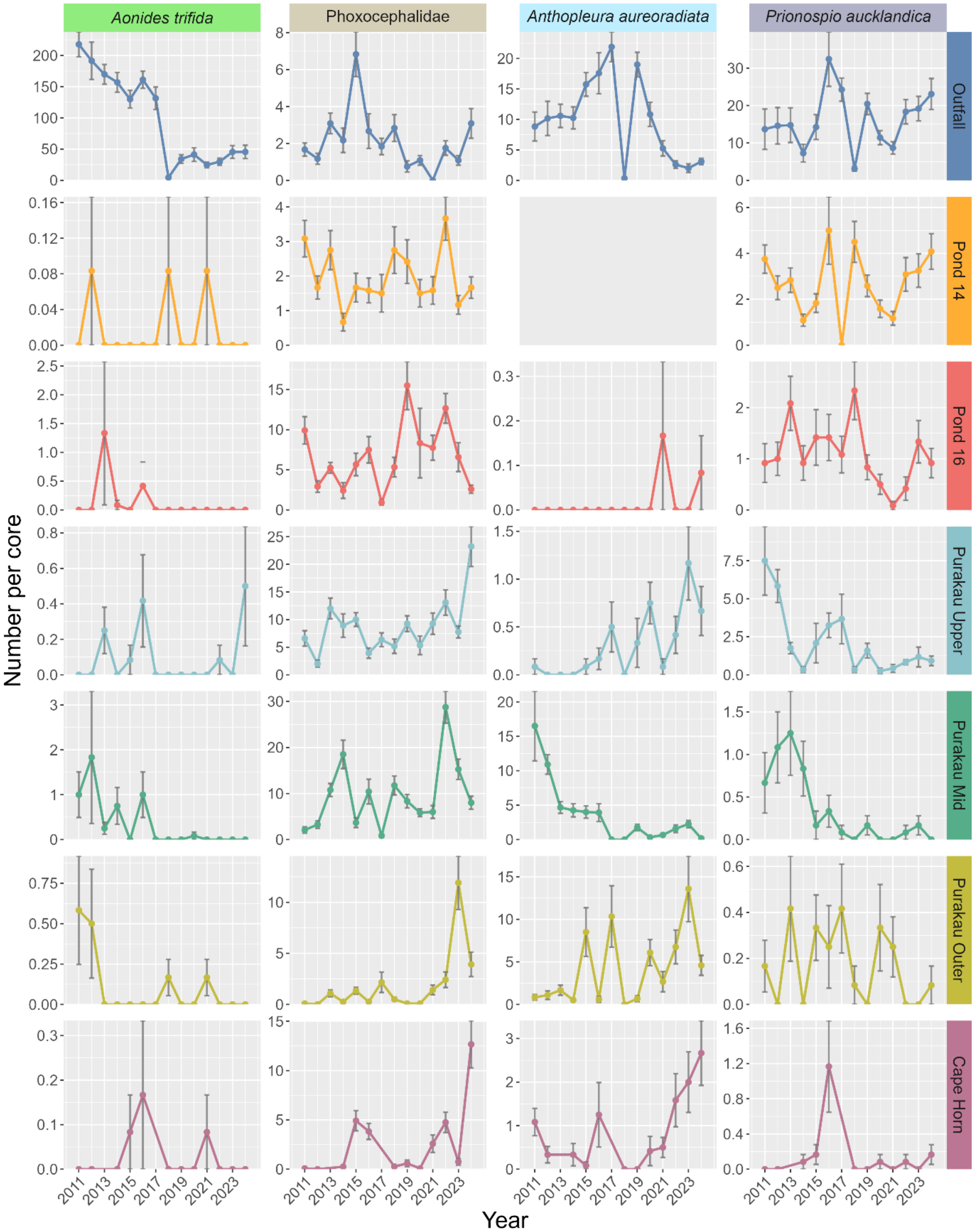


Figure 55 cont.: Variation in the mean (± S.E.) counts of taxa ranked 9–12 for mean percentage contributions to dissimilarity between clusters. Note that the scale of the y-axes varies among plots. Taxa were not recorded at sites with blank plots.

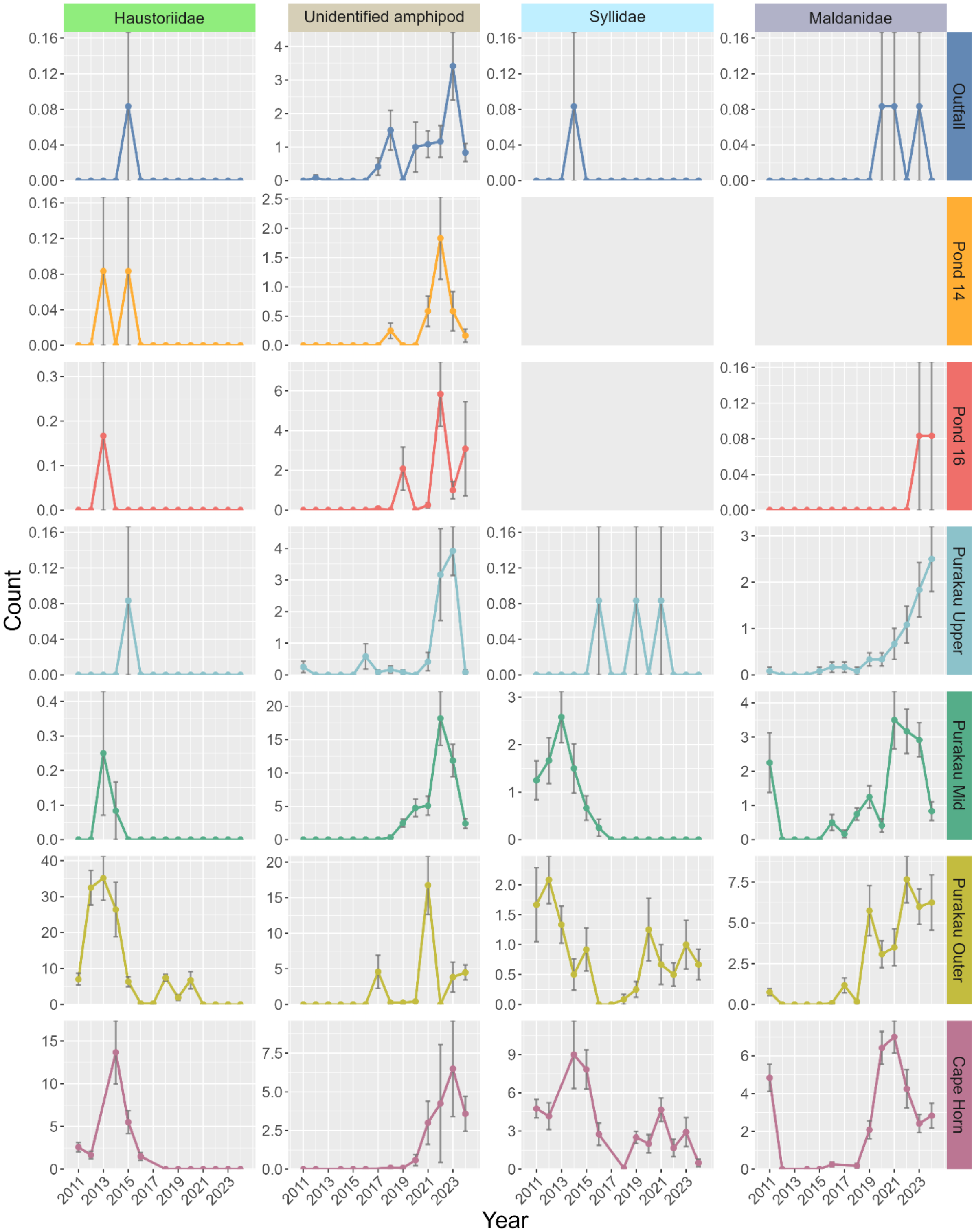


Figure 55 cont.: Variation in the mean (± S.E.) counts of taxa ranked 13–16 for mean percentage contributions to dissimilarity between clusters. Note that the scale of the y-axes varies among plots. Taxa were not recorded at sites with blank plots.

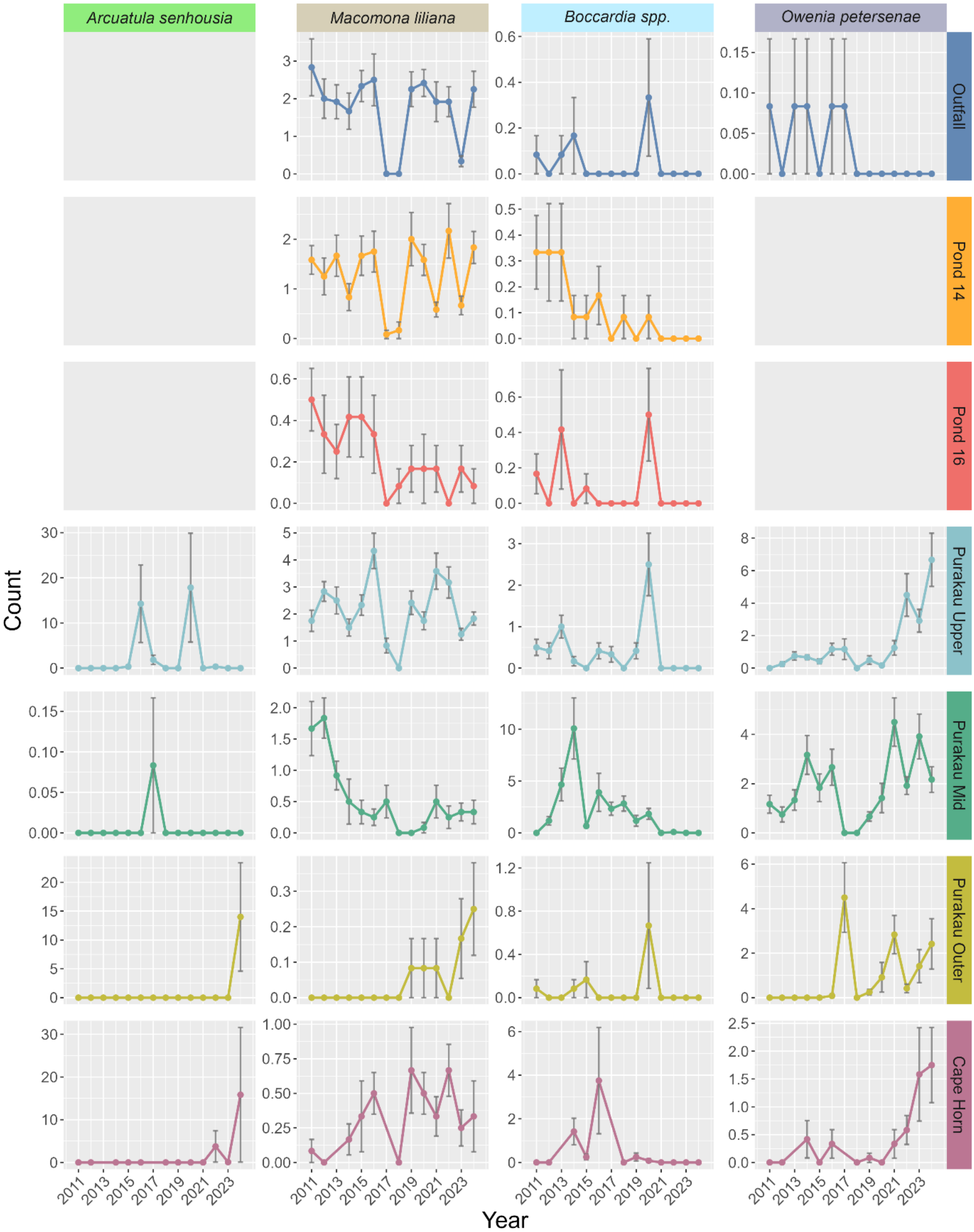


Figure 55 cont.: Variation in the mean (± S.E.) counts of taxa ranked 17–20 for mean percentage contributions to dissimilarity between clusters. Note that the scale of the y-axes varies among plots. Taxa were not recorded at sites with blank plots.

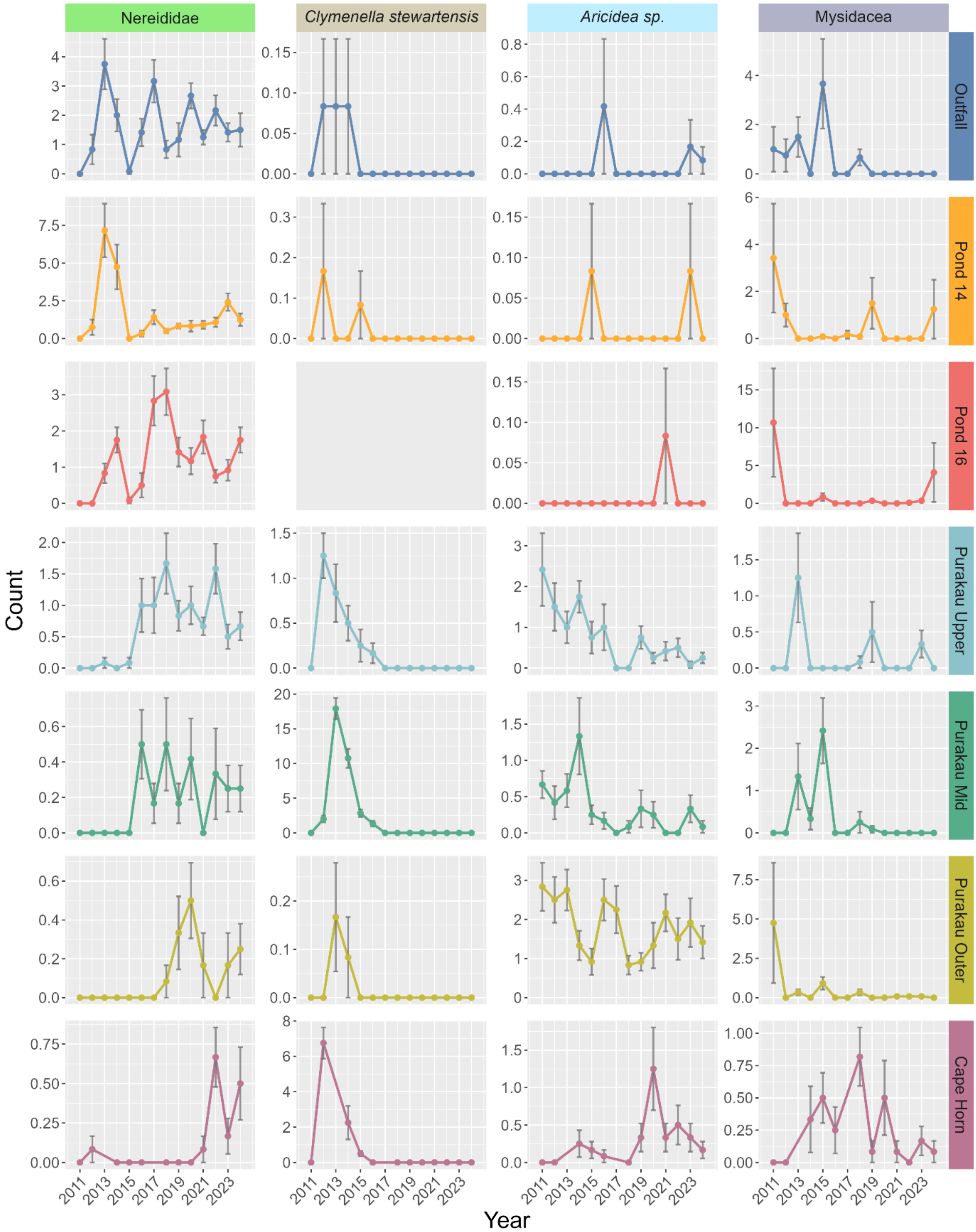
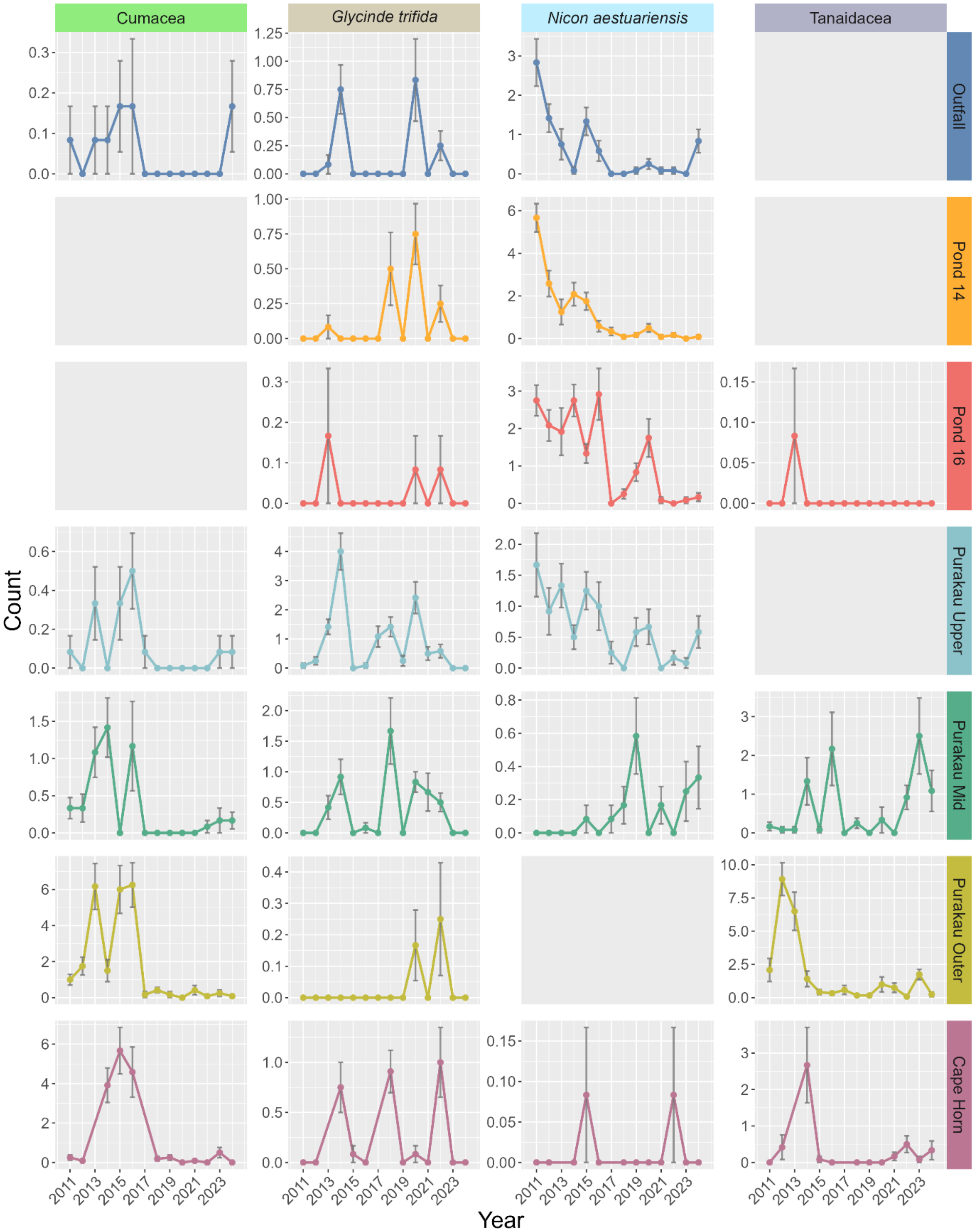


Figure 55 cont.: Variation in the mean (± S.E.) counts of taxa ranked 21–24 for mean percentage contributions to dissimilarity between clusters. Note that the scale of the y-axes varies among plots. Taxa were not recorded at sites with blank plots.



7 DISCUSSION

7.1 DISCHARGE QUALITY

Between July 2015 and June 2025, statistically significant declining trends were detected in ammoniacal-N, soluble reactive phosphorus (SRP), total phosphorus (TP) and BOD_5 loads. None of the parameters monitored displayed statistically significant increasing trends. However, LOESS smoothing lines show that while discharge volumes were relatively stable over the 10-year period, loads of NNN, SRP and TP dipped, and then have been increasing over recent years. The NNN minimum was centred around 2021, and the SRP and TP minima were centred around 2022. Since then, loads of all three parameters have increased substantially, and in 2025 they were comparable to those at the start of the 10-year period (2015). In contrast, only slight fluctuations occurred in ammoniacal-N, total suspended solids (TSS), and BOD_5 loads over the same period.

Twelve bypass events occurred between July 2024 and June 2025. Seasonal and interannual variation was apparent in the occurrence, volume and durations of bypass events occurring between July 2015 and June 2025, but there did not appear to be any consistent long-term trends in the occurrence of those events.

7.2 HARBOUR WATER QUALITY

Changes in the laboratory used for the analysis of water samples from Auckland Council sites in 2017, led to slight step changes in the analytical results of ammoniacal-N, TN, chlorophyll *a*, Total Kjeldahl Nitrogen (TKN), and TSS. Similarly, necessary changes to the method used for determining TN concentrations in seawater also led to a slight step change in 2015–16 (see Appendix H). Consequently, 2014–24 trend estimates were not obtained for ammoniacal-N, chlorophyll *a*, TKN, and TSS at the Wairopa, Puketutu, Titirangi, Harbour Mouth, Grahams Beach, Clarks or Weymouth sites, and TN trend estimates were not obtained from any site.

For the period between July 2015 and June 2025, statistical trends and other notable results from the analysis of key water quality parameters included:

- No significant 10-year trends in ammoniacal-N, TIN, SRP, water temperature or pH, but:
  - An upswing was apparent in TIN concentrations at the Puketutu site in 2022, with a subsequent increase in TIN variability since 2023 (this mirrors the patterns below for NNN). Concentrations at other sites have fluctuated over time without displaying consistent patterns.
  - An upswing in SRP concentrations and variability at the Puketutu site since 2022, which coincides with the similar upswing in discharge loads. Rising SRP concentrations since 2022 at sites along Wairopa Channel also mirror the recent increases in discharge loads.
  - Strong seasonality in temperature readings, but interannual patterns were not apparent over the 10-year period.
  - Similar temporal fluctuations in pH at all sites, with no consistent trend.

- A significant increasing 10-year trend in NNN concentrations at the Puketutu site, which appears to be related to an upswing in NNN concentrations since 2022, and a subsequent increase in NNN variability since 2023. NNN concentrations at other sites have fluctuated over time without displaying consistent patterns or trends.
- Significant declining 10-year trends in TP at six of the 11 monitoring sites, and a significant increasing trend at the Puketutu site. The increasing trend is related to an upswing in total phosphorus concentrations and variability at the Puketutu site since 2022, and coincides with a similar upswing in discharge loads. Total phosphorus concentrations at sites along Wairopa Channel have also increased since 2022, mirroring the recent increases in discharge loads.
- Significant declining 10-year trends in turbidity at eight of the 11 monitoring sites.
- Significant declining 10-year trends in TSS at two of the four sites with sufficient data for trend analyses (HWQ 30 and HWQ 80), and a significant increase at the HWQ 70 site.
- Significant declining 10-year trends in chlorophyll *a* concentrations at three of the four sites with sufficient data for trend analyses (HWQ 30, HWQ 60, HWQ 70).
- Seasonal fluctuations in DO concentrations with a slight, but statistically significant declining 10-year trend at the HWQ 60 site.

While formal trend analyses were not carried out on TN concentrations, plotted data from the period since the laboratory-related step-changes suggest that significant trends are unlikely to have occurred at all sites except Puketutu, where TN displayed an upswing in concentrations in 2022, and a subsequent increase in variability since 2023.

Least squares linear regression did not detect consistent temporal trends in mean summer TN or $\log_{10}$ chlorophyll *a* concentrations at 10 of the 11 sites. The exception was Puketutu, where a significant increasing trend in summer TN concentrations was detected between 2018 and 2024. Conversely, a significant decreasing trend in summer chlorophyll *a* concentrations was detected at the Puketutu site over the same period.

Apart from Puketutu and Wairoa, strong positive relationships were detected between mean TN concentrations and mean and maximum chlorophyll *a* concentrations at the Watercare and Auckland Council sites. Surprisingly, negative relationships were detected between mean summer concentrations of TN and mean and maximum concentrations of chlorophyll *a* in pooled data from the Puketutu and Wairoa sites. The reasons for the negative relationship are not known.

7.3 SEDIMENT METALS, DDT AND DIELDRIN

Sediment concentrations for cadmium, mercury, copper, lead and zinc were at the lower range of concentrations obtained from marine sediment samples in the Auckland Region (Kelly 2023, Allen 2025), with no exceedances of sediment quality guidelines in 2024. Total DDT and dieldrin concentrations in all samples were also below detection limits. These results are consistent with those of previous years (Kelly 2023), and suggest that the discharge is not having a marked adverse effect on heavy metal or legacy persistent organochlorine pesticides (POP) in marine sediments.

Except for PCP, all persistent organochlorine pesticides (which include DDT and dieldrin) were formally deregistered by the New Zealand Pesticides Board in 1989 (PCP was deregistered in 1991). Monitoring results have shown that sediment concentrations have fallen below detection limits, and because those contaminants have not been used for decades, ongoing monitoring of DDT and dieldrin is no longer warranted. It is therefore recommended that the HEMP be amended to remove that requirement.

7.4 BENTHIC HABITATS AND ECOLOGY

7.4.1 SEDIMENTS

Since 2011, sediments at the Outfall, Pond and Upper Purakau sites have been relatively stable, but replicated sampling since 2018[20] shows that within-year variability in sediment mud content at those sites is high. Apart from the Purakau Outer and Cape Horn sites in 2024, the mud content of sediments at the other monitoring sites displayed much less within-year variation. Temporal changes in sediment mud content at the Purakau and Cape Horn sites have included:

- Mud content at the Purakau Mid site steadily increased between 2011 and 2023, before dropping sharply in 2024.
- A large increase in both mean mud content and within-year variation at the Purakau Outer and Cape Horn sites in 2024. That change was associated with particularly high levels of mud in one of the six samples collected at each site.

The TOM content of sediments also differs among sites, with the highest levels at the Pond and Outfall sites, intermediate concentrations at the Purakau Upper and Mid sites, and lowest levels at the Purakau Outer and Cape Horn sites. Temporal variation in organic content was very similar at all sites between 2011 and 2024, with a large spike occurring between 2019 and 2023 at all sites, and mean TOM continuing to fall at five of the seven monitoring sites in 2024. Levels at those sites are now the lowest recorded since 2011. In contrast, mean TOM rose slightly at Cape Horn, and dropped only marginally at Purakau Outer in 2024. Like mud content, within-site variability at both sites was unusually high, due to a single outlier among the six samples collected at each site.

Patterns in sediment chlorophyll *a* concentrations differed from those of sediment mud and organic content. Unsurprisingly, highest chlorophyll *a* concentrations have generally been obtained from the Outfall site. Lowest chlorophyll *a* concentrations have consistently been obtained from the Purakau Upper and Cape Horn sites. The remaining sites tend to have intermediate concentrations. Within-site variability in chlorophyll *a* concentrations was also unusually high at the Cape Horn and Purakau Outer sites in 2024, due to a single outlier among the six samples collected from each site.

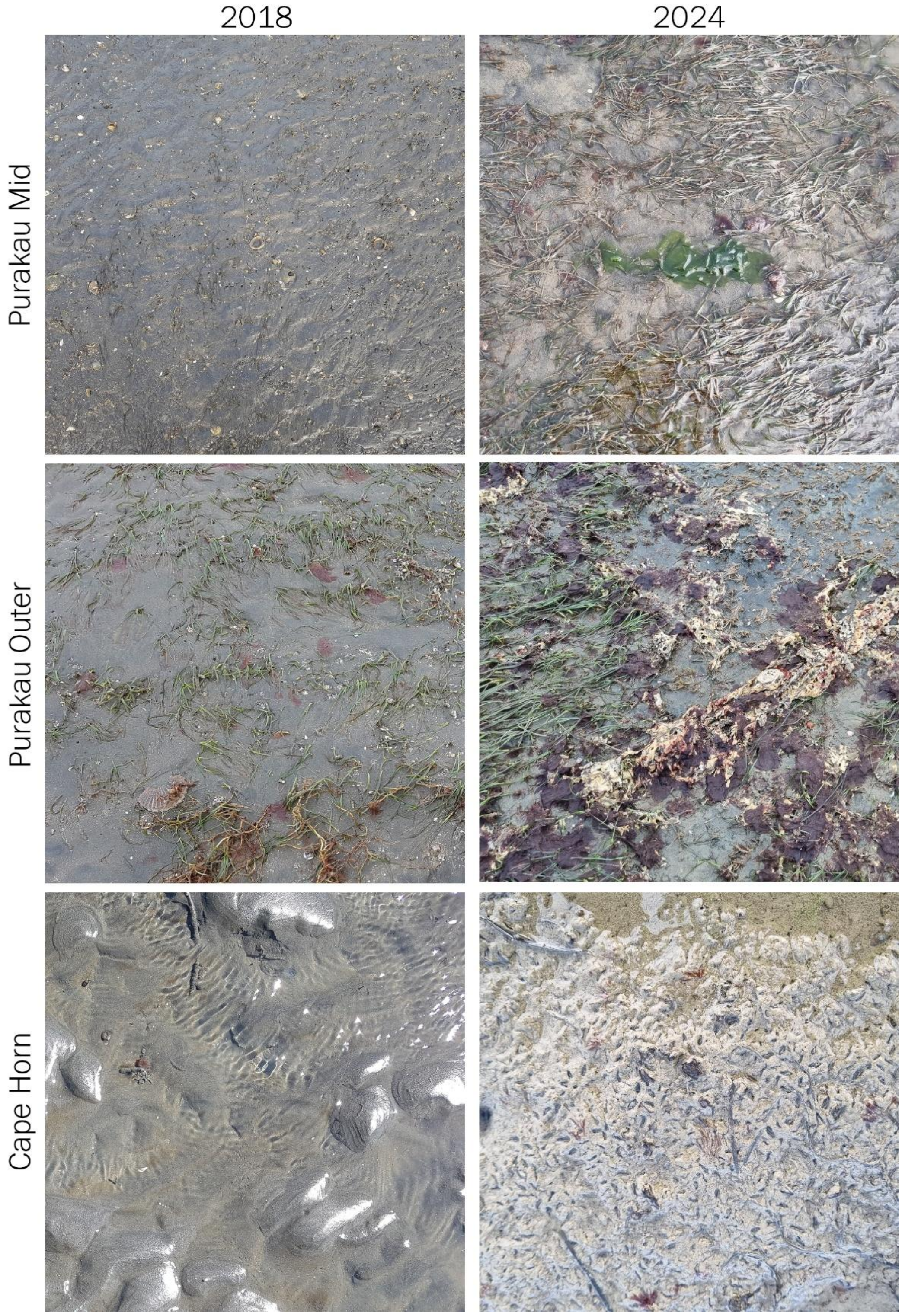
The single outliers obtained from samples at the Cape Horn and Purakau Outer sites were clear anomalies, so consideration was given to omitting those samples from the analyses. However, photographs taken during sampling between 2018 and 2024 (provided by Bioresearches) showed that those sites are very dynamic, with significant physical and ecological changes occurring between 2011 and 2024 (see Figure 56 & Figure 57 for examples from 2018 and 2024, and Appendix F for most of the photos taken in those years). These included switching

[20] Except for 2011, single samples were obtained prior to 2018.

from largely homogeneous sandflat habitats with sparse seagrass, to a complex matrix of sandy habitats with extensive seagrass and *Solieria* cover (particularly in the Purakau Outer site), and the increasing presence of other habitat-forming taxa such as Asian date mussels (a habitat-forming, boom-and-bust species). Consequently, it is likely that those results accurately reflect the spatial variation that existed within those sites in 2024.

Figure 56: Example overview photographs of the Purakau Mid, Purakau Outer and Cape Horn monitoring sites taken by Bioresearches during benthic ecological sample collection in 2019 and 2024.

Figure 57: Example close-up photographs of the Purakau Mid, Purakau Outer and Cape Horn monitoring sites taken by Bioresearches during benthic ecological sample collection in 2019 and 2024, showing what appears to be changes in the presence and cover of: seagrass at the Purakau Mid site, seagrass, *Solieria* and the presence of a colonial ascidian? at the Purakau Outer site, Asian date mussels at the Cape Horn site.



7.4.2 BENTHIC COMMUNITIES

Spatial and temporal variability is a natural feature of benthic macrofaunal communities with taxa commonly exhibiting multi-year cycles in abundance (e.g., Greenfield et al. 2019, Carter & Hailes 2020). Such patterns are now emerging in the longer-term data obtained from the MWWTP monitoring programme. Two high-level patterns emerge from analyses of the data:

- Consistent differences in benthic community composition exist among sites, with patterns likely to be associated with variation in sediment characteristics, hydrodynamics and water quality, along with the habitat preferences/tolerances of individual species. Community composition varies along a gradient running from sheltered, muddy and enriched Pond and Outfall sites, to the exposed, sandy outer harbour sites. Changes in composition arise from differences in the relative abundance of taxa among sites, as well as differences in the distributions of taxa, with some taxa largely restricted to particular habitat conditions, while others tend to be more ubiquitous.
- There are differences in the amount of temporal variation in community composition, with the Pond and Outfall sites displaying less variation than the Purakau and Cape Horn sites. Discrete shifts in the composition of benthic communities were detected at all Watercare sites between 2011 and 2024.

Temporal variation in community composition is likely to be related to multiple factors, which potentially include:

- Natural variation in climatic conditions that affect sea and air temperature, wind direction and strength, and rainfall. Since 2016:
  - New Zealand has experienced a prolonged period of high temperatures, with record temperatures recorded in 2021 (NIWA 2022) and again in 2022 (NIWA 2023), and second-highest temperatures recorded in 2018 (NIWA 2019) and 2023 (NIWA 2024).
  - A severe meteorological drought occurred between December 2021 and January 2022, where Auckland City experienced its second-longest dry spell since records began in 1943.
  - On the east coast, a significant marine heat wave began in November 2021 and lasted 205 days, over which average and maximum sea surface temperatures increased by 2 °C and 3.8 °C, respectively (see Kelly et al. 2023 and references within). That coincided with a prolonged period of increasing sea temperatures in Manukau Harbour (Kelly 2022).
  - The summer of 2022–23 was wettest summer on record, with Auckland hit by two ex-tropical cyclones in quick succession, resulting in historic flooding and widespread destruction (Kelly et al. 2023).
- Variation in the physical and biological characteristics of the seabed, particularly at the Purakau Mid, Outer and Cape Horn sites, where significant changes have occurred in the extent and density of seagrass. As noted earlier, photographs taken during sampling between 2018 and 2024 (provided by Bioresearches) show that those sites are very dynamic, with significant physical and ecological changes occurring between 2011 and

2024 (see Figure 56 & Figure 57 for examples from 2018 and 2024, and Appendix F for most of the photos taken in those years). These included switching from largely homogeneous sandflat habitats with sparse seagrass, to a complex matrix of sandy habitats with extensive seagrass and *Solieria* cover (particularly in the Purakau Outer site), and the increasing presence of other habitat-forming taxa such as Asian date mussels, and epifaunal taxa. Those changes are highly likely to have influenced the relative abundances of individual infaunal taxa, as well as overall taxa diversity and abundance. That conclusion is supported by results from the Purakau Outer site, where mean numbers of taxa were low and relatively stable in the eight years between 2011 and 2018, and community composition was grouped into two clusters (with 2017 forming one of those). Since 2018, taxa numbers at the Purakau Outer site have displayed a steadily increasing trend, and in 2023–24 were amongst the highest recorded. Over that same six-year period, community composition has also shifted between four clusters.

- Variation in discharge volumes and loads from Mangere WWTP. The latest trend analyses in this report indicates that while 10-year trends have been stable or declining, a recent upswing has occurred in the loads of several parameters.

The discharge clearly influences the organic content of sediments in the NE Manukau Harbour, and has a strong and persistent influence on benthic community composition at the Outfall site, which is within the non-compliance zone. The sediment characteristics and the composition of the benthic community of this site are consistent with habitats that have intermediate levels of organic enrichment (Pearson & Rosenberg 1978, Keeley 2013), including:

- elevated concentrations of organic matter (content) and benthic primary productivity, as indicated by benthic chlorophyll *a* concentrations;
- moderate taxa diversity and elevated counts of individuals, due to the proliferation of one, or a few, enrichment-tolerant species (such as the deposit-feeding polychaete, *Aonides trifida,* whose numbers have fallen over the past 10 years).

As noted in the 2023 monitoring report (Kelly 2023), the composition of communities in the old pond sites appears to reflect their muddier sediments (noting that the construction of coastal structures may have exacerbated the retention and accumulation of mud), and the effects of the discharge (as suggested by the pond sites having elevated concentrations of organic matter that are similar to the Outfall site). Historically high concentrations of heavy metals, which were present when the treatment ponds were decommissioned, have declined and stabilised at regionally low levels, while DDT and dieldrin concentrations have dropped below detection limits. Those contaminants are therefore unlikely to have a detectable influence on benthic communities, and DDT and dieldrin are no longer of concern.

A variety of factors appear to influence the benthic communities at the Purakau and Cape Horn sites. However, aerial and site photos, and ecological monitoring results show that the central harbour continues to sustain a complex and highly dynamic benthic ecosystem.

7.5 CONCLUSIONS AND RECOMMENDATIONS

Overall, the monitoring results indicate that the MWWTP influences water quality in the north-eastern Manukau Harbour, leading to elevated nutrient concentrations and higher, and more variable, chlorophyll *a* concentrations in that area. Ten-year trends in discharge volumes and loads of nutrients, TSS and BOD_5 have been stable or reducing over the past 10 years. However, since 2021–22 loads of NNN, SRP and TP have increased substantially, and in 2025 were comparable to those in 2015. In contrast, only slight fluctuations occurred in ammoniacal-N, TSS, and BOD_5 loads over the same period.

The recent upswings in discharge loads of NNN, SRP and TP were mirrored by corresponding upswings in the concentrations of those variables at the Puketutu water quality monitoring site, and in the case of SRP and TP, at sites along Wairopa Channel. It is recommended that information on the causes of these upswings be determined, and if possible, actions taken to reverse recent trends.

No metals exceeded sediment quality guidelines in 2024, and total DDT and dieldrin concentrations in all sediment samples were below detection limits. It is recommended that the HEMP be amended to remove future requirements for DDT and dieldrin monitoring.

Temporal variation in sediment organic content was very similar at all ecological monitoring sites between 2011 and 2024, with a large spike occurring between 2019 and 2023, and mean TOM decreasing at five of the seven monitoring sites thereafter. Levels at those sites are now the lowest recorded since 2011. Having said that, the gradient in the organic content of sediments with distance from the discharge, and the degree of correlation between sites suggest that the discharge has a relatively strong influence on spatial and temporal variation in the organic content of sediments of the NE Manukau. However, data on other key indicators of sediment enrichment are not currently collected. The 2024 monitoring report therefore recommended that sediment samples from the ecological monitoring sites are also analysed for total organic carbon, TN, and total recoverable phosphorus whenever ecological sampling is carried out. It is understood that those analyses were included in the latest round of monitoring.

Adverse effects of the discharge on benthic macrofaunal communities appear to be fairly localised, and communities in the two decommissioned pond sites appear to have stabilised. Further changes in the benthic communities of those sites are likely to be constrained by the muddy nature of the sediments within that area. Aerial and onsite photos and ecological monitoring results show that the central harbour continues to sustain a complex and highly dynamic benthic ecosystem that is influenced by a variety of factors.

8 ACKNOWLEDGEMENTS

Water and sediment quality samples were collected by Auckland Council (RIMU) and analysed by Watercare Laboratory Services. Additional monitoring data was also provided by RIMU. Ecological samples and site photographs were collected by Bioresearches, while samples were analysed by Biolive and NIWA. Staff from Watercare Services and RIMU assisted with the provision of background information and advice.

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10 APPENDICES

10.1 APPENDIX A: SITE COORDINATES

10.1.1 WATER QUALITY

Site Name	NZTM_X	NZTM_Y	Sampling Frequency
Clarks	1749512	5888278	Monthly
Grahams	1748682	5898752	Monthly
Harbour Mouth	1739595	5899601	Monthly
HWQ 30	1751679	5911376	Monthly
HWQ 60	1749758	5904803	Monthly
HWQ 70	1745368	5902877	Monthly
HWQ 80	1761984	5900693	Monthly
Puketutu	1753988	5908974	Monthly
Titirangi	1748407	5908572	Monthly
Wairopa	1758239	5910898	Monthly
Weymouth	1764842	5897757	Monthly

10.1.2 BENTHIC ECOLOGY

Site Name	NZTM_X	NZTM_Y	Sampling Frequency
Auckland Airport	1762116	5901701	Yearly
Clarks Beach	1751298	5890512	Yearly
Cape Horn	1749143	5908551	Yearly
Outfall	1755656	5908564	Yearly
Pond 14	1756985	5908642	Yearly
Pond 16	1757147	5907764	Yearly
Purakau Mid	1751966	5905873	Yearly
Purakau Outer	1748244	5905085	Yearly
Purakau Upper	1754484	5909957	Yearly

10.1.3 SEDIMENT CONTAMINANTS

Site Name	NZTM_X	NZTM_Y	Sampling Frequency
Metals 1	1755654	5908564	Two Yearly
Metals 2	1754771	5908717	Two Yearly
Metals 3	1754522	5909353	Two Yearly
Metals 4	1754167	5908308	Two Yearly
Metals 5	1753812	5907589	Two Yearly
Metals 6	1754273	5909990	Two Yearly
Metals 7	1751966	5905873	Four Yearly
Metals 8	1748193	5905046	Four Yearly
Metals 9	1749084	5908556	Four Yearly
Metals 10	1762116	5901701	Four Yearly
Metals 11	1751298	5890512	Four Yearly
Pond 14	1756985	5908642	Two Yearly
Pond 16	1757147	5907764	Two Yearly

10.1.4 SHELLFISH (OYSTER) CONTAMINANTS

Site Name	NZTM_X	NZTM_Y	Sampling Frequency
Cape Horn	1754135	5910475	Four Yearly
Puketutu Light	1753860	5908088	Four Yearly

10.2 APPENDIX B: 2024–25 WATER QUALITY DATA

Site	Date	NH_3NH_4	NO_3	NO_2	NNN	TN	TKN	SRP	TP	Chlorophyll *a*
Clarks	4/07/2024	0.023	0.071	0.0056	0.077	0.19	0.113	0.0182	0.028	0.0004
Clarks	1/08/2024	0.024	0.061	0.0039	0.065	0.2	0.137	0.0165	0.024	0.0011
Clarks	18/09/2024	0.021	0.038	0.0027	0.04	0.155	0.114	0.0135	0.05	0.0014
Clarks	14/10/2024	0.021	0.048	0.0034	0.052	0.24	0.187	0.0103	0.026	0.0012
Clarks	12/11/2024	0.012	0.0037	<0.001	0.0046	0.2	0.199	0.0067	0.032	0.0022
Clarks	13/12/2024	0.013	0.0013	<0.001	0.0019	0.184	0.182	0.0151	0.031	0.0035
Clarks	10/01/2025	0.014	<0.001	<0.001	<0.001	0.174	0.174	0.017	0.028	0.0026
Clarks	24/02/2025	0.013	<0.001	<0.001	<0.001	0.21	0.21	0.022	0.03	0.0043
Clarks	10/03/2025	0.015	0.0036	0.0017	0.0052	0.23	0.22	0.023	0.032	0.0025
Clarks	9/04/2025	0.046	0.0152	0.0043	0.0194	0.28	0.26	0.028	0.042	0.002
Clarks	26/05/2025	0.02	0.0187	0.0022	0.021	0.171	0.15	0.0198	0.027	0.001
Clarks	24/06/2025	0.037	0.156	0.0074	0.163	0.34	0.182	0.0195	0.024	0.001
Grahams	4/07/2024	0.018	0.035	0.0047	0.039	0.145	0.106	0.0145	0.021	0.0004
Grahams	1/08/2024	0.016	0.0166	0.004	0.021	0.112	0.092	0.0121	0.016	0.001
Grahams	18/09/2024	0.015	0.0197	0.0019	0.022	0.146	0.125	0.0133	0.043	0.0013
Grahams	14/10/2024	0.014	0.0081	0.0012	0.0093	0.23	0.22	0.008	0.017	0.0014
Grahams	12/11/2024	0.009	<0.001	<0.001	<0.001	0.174	0.174	0.0056	0.022	0.0015
Grahams	13/12/2024	0.012	<0.001	<0.001	<0.001	0.153	0.153	0.0135	0.023	0.0025
Grahams	10/01/2025	0.013	<0.001	<0.001	<0.001	0.2	0.2	0.0153	0.025	0.0019
Grahams	24/02/2025	0.017	<0.001	<0.001	<0.001	0.183	0.183	0.0164	0.022	0.0022
Grahams	10/03/2025	0.012	<0.001	<0.001	<0.001	0.21	0.21	0.0185	0.027	0.0012
Grahams	9/04/2025	0.027	0.0063	0.0017	0.008	0.22	0.21	0.024	0.032	0.001

Site	Date	NH_3NH_4	NO_3	NO_2	NNN	TN	TKN	SRP	TP	Chlorophyll *a*
Grahams	26/05/2025	0.02	0.017	0.0021	0.0192	0.184	0.165	0.0186	0.028	0.0014
Grahams	24/06/2025	0.023	0.08	0.0064	0.086	0.25	0.163	0.0175	0.02	0.0012
HWQ 30	4/07/2024	0.042	0.2	0.0073	0.211	0.32	0.1	0.067	0.063	0.0024
HWQ 30	1/08/2024	<0.005	0.079	0.0028	0.0816	0.23	0.14	0.025	0.026	0.002
HWQ 30	18/09/2024	0.05	0.1	0.0076	0.111	0.23	0.12	0.038	0.048	0.004
HWQ 30	14/10/2024	0.015	0.1	0.0038	0.108	0.28	0.18	0.039	0.059	0.0018
HWQ 30	12/11/2024	0.012	0.039	<0.002	0.0389	0.41	0.37	0.048	0.061	0.0029
HWQ 30	13/12/2024	<0.005	<0.002	<0.002	<0.002	0.2	0.2	0.038	0.058	0.0062
HWQ 30	10/01/2025	<0.005	<0.002	<0.002	<0.002	0.24	0.24	0.066	0.075	0.0089
HWQ 30	24/02/2025	<0.005	0.0078	<0.002	0.0078	0.25	0.24	0.059	0.068	0.0041
HWQ 30	10/03/2025	0.059	0.021	<0.002	0.0213	0.35	0.33	0.063	0.067	0.0023
HWQ 30	9/04/2025	0.081	0.11	0.0058	0.118	0.38	0.27	0.069	0.068	0.0011
HWQ 30	26/05/2025	0.032	0.1	0.0028	0.102	0.28	0.18	0.04	0.054	0.0015
HWQ 30	24/06/2025	0.058	0.25	0.0087	0.255	0.52	0.27	0.056	0.062	0.0014
HWQ 60	4/07/2024	0.017	0.052	0.0033	0.0549	0.097	0.042	0.018	0.017	<0.0006
HWQ 60	1/08/2024	<0.005	0.068	0.0038	0.0713	0.2	0.13	0.028	0.027	<0.0006
HWQ 60	18/09/2024	0.039	0.02	0.0044	0.0244	0.13	0.1	0.014	0.023	<0.0006
HWQ 60	14/10/2024	<0.005	0.019	<0.002	0.019	0.17	0.15	0.012	0.022	0.0008
HWQ 60	12/11/2024	<0.005	<0.002	<0.002	<0.002	0.16	0.16	0.013	0.014	<0.0006
HWQ 60	13/12/2024	<0.005	0.0057	<0.002	0.0057	0.17	0.16	0.029	0.035	0.0017
HWQ 60	10/01/2025	<0.005	0.004	<0.002	0.004	0.17	0.17	0.036	0.043	0.001
HWQ 60	24/02/2025	<0.005	<0.002	<0.002	<0.002	0.16	0.16	0.026	0.031	<0.0006
HWQ 60	10/03/2025	0.015	<0.002	<0.002	<0.002	0.18	0.18	0.028	0.031	0.0021
HWQ 60	9/04/2025	0.031	0.03	<0.002	0.0296	0.17	0.14	0.036	0.044	0.0015
HWQ 60	26/05/2025	0.011	0.037	<0.002	0.0374	0.16	0.12	0.024	0.029	0.001
HWQ 60	24/06/2025	0.024	0.11	0.0048	0.115	0.27	0.15	0.025	0.027	<0.0006

Site	Date	NH_3NH_4	NO_3	NO_2	NNN	TN	TKN	SRP	TP	Chlorophyll *a*
HWQ 70	4/07/2024	<0.005	0.029	0.0051	0.0342	0.077	0.043	0.014	0.02	0.0017
HWQ 70	1/08/2024	0.0052	0.013	<0.002	0.013	0.1	0.09	0.009	0.009	0.0017
HWQ 70	18/09/2024	0.032	0.011	0.0031	0.014	0.078	0.064	0.008	0.013	0.0021
HWQ 70	14/10/2024	<0.005	0.0059	<0.002	0.0059	0.12	0.11	0.007	0.015	0.0018
HWQ 70	12/11/2024	<0.005	<0.002	<0.002	<0.002	0.14	0.14	0.008	0.01	0.0009
HWQ 70	13/12/2024	<0.005	<0.002	<0.002	<0.002	0.096	0.096	0.009	0.013	0.0015
HWQ 70	10/01/2025	<0.005	<0.002	<0.002	<0.002	0.11	0.11	0.011	0.015	0.0013
HWQ 70	24/02/2025	<0.005	<0.002	<0.002	<0.002	0.11	0.11	0.012	0.015	0.0018
HWQ 70	10/03/2025	0.016	<0.002	<0.002	<0.002	0.13	0.13	0.013	0.018	0.0021
HWQ 70	9/04/2025	<0.005	0.0073	<0.002	0.0073	0.062	0.055	0.014	0.014	0.0016
HWQ 70	26/05/2025	<0.005	0.018	<0.002	0.018	0.067	0.049	0.012	0.016	<0.0006
HWQ 70	24/06/2025	0.018	0.075	0.0041	0.0787	0.2	0.12	0.02	0.022	0.0016
HWQ 80	4/07/2024	0.023	0.092	0.0033	0.0952	0.14	0.048	0.02	0.019	0.0012
HWQ 80	1/08/2024	<0.005	0.055	<0.002	0.0551	0.24	0.18	0.019	0.019	0.0008
HWQ 80	18/09/2024	0.041	0.05	0.0045	0.0549	0.18	0.12	0.016	0.023	0.0009
HWQ 80	14/10/2024	0.023	0.07	0.0025	0.0728	0.25	0.17	0.014	0.031	0.0031
HWQ 80	12/11/2024	0.0093	0.0092	<0.002	0.0092	0.26	0.25	0.012	0.03	0.0032
HWQ 80	13/12/2024	0.011	0.0069	<0.002	0.0069	0.26	0.25	0.023	0.041	0.0031
HWQ 80	10/01/2025	<0.005	<0.002	<0.002	<0.002	0.22	0.22	0.022	0.043	0.0028
HWQ 80	24/02/2025	<0.005	<0.002	<0.002	<0.002	0.19	0.19	0.029	0.039	0.0027
HWQ 80	10/03/2025	0.018	<0.002	<0.002	<0.002	0.25	0.25	0.03	0.04	0.012
HWQ 80	9/04/2025	0.036	0.029	<0.002	0.0289	0.17	0.14	0.035	0.039	0.001
HWQ 80	26/05/2025	0.013	0.028	<0.002	0.0284	0.12	0.092	0.024	0.033	0.0018
HWQ 80	24/06/2025	0.036	0.14	0.0048	0.146	0.37	0.22	0.023	0.043	0.0032
Harbour Mouth	4/07/2024	0.016	0.029	0.0073	0.036	0.118	0.081	0.0113	0.017	0.0004
Harbour Mouth	1/08/2024	0.012	0.0095	0.0032	0.0127	0.08	0.067	0.0077	0.01	0.0011

Site	Date	NH_3NH_4	NO_3	NO_2	NNN	TN	TKN	SRP	TP	Chlorophyll *a*
Harbour Mouth	18/09/2024	0.015	0.013	0.0012	0.0142	0.121	0.107	0.0079	0.016	0.0009
Harbour Mouth	14/10/2024	0.014	0.0052	<0.001	0.0058	0.15	0.144	0.006	0.008	0.0007
Harbour Mouth	12/11/2024	0.01	<0.001	<0.001	<0.001	0.171	0.171	0.0055	0.01	0.0012
Harbour Mouth	13/12/2024	0.011	<0.001	<0.001	<0.001	0.125	0.125	0.0031	0.007	0.0014
Harbour Mouth	10/01/2025	0.014	<0.001	<0.001	<0.001	0.164	0.164	0.0109	0.015	0.0013
Harbour Mouth	24/02/2025	0.013	<0.001	<0.001	<0.001	0.107	0.107	0.0061	0.009	0.0007
Harbour Mouth	10/03/2025	0.012	<0.001	<0.001	<0.001	0.153	0.153	0.0092	0.013	0.001
Harbour Mouth	9/04/2025	0.017	0.0025	<0.001	0.0034	0.164	0.16	0.0094	0.013	0.0011
Harbour Mouth	26/05/2025	0.011	0.0136	0.0023	0.0159	0.124	0.108	0.0103	0.012	0.0008
Harbour Mouth	24/06/2025	0.023	0.052	0.0057	0.057	0.2	0.143	0.0137	0.014	0.0011
Puketutu	4/07/2024	0.056	0.25	0.0119	0.26	0.45	0.188	0.084	0.098	0.0005
Puketutu	1/08/2024	0.23	0.44	0.041	0.48	0.95	0.47	0.176	0.21	0.0014
Puketutu	18/09/2024	0.028	0.075	0.0044	0.079	0.23	0.146	0.037	0.079	0.0009
Puketutu	14/10/2024	0.054	0.63	0.021	0.65	1.02	0.37	0.142	0.163	0.0006
Puketutu	12/11/2024	0.039	0.41	0.0171	0.42	0.8	0.38	0.31	0.34	0.0014
Puketutu	13/12/2024	0.046	0.21	0.0109	0.22	0.52	0.3	0.048	0.063	0.0025
Puketutu	10/01/2025	0.039	0.177	0.0061	0.183	0.48	0.3	0.124	0.143	0.0018
Puketutu	24/02/2025	0.036	1.36	0.0139	1.38	1.85	0.47	0.33	0.4	0.0016
Puketutu	10/03/2025	0.042	0.41	0.0063	0.42	0.78	0.36	0.173	0.199	0.001
Puketutu	9/04/2025	0.128	0.58	0.032	0.61	1.14	0.53	0.32	0.36	0.0015
Puketutu	26/05/2025	0.053	0.191	0.0061	0.197	0.45	0.25	0.065	0.071	0.0017
Puketutu	24/06/2025	0.062	0.35	0.0131	0.37	0.6	0.24	0.073	0.089	0.0021
Titirangi	4/07/2024	0.033	0.113	0.0071	0.12	0.26	0.135	0.039	0.048	0.0006
Titirangi	1/08/2024	0.02	0.049	0.0047	0.053	0.16	0.106	0.023	0.026	0.0014
Titirangi	18/09/2024	0.025	0.083	0.0047	0.088	0.26	0.168	0.031	0.09	0.0014
Titirangi	14/10/2024	0.023	0.039	0.0026	0.042	0.27	0.23	0.025	0.034	0.0007

Site	Date	NH_3NH_4	NO_3	NO_2	NNN	TN	TKN	SRP	TP	Chlorophyll *a*
Titirangi	12/11/2024	0.014	0.0053	<0.001	0.006	0.24	0.24	0.032	0.041	0.0014
Titirangi	13/12/2024	0.015	0.0017	<0.001	0.002	0.26	0.26	0.035	0.057	0.0042
Titirangi	10/01/2025	0.013	<0.001	<0.001	<0.001	0.25	0.25	0.051	0.063	0.0058
Titirangi	24/02/2025	0.015	<0.001	<0.001	<0.001	0.22	0.22	0.043	0.052	0.0015
Titirangi	10/03/2025	0.014	0.0047	<0.001	0.0051	0.23	0.23	0.042	0.049	0.0016
Titirangi	9/04/2025	0.058	0.042	0.005	0.047	0.31	0.27	0.045	0.054	0.0019
Titirangi	26/05/2025	0.034	0.068	0.0035	0.071	0.27	0.2	0.037	0.039	0.0012
Titirangi	24/06/2025	0.046	0.21	0.0095	0.22	0.48	0.26	0.043	0.055	0.0019
Wairopa	4/07/2024	0.075	0.36	0.0131	0.37	0.59	0.22	0.097	0.126	0.0005
Wairopa	1/08/2024	0.049	0.22	0.008	0.23	0.43	0.2	0.047	0.06	0.0013
Wairopa	18/09/2024	0.051	0.22	0.0096	0.23	0.55	0.31	0.065	0.143	0.0022
Wairopa	14/10/2024	0.061	0.29	0.011	0.3	0.64	0.34	0.072	0.104	0.0007
Wairopa	12/11/2024	0.022	0.115	0.0062	0.121	0.46	0.34	0.076	0.105	0.0039
Wairopa	13/12/2024	0.013	0.0037	<0.001	0.0041	0.39	0.39	0.062	0.09	0.0086
Wairopa	10/01/2025	0.018	0.021	0.0021	0.023	0.31	0.29	0.095	0.127	0.007
Wairopa	24/02/2025	0.022	0.0069	0.0024	0.0093	0.32	0.31	0.092	0.121	0.0056
Wairopa	10/03/2025	0.063	0.026	0.0039	0.029	0.39	0.36	0.097	0.114	0.0011
Wairopa	9/04/2025	0.193	0.138	0.014	0.152	0.66	0.5	0.091	0.118	0.0018
Wairopa	26/05/2025	0.074	0.24	0.01	0.25	0.56	0.32	0.075	0.106	0.0025
Wairopa	24/06/2025	0.094	0.42	0.0169	0.44	0.79	0.35	0.07	0.094	0.0038
Weymouth	4/07/2024	0.035	0.129	0.0056	0.135	0.29	0.15	0.021	0.031	0.0005
Weymouth	1/08/2024	0.029	0.113	0.0046	0.117	0.27	0.149	0.0168	0.022	0.0013
Weymouth	18/09/2024	0.024	0.054	0.0026	0.056	0.22	0.165	0.0154	0.084	0.0036
Weymouth	14/10/2024	0.034	0.092	0.0037	0.096	0.34	0.25	0.0137	0.03	0.0014
Weymouth	12/11/2024	0.016	0.0179	0.0015	0.0195	0.33	0.31	0.0099	0.037	0.0031
Weymouth	13/12/2024	0.025	0.0076	0.0013	0.009	0.25	0.24	0.023	0.039	0.0036

Site	Date	NH_3NH_4	NO_3	NO_2	NNN	TN	TKN	SRP	TP	Chlorophyll *a*
Weymouth	10/01/2025	0.013	<0.001	<0.001	<0.001	0.25	0.25	0.021	0.039	0.0035
Weymouth	24/02/2025	0.013	<0.001	<0.001	<0.001	0.24	0.24	0.032	0.045	0.003
Weymouth	10/03/2025	0.017	<0.001	<0.001	<0.001	0.23	0.23	0.029	0.04	0.0019
Weymouth	9/04/2025	0.058	0.032	0.0036	0.036	0.36	0.32	0.034	0.052	0.0017
Weymouth	26/05/2025	0.025	0.025	0.0022	0.027	0.195	0.168	0.024	0.028	0.0012
Weymouth	24/06/2025	0.041	0.186	0.007	0.193	0.44	0.25	0.027	0.046	0.0022

Site	Date	TSS	Turbidity	DOconc	DO%	Salinity	pH	Temp	*E. coli*	Enterococci
Clarks	4/07/2024	11	2.5	8.44	96.8	31.72	8.08	12.62		
Clarks	1/08/2024	7	3.1	8.33	96.3	30.19	8.1	13.44		
Clarks	18/09/2024	38	16	8.17	96.4	32.07	8.12	13.85		
Clarks	14/10/2024	15	7.2	7.86	97.5	31.5	8.11	16.59		
Clarks	12/11/2024	26	4.4	7.31	97.7	33.19	8.07	19.94		
Clarks	13/12/2024	12	5.8	7.1	98.4	33.83	8.08	21.73		
Clarks	10/01/2025	12	4.8	7.28	100.1	34.83	8.13	21.01		
Clarks	24/02/2025	6	1.96	7.02	99.9	35.81	8.14	22.58		
Clarks	10/03/2025	10	3.1	7.06	97.1	35.81	8.15	20.73		
Clarks	9/04/2025	14	5.1	7.23	96	34.54	8.08	19.14		
Clarks	26/05/2025	13	4.4	7.91	97.2	32.82	8.17	15.62		
Clarks	24/06/2025	13	4.2	8.43	97.8	29.84	8.11	13.74		
Grahams	4/07/2024	8	1.59	8.49	98.4	32.48	8.11	12.88		
Grahams	1/08/2024	<3	1.53	8.33	98.5	32.73	8.12	13.77		
Grahams	18/09/2024	35	14.2	8.22	97.5	32.63	8.14	13.97		
Grahams	14/10/2024	9	3.4	8.01	99.7	32.23	8.14	16.49		
Grahams	12/11/2024	12	1.65	7.55	100.6	33.72	8.12	19.6		

Site	Date	TSS	Turbidity	DOconc	DO%	Salinity	pH	Temp	*E. coli*	Enterococci
Grahams	13/12/2024	9	2.4	7.39	101.4	34.22	8.13	21.08		
Grahams	10/01/2025	8	3.1	7.5	102.7	34.79	8.17	20.77		
Grahams	24/02/2025	5	1.38	7.31	104	35.78	8.23	22.55		
Grahams	10/03/2025	7	2.8	7.29	100.7	35.89	8.23	20.91		
Grahams	9/04/2025	30	1.59	7.49	99.8	35	8.13	19.19		
Grahams	26/05/2025	16	4.8	7.97	98.9	33.37	8.18	15.96		
Grahams	24/06/2025	13	3	8.39	99.3	31.48	8.14	14.19		
HWQ 30	4/07/2024	9	2.6	8.6	98.8	31.23	8.1	12.81	<1.6	<10
HWQ 30	1/08/2024	11	1.9	8.57	100.3	31.32	8.14	13.72	25	10
HWQ 30	18/09/2024	65	35	8.26	95	31.13	8.12	12.93	18	<10
HWQ 30	14/10/2024	11	5	8.05	99.1	30.62	8.16	16.41	<1.6	10
HWQ 30	12/11/2024	22	5.5	7.67	102.7	32.93	8.19	20.16	8.2	<10
HWQ 30	13/12/2024	16	3.6	7.53	104.3	33.46	8.19	21.85	3.3	<10
HWQ 30	10/01/2025	14	5.5	7.98	111.2	34.69	8.25	21.79	<1.6	<10
HWQ 30	24/02/2025	13	3.5	7.53	106.4	35.47	8.3	22.31	<1.7	<10
HWQ 30	10/03/2025	11	3.3	7.72	106.5	35.71	8.3	20.93	<1.6	<10
HWQ 30	9/04/2025	16	3	7.34	96.5	33.44	8.11	19.01	4.9	10
HWQ 30	26/05/2025	21	8.1	7.93	97.4	32.62	8.17	15.69	5	<10
HWQ 30	24/06/2025	37	16	8.34	96.8	29.77	8.13	13.76	3.3	<10
HWQ 60	4/07/2024	3.4	0.6	8.27	94.8	32.22	8.08	12.42	<1.6	10
HWQ 60	1/08/2024	4	0.85	8.41	99.4	32.08	8.14	13.9	4.9	<10
HWQ 60	18/09/2024	36	18	8.35	96.7	31.95	8.12	12.96	1.6	<10
HWQ 60	14/10/2024	8.4	2.6	8.26	102.4	31.24	8.22	16.62	<1.6	10
HWQ 60	12/11/2024	6.4	1.7	7.26	96.4	33.67	8.1	19.44	<1.6	<10
HWQ 60	13/12/2024	12	2.3	7.28	100.3	33.82	8.15	21.44	<1.7	<10
HWQ 60	10/01/2025	4.8	1	7.81	108.8	34.79	8.21	21.68	<1.6	<10

Site	Date	TSS	Turbidity	DOconc	DO%	Salinity	pH	Temp	*E. coli*	Enterococci
HWQ 60	24/02/2025	9	1.1	7.52	106.4	35.88	8.3	22.22	<1.7	<10
HWQ 60	10/03/2025	18	1.3	7.66	105.8	35.83	8.3	20.89	<1.6	<10
HWQ 60	9/04/2025	15	3	7.31	95	34.95	8.15	17.9	<1.6	<10
HWQ 60	26/05/2025	5.4	1.6	7.61	94.2	33.35	8.15	15.9	<1.7	<10
HWQ 60	24/06/2025	17	6.8	8.33	98.2	31.2	8.16	14.1	1.6	<10
HWQ 70	4/07/2024	3.6	0.75	8.52	101.3	33.44	8.12	13.83	<1.6	<10
HWQ 70	1/08/2024	4.8	1.2	8.47	101.4	33.59	8.15	14.14	<1.6	<10
HWQ 70	18/09/2024	21	7.6	8.39	100.9	33.1	8.17	14.49	<1.6	<10
HWQ 70	14/10/2024	6.6	3.2	8.1	101.2	33.18	8.16	16.42	<1.6	<10
HWQ 70	12/11/2024	6	1.1	7.98	105.4	34.23	8.15	19	<1.6	<10
HWQ 70	13/12/2024	8.6	2.4	7.67	104.1	34.42	8.14	20.39	<1.7	<10
HWQ 70	10/01/2025	7	1.3	7.78	105.3	34.89	8.17	20.11	<1.6	<10
HWQ 70	24/02/2025	8.8	0.9	7.52	106.2	35.52	8.21	22.3	<1.7	<10
HWQ 70	10/03/2025	9.4	1.4	7.54	103.7	35.41	8.22	20.82	1.6	<10
HWQ 70	9/04/2025	17	1.1	7.69	102.9	35.28	8.16	19.35	<1.6	<10
HWQ 70	26/05/2025	11	3	8.11	102.9	34.22	8.18	16.87	<1.7	<10
HWQ 70	24/06/2025	10	3.8	8.26	98	31.75	8.16	14.24	<1.6	<10
HWQ 80	4/07/2024	8.8	1.8	8.33	94.1	30.39	8.07	12.3	4.9	<10
HWQ 80	1/08/2024	6.2	3	8.19	94.6	29.95	8.07	13.44	34	10
HWQ 80	18/09/2024	48	25	8.29	94.6	30.24	8.09	12.8	28	<10
HWQ 80	14/10/2024	13	6	7.89	95.3	29.31	8.1	15.92	6.6	<10
HWQ 80	12/11/2024	25	12	7.21	95.8	32.69	8.07	19.82	3.3	<10
HWQ 80	13/12/2024	30	14	7	96	33.34	8.09	21.28	3.3	<10
HWQ 80	10/01/2025	21	6.8	7.21	99.8	34.52	8.12	21.43	<1.6	<10
HWQ 80	24/02/2025	7	2.4	6.96	98.8	35.99	8.17	22.35	<1.7	<10
HWQ 80	10/03/2025	12	4.4	7.06	96.4	36.19	8.19	20.17	<1.6	<10

Site	Date	TSS	Turbidity	DOconc	DO%	Salinity	pH	Temp	*E. coli*	Enterococci
HWQ 80	9/04/2025	11	4.4	7.28	94.8	33.75	8.1	18.38	3.3	<10
HWQ 80	26/05/2025	7.4	3.1	7.88	96.5	32.58	8.2	15.56	3.3	<10
HWQ 80	24/06/2025	31	14	8.24	94.5	28.52	8	13.54	8.2	10
Harbour Mouth	4/07/2024	6	1.2	8.38	99.7	33.47	8.11	13.86		
Harbour Mouth	1/08/2024	4	0.35	8.46	101.4	33.45	8.14	14.2		
Harbour Mouth	18/09/2024	12	3.2	8.38	100.5	33.22	8.16	14.33		
Harbour Mouth	14/10/2024	3	1.16	8.1	101.1	33.18	8.15	16.36		
Harbour Mouth	12/11/2024	6	0.49	7.83	103.1	34.24	8.13	18.84		
Harbour Mouth	13/12/2024	<3	0.94	7.7	103.2	34.61	8.14	19.65		
Harbour Mouth	10/01/2025	3	0.98	7.67	103.4	34.93	8.16	19.86		
Harbour Mouth	24/02/2025	<3	0.52	7.43	104.3	35.36	8.19	21.95		
Harbour Mouth	10/03/2025	<3	1.02	7.45	102.1	35.3	8.19	20.62		
Harbour Mouth	9/04/2025	4	1.02	7.68	103	35.31	8.16	19.49		
Harbour Mouth	26/05/2025	5	1.94	8.07	102.7	34.4	8.17	16.99		
Harbour Mouth	24/06/2025	8	2	8.35	100.7	32.64	8.15	14.78		
Puketutu	4/07/2024	6	2.7	8.59	98.2	30.86	8.08	12.66		
Puketutu	1/08/2024	6	1.77	8.36	97.1	29.69	8.05	13.77		
Puketutu	18/09/2024	40	17.9	8.3	96.6	31.7	8.13	13.3		
Puketutu	14/10/2024	5	2.3	8.07	98.4	29.01	8.11	16.45		
Puketutu	12/11/2024	6	2.8	7.87	104.6	31.57	8.16	20.18		
Puketutu	13/12/2024	7	3.8	7.43	101.8	32	8.14	21.74		
Puketutu	10/01/2025	<3	1.58	7.53	104.3	33.57	8.16	21.85		
Puketutu	24/02/2025	4	2	7.36	101.8	32.22	8.21	22.19		
Puketutu	10/03/2025	9	3.7	7.56	102.6	34.44	8.24	20.44		
Puketutu	9/04/2025	10	3	7.54	97.2	31.43	8.05	18.55		
Puketutu	26/05/2025	11	4.7	8.15	100	32.12	8.17	15.81		

Site	Date	TSS	Turbidity	DOconc	DO%	Salinity	pH	Temp	*E. coli*	Enterococci
Puketutu	24/06/2025	21	7.5	8.72	101.1	29.14	8.14	13.88		
Titirangi	4/07/2024	6	1.78	8.58	99.3	31.99	8.12	12.92		
Titirangi	1/08/2024	3	0.63	8.6	101.2	31.94	8.16	13.79		
Titirangi	18/09/2024	57	26	8.25	95.8	31.52	8.13	13.27		
Titirangi	14/10/2024	7	3	8.03	99.5	31.33	8.18	16.54		
Titirangi	12/11/2024	10	3	7.93	107	33.35	8.21	20.45		
Titirangi	13/12/2024	17	7.1	7.12	98.2	33.7	8.17	21.51		
Titirangi	10/01/2025	13	4.5	8.1	112.5	34.69	8.27	21.53		
Titirangi	24/02/2025	3	1.28	7.2	101.2	35.69	8.35	21.94		
Titirangi	10/03/2025	5	2.8	7.93	109.2	35.8	8.34	20.73		
Titirangi	9/04/2025	7	1.51	7.5	99.4	34.16	8.14	19.21		
Titirangi	26/05/2025	9	3.1	8.14	100.5	32.9	8.19	15.87		
Titirangi	24/06/2025	21	7.4	8.48	98.6	30.03	8.16	13.76		
Wairopa	4/07/2024	14	5	8.31	93.7	29.24	8	12.51		
Wairopa	1/08/2024	8	3.2	8.06	92.9	28.65	8.03	13.74		
Wairopa	18/09/2024	79	35	8.44	96	29.18	8.08	12.98		
Wairopa	14/10/2024	22	10.7	7.89	95.5	28.25	8.05	16.26		
Wairopa	12/11/2024	18	6.1	7.63	101.8	31.63	8.08	20.42		
Wairopa	13/12/2024	20	8	7.8	107.3	31.91	8.2	21.99		
Wairopa	10/01/2025	10	5	7.79	108.6	34.04	8.11	22.02		
Wairopa	24/02/2025	7	3.5	7.7	108.7	34.69	8.22	22.53		
Wairopa	10/03/2025	10	4.1	7.32	100.2	35.35	8.2	20.63		
Wairopa	9/04/2025	11	5.3	7.01	90.5	31.29	8.01	18.7		
Wairopa	26/05/2025	35	15.4	7.67	93	30.91	8.09	15.55		
Wairopa	24/06/2025	29	12.1	8.22	93.6	27.11	8.03	13.61		
Weymouth	4/07/2024	10	3.9	8.42	95.5	30.18	8.07	12.55		

Site	Date	TSS	Turbidity	DOconc	DO%	Salinity	pH	Temp	*E. coli*	Enterococci
Weymouth	1/08/2024	4	1.23	8.33	96.9	30.49	8.1	13.69		
Weymouth	18/09/2024	66	32	8.33	95.7	30.54	8.1	13.04		
Weymouth	14/10/2024	12	7	7.95	96.4	29.27	8.09	16.08		
Weymouth	12/11/2024	26	7.5	7.35	98.1	32.48	8.09	20.12		
Weymouth	13/12/2024	13	6	7.05	96.8	33.2	8.08	21.44		
Weymouth	10/01/2025	15	6.6	7.2	99.6	34.66	8.13	21.36		
Weymouth	24/02/2025	4	2.3	7.08	100.8	35.87	8.17	22.62		
Weymouth	10/03/2025	8	2.6	7.37	101.8	36.14	8.22	20.76		
Weymouth	9/04/2025	14	7	7.27	95	33.34	8.09	18.69		
Weymouth	26/05/2025	13	5	7.94	97.5	32.76	8.19	15.66		
Weymouth	24/06/2025	38	11.6	8.35	95.7	28.39	8.06	13.58		

10.3 APPENDIX C: 2024 ECOLOGICAL DATA FROM WATERCARE SITES (TOTAL COUNTS)

Taxa	Outfall	Pond 14	Pond 16	Purakau Mid	Purakau Outer	Purakau Upper	Cape Horn
Heteromastus filiformis	114	420	16	28	55	254	101
Phoxocephalidae	37	20	31	96	47	279	152
Aonides trifida	546	0	0	0	0	6	0
Austrovenus stutchburyi	337	41	3	1	0	0	1
Arcuatula senhousia	0	0	0	0	168	0	190
Prionospio aucklandica	277	49	11	0	1	11	2
Unidentified amphipod	10	2	37	29	54	1	43
Linucula hartvigiana	156	5	0	5	0	4	2
Polydora spp.	0	0	0	62	4	15	84
Owenia petersenae	0	0	0	26	29	80	21
Maldanidae	0	0	1	10	75	30	34
Magelona cf dakini	2	9	1	1	12	116	2
Anthopleura aureoradiata	37	0	1	2	55	8	32
Macomona liliana	27	22	1	4	3	22	4
Nereididae	18	15	21	3	3	8	6
Mysidacea	0	15	49	0	0	0	1
Notoacmea spp.	53	0	0	0	0	0	0
Halicarcinus cookii	0	0	0	5	22	2	16
Tritia burchardi	2	0	0	2	0	2	35
Platynereis australis	0	0	1	0	34	0	5
Scoloplos cylindrifer	7	28	0	0	1	2	0
Scolecolepides benhami	4	6	15	0	0	2	1
Aricidea sp.	1	0	0	1	17	3	2
Nemertea	4	1	1	3	4	6	5
Cirratulidae	0	0	0	0	17	0	7
Nicon aestuariensis	10	1	2	4	0	7	0
Euchone pallida	0	0	0	0	23	0	0
Tanaidacea	0	0	0	13	3	0	4
Armandia maculata	0	0	0	0	18	0	0
Hemiplax hirtipes	0	5	3	1	0	2	7
Goniadidae	1	2	0	0	4	9	2
Dorvilleidae	1	0	0	1	9	0	7
Perinereis vallata	2	2	4	0	0	9	0
Pygospio sp.	0	0	0	14	0	0	1
Urothoidae	0	0	0	0	15	0	0
Phoronida	0	0	0	0	13	0	1
Syllidae	0	0	0	0	8	0	6
Parasterope quadrata	0	0	0	1	4	1	7

Diasterope grisea	0	0	0	3	7	0	3
Cominella glandiformis	7	2	0	2	0	1	0
Cossura consimilis	1	0	0	0	0	10	0
Unidentified sponge	0	0	0	0	6	0	4
Prionospio multicristata	0	0	0	0	9	0	0
Glyceridae	1	0	0	2	0	1	5
Cumacea	2	0	0	2	1	1	0
Arthritica bifurca	2	0	0	1	0	2	1
Orbinia papillosa	0	0	0	0	3	0	3
Exogoninae	1	0	0	0	3	0	1
Chiton glaucus	4	0	0	0	0	0	0
Austrohelice crassa	2	0	2	0	0	0	0
Lumbrineridae	0	0	0	0	4	0	0
Philine sp.	0	0	0	0	2	1	0
Stomatopoda	0	0	0	3	0	0	0
Zemysia zelandica	0	0	0	0	3	0	0
Nebalia sp.	1	0	0	0	2	0	0
Philocheras australis	0	0	0	1	0	0	1
Ampharetidae	0	0	0	0	2	0	0
Taeniogyrus dendyi	1	0	0	0	0	1	0
Dosinia lambata	0	0	0	0	2	0	0
Euphilomedes agilis	1	0	0	0	1	0	0
Paraonidae	0	0	0	0	1	1	0
Proscoloplos cygnochaetus	0	0	0	1	1	0	0
Aglaophamus macroura	0	0	0	0	1	0	1
Lysianassidae	0	0	0	0	0	0	2
Oligochaeta	0	0	1	0	0	1	0
Hemigrapsus crenulatus	1	0	0	0	0	0	0
Saccostrea cucullata	1	0	0	0	0	0	0
Leitoscoloplos kerguelensis	0	1	0	0	0	0	0
Eurylana sp.	0	0	0	0	1	0	0
Platyhelminthes	0	0	0	0	0	1	0
Dolichopodidae larvae	0	0	1	0	0	0	0
Terebellidae	0	0	0	0	1	0	0
Theora lubrica	0	0	0	0	0	1	0
Divalucina cumingi	0	0	0	0	1	0	0
Cyclomactra ovata	0	1	0	0	0	0	0
Pagurus sp.	0	0	0	0	1	0	0
Hesionidae	0	0	0	0	0	1	0
Exosphaeroma spp.	1	0	0	0	0	0	0

10.4 APPENDIX D: 2024 SEDIMENT CHARACTERISTICS

Site	Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt (%)	Clay (%)	Mud	Organic Matter (%)
M2	1.040	0.120	0.372	65.125	29.185	3.179	0.978	4.157	n/a
M3	1.997	0.712	0.745	45.696	23.458	22.341	5.051	27.392	n/a
M4	2.133	1.587	1.189	63.514	25.450	4.633	1.494	6.127	n/a
M5	2.912	0.277	0.184	64.010	25.919	5.358	1.340	6.698	n/a
CH B	0.580	0.128	3.577	82.779	6.479	4.696	1.761	6.457	0.531
CH D	0.188	0.176	3.931	76.331	10.614	7.045	1.714	8.759	0.683
CH F	0.205	0.120	0.995	81.656	10.275	6.135	0.613	6.748	0.601
CH H	5.909	0.476	0.476	51.160	7.996	24.879	9.102	33.982	2.444
CH J	0.341	0.080	0.731	76.672	12.808	7.113	2.255	9.368	0.593
CH L	0.375	0.142	0.459	80.672	10.346	6.404	1.601	8.005	0.847
OUT B	9.375	2.828	1.871	42.577	35.964	6.291	1.094	7.385	0.629
OUT D	6.094	1.459	1.225	50.194	34.068	5.929	1.031	6.960	0.543
OUT F	5.897	2.001	1.353	39.252	39.598	8.990	2.909	11.899	1.041
OUT H	7.613	1.315	0.792	16.987	44.484	22.367	6.442	28.809	0.601
OUT J	12.673	3.344	1.508	36.522	35.099	8.100	2.754	10.855	0.675
OUT L	3.070	2.171	1.317	26.057	48.995	14.711	3.678	18.389	0.750
P14 B	1.849	1.162	0.326	2.435	45.415	44.375	4.438	48.813	0.793
P14 D	1.191	1.382	0.344	2.664	48.950	40.812	4.656	45.468	0.689
P14 F	0.765	1.505	0.309	2.605	45.754	44.090	4.971	49.061	0.749
P14 H	0.000	0.061	0.041	2.380	36.900	53.594	7.024	60.618	1.118
P14 J	6.551	1.433	0.273	2.874	45.659	39.344	3.866	43.210	1.049
P14 L	5.900	3.180	0.951	4.197	41.031	39.607	5.134	44.741	0.685
P16 B	0.011	0.099	0.110	3.898	31.528	59.317	5.036	64.354	1.024
P16 D	0.851	0.688	0.325	7.610	36.791	48.466	5.268	53.734	0.826
P16 F	2.688	1.674	0.555	8.073	34.819	45.734	6.457	52.191	0.938
P16 H	0.000	0.027	0.082	2.516	34.750	55.131	7.494	62.624	1.227
P16 J	0.067	0.243	0.143	3.930	42.952	46.549	6.118	52.667	1.022
P16 L	2.452	2.180	0.752	10.390	40.719	38.519	4.988	43.507	0.818
PM B	0.158	0.057	0.857	79.371	16.419	2.896	0.241	3.137	0.368
PM D	0.504	0.120	0.702	80.885	14.857	2.255	0.677	2.932	0.383
PM F	5.545	0.079	1.047	70.684	17.994	4.293	0.358	4.651	0.634
PM H	0.597	0.255	2.561	76.994	15.041	4.336	0.217	4.553	0.411
PM J	0.767	0.210	0.803	73.296	19.961	3.412	1.551	4.963	0.462
PM L	0.252	0.118	1.081	77.419	16.260	4.174	0.696	4.869	0.357
PO B	0.798	0.232	1.840	62.428	22.645	8.485	3.573	12.057	0.630
PO D	1.096	0.286	1.696	64.132	24.971	7.076	0.745	7.821	0.316
PO F	1.016	0.317	2.098	66.939	17.152	9.075	3.403	12.478	0.706

Site	Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt (%)	Clay (%)	Mud	Organic Matter (%)
PO H	1.616	0.451	0.689	43.487	27.129	20.201	6.428	26.628	1.583
PO J	1.712	0.207	1.640	78.779	14.918	1.478	1.267	2.745	0.220
PO L	2.588	0.107	2.675	77.620	15.818	0.714	0.476	1.191	0.077
PU B	0.113	0.159	0.340	74.949	15.950	7.251	1.238	8.489	0.286
PU D	0.356	0.131	0.229	70.579	19.028	8.631	1.046	9.677	0.305
PU F	0.088	0.118	0.320	75.792	16.598	6.822	0.262	7.084	0.271
PU H	0.325	0.150	0.261	69.738	18.172	9.350	2.004	11.354	0.347
PU J	0.093	0.151	0.309	65.302	22.734	9.008	2.402	11.411	0.473
PU L	0.004	0.159	0.336	66.074	22.195	9.862	1.370	11.232	0.350

10.5 APPENDIX E: 2024 SEDIMENT METALS, DDT AND DIELDRIN

Site	Parameter	Replicate	mg/kg
Metals 2	Cadmium	1	0.014
Metals 2	Copper	1	3.1
Metals 2	Lead	1	4.3
Metals 2	Zinc	1	40
Metals 2	Mercury	1	<0.02
Metals 2	Cadmium	2	0.014
Metals 2	Copper	2	3.7
Metals 2	Lead	2	4.4
Metals 2	Zinc	2	43
Metals 2	Mercury	2	<0.02
Metals 2	Cadmium	3	0.014
Metals 2	Copper	3	3.6
Metals 2	Lead	3	4.4
Metals 2	Zinc	3	43
Metals 2	Mercury	3	<0.02
Metals 3	Cadmium	1	0.028
Metals 3	Copper	1	4.7
Metals 3	Lead	1	6.1
Metals 3	Zinc	1	51
Metals 3	Mercury	1	<0.02
Metals 3	Cadmium	2	0.031
Metals 3	Copper	2	5.7
Metals 3	Lead	2	7.2
Metals 3	Zinc	2	58
Metals 3	Mercury	2	0.02

Site	Parameter	Replicate	mg/kg
Metals 3	Cadmium	3	0.029
Metals 3	Copper	3	5.1
Metals 3	Lead	3	6.1
Metals 3	Zinc	3	53
Metals 3	Mercury	3	<0.02
Metals 4	Cadmium	1	0.017
Metals 4	Copper	1	3.1
Metals 4	Lead	1	4.1
Metals 4	Zinc	1	36
Metals 4	Mercury	1	<0.02
Metals 4	Cadmium	2	0.016
Metals 4	Copper	2	2.9
Metals 4	Lead	2	4.2
Metals 4	Zinc	2	36
Metals 4	Mercury	2	<0.02
Metals 4	Cadmium	3	0.018
Metals 4	Copper	3	3.2
Metals 4	Lead	3	4.3
Metals 4	Zinc	3	38
Metals 4	Mercury	3	<0.02
Metals 5	Cadmium	1	0.016
Metals 5	Copper	1	3
Metals 5	Lead	1	3.7
Metals 5	Zinc	1	36
Metals 5	Mercury	1	<0.02
Metals 5	Cadmium	2	0.014
Metals 5	Copper	2	2.9
Metals 5	Lead	2	3.7
Metals 5	Zinc	2	36
Metals 5	Mercury	2	<0.02
Metals 5	Cadmium	3	0.014
Metals 5	Copper	3	2.9
Metals 5	Lead	3	3.9
Metals 5	Zinc	3	36
Metals 5	Mercury	3	<0.02
Outfall	Cadmium	1	0.023
Outfall	Copper	1	3.1
Outfall	Lead	1	4.2
Outfall	Zinc	1	38
Outfall	Mercury	1	<0.02
Outfall	Dieldrin	1	<0.001
Outfall	DDT Isomers	1	<0.006

Site	Parameter	Replicate	mg/kg
Outfall	Cadmium	2	0.024
Outfall	Copper	2	3.5
Outfall	Lead	2	4.4
Outfall	Zinc	2	38
Outfall	Mercury	2	<0.02
Outfall	Cadmium	3	0.018
Outfall	Copper	3	3.3
Outfall	Lead	3	4
Outfall	Zinc	3	35
Outfall	Mercury	3	<0.02
Pond 14	Cadmium	1	0.049
Pond 14	Copper	1	4.3
Pond 14	Lead	1	5.6
Pond 14	Zinc	1	52
Pond 14	Mercury	1	<0.02
Pond 14	Dieldrin	1	<0.001
Pond 14	DDT Isomers	1	<0.006
Pond 14	Cadmium	2	0.052
Pond 14	Copper	2	5.1
Pond 14	Lead	2	6.3
Pond 14	Zinc	2	54
Pond 14	Mercury	2	<0.02
Pond 14	Dieldrin	2	<0.001
Pond 14	DDT Isomers	2	<0.006
Pond 14	Cadmium	3	0.048
Pond 14	Copper	3	4.8
Pond 14	Lead	3	6.2
Pond 14	Zinc	3	54
Pond 14	Mercury	3	<0.02
Pond 14	Dieldrin	3	<0.001
Pond 14	DDT Isomers	3	<0.006
Pond 16	Cadmium	1	0.06
Pond 16	Copper	1	5.3
Pond 16	Lead	1	6.4
Pond 16	Zinc	1	54
Pond 16	Mercury	1	0.02
Pond 16	Dieldrin	1	<0.001
Pond 16	DDT Isomers	1	<0.006
Pond 16	Cadmium	2	0.063
Pond 16	Copper	2	5.4
Pond 16	Lead	2	6.2
Pond 16	Zinc	2	54

Site	Parameter	Replicate	mg/kg
Pond 16	Mercury	2	<0.02
Pond 16	Dieldrin	2	<0.001
Pond 16	DDT Isomers	2	<0.006
Pond 16	Cadmium	3	0.059
Pond 16	Copper	3	5.3
Pond 16	Lead	3	6.4
Pond 16	Zinc	3	54
Pond 16	Mercury	3	0.02
Pond 16	Dieldrin	3	<0.001
Pond 16	DDT Isomers	3	<0.006
Purakau Upper	Cadmium	1	0.023
Purakau Upper	Copper	1	3.4
Purakau Upper	Lead	1	4.6
Purakau Upper	Zinc	1	42
Purakau Upper	Mercury	1	<0.02
Purakau Upper	Cadmium	2	0.022
Purakau Upper	Copper	2	3.3
Purakau Upper	Lead	2	4.6
Purakau Upper	Zinc	2	41
Purakau Upper	Mercury	2	<0.02
Purakau Upper	Cadmium	3	0.024
Purakau Upper	Copper	3	3.4
Purakau Upper	Lead	3	4.7
Purakau Upper	Zinc	3	41
Purakau Upper	Mercury	3	<0.02

10.6 APPENDIX F: ECOLOGICAL SITE PHOTOS FROM 2018 AND 2024


Pond 16 2018
Pond 16 2024
Purakau Upper 2018
Purakau Upper 2024


Purakau Mid 2018



Purakau Mid 2018

Purakau Mid 2024

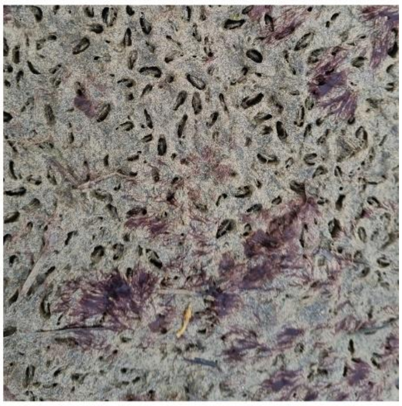

Purakau Outer 2018


Purakau Outer 2018


Purakau Outer 2024



Purakau Outer 2024



Purakau Outer 2024



Purakau Outer 2024


Cape Horn 2018
Cape Horn 2024
Cape Horn 2024

10.7 APPENDIX G: MAJOR CHANGES TO THE OPERATION OF MANGERE WASTEWATER TREATMENT PLANT SINCE THE PROJECT MANUKAU UPGRADE.

1998 to 2000	Project Manukau Upgrade (change from pond-based treatment to high-rate land-based treatment).
2002	Sludge Thickening Upgrade with installation of Gravity Belt Thickeners (this increased digester solids retention time).
2003	Digester spill and fill operation (to control digester foaming).
2005	Tidal Storage Basin volume decrease to minimise the midge habitat.
August 2008	Chlorine RC RAS Dosing (to improve sludge settleability that results in the discharge of less solids from RC's).
2010	UV Reduced Equivalent Dose (RED) introduction.
2011	ASU and Centrifuge Upgrade (the installation of two larger centrifuges to replace two smaller centrifuges).
2013 to present	Blower building chiller installation during summer months (to decrease the amount of blower surges due to heat accumulation in blower building).
2014	Digester 8 commissioning.
2018	New BNR plant brought online, providing 2 new reactors and clarifiers, and adding capacity that should reduce secondary partial bypasses.
2019	New Gravity Belt Thickening plant brought on-line (to increase the solids handling stream) Digester 5 taken out of service in November for overhaul.
2021	Digester 5 returned to service in November.
2022	Digester 7 was taken out of service in January for overhaul.
2023	Nitrogen non-compliances occurred in December 23, with an ammonia monthly maximum of 10.2 g/m^3, which was above the summer limit of 6 g/m^3, and the Total Nitrogen monthly mean was 10.2 g/m^3, which was above the summer limit of 9.5 g/m^3. The high nitrogen results were caused by the loss of blowers in warm temperatures. A delay in the refrigeration upgrade project and the loss of the blowers disrupted nitrogen removal in the reactor clarifiers. The project was completed in December and the effluent quality returned to full compliance. Digester 7 returned to service in April. Digester 8 taken out of service in May for overhaul.

2025	Final effluent monthly mean Dissolved Oxygen (DO) for June 2025 (79%) was slightly below the minimum standard specified in Table 2 of Consent 30083 (i.e., 80%).

(Information provided by Watercare Services Ltd).

10.8 APPENDIX H: NOTES ON TOTAL NITROGEN

The reference APHA[21] total nitrogen analysis method is moderately complex and has several steps:

1. Digest the sample under oxidising conditions to convert all forms of nitrogen to nitrate.
2. Reduce the nitrate to nitrite using cadmium.
3. Measure the nitrite by converting it to diazonium ion that can be reacted with N-1-napthyl)ethylenediamine dihydrochloride to form a coloured complex that can be detected spectrophotometrically.

Step 1 of the analysis is carried out manually, while steps 2–3 are performed by the flow injection analysis method.

Watercare Laboratories has been running this method across different instrument generations for over 25 years. Originally, the main sample types being processed were those specified in the reference method, i.e., surface waters and wastewaters. At some point, the method also became widely applied to seawater, and despite seawater not being included in the reference method's scope, its use for coastal water quality monitoring was stipulated by New Zealand's National Environmental Monitoring Standards (NEMS).

Around 2015, Watercare Laboratory Services investigated whether the unmodified method was directly applicable to seawater. That showed, for a reference nitrate solution, a high sample salinity matrix caused depressed TN results relative to a freshwater matrix. This was attributed to the refractive index difference when measuring final colour absorbance during analysis. The bias was corrected by preparing all calibration standards and controls in a synthetic seawater matrix. That method improvement was moved into production.

The laboratory understands the far-reaching consequences of changing methods and seeks to engage with stakeholders before implementation. It has advised that it is currently implementing new methods for some nutrients that will affect customers and that it has reached agreements regarding when and how the implementation will occur. For TN analysis, the laboratory expects to retain its existing method for another year before obsolescence forces it to replace instruments. As the colorimetric methods used are empirical and not absolute, it is likely that the change in instruments will produce another step change.

[21] American Public Health Association, *Standard Methods for the Examination of Water and Wastewater*