

Marine Water Quality Annual Report 2013

October 2014

Technical Report 2014/030

Auckland Council
Technical report, TR2014/030
ISSN 2230-4525
ISSN 2230-4533

ISBN 978-1-927216-49-1
ISBN 978-1-927216-50-7

This report has been peer reviewed by the Peer Review Panel

Submitted for review on 4 September 2014

Review completed on 22 October 2014

Reviewed by one reviewer

Approved for Auckland Council publication by:



Name: Grant Barnes

Position: Manager, Research, Investigations and Monitoring Unit

Date: 22 October 2014

Recommended citation:

Walker, J and Vaughan, M (2014). Marine water quality annual report 2013.

Auckland Council technical report, TR2014/030

© 2014 Auckland Council

This publication is provided strictly subject to Auckland Council's copyright and other intellectual property rights (if any) in the publication. Users of the publication may only access, reproduce and use the publication, in a secure digital medium or hard copy, for responsible genuine non-commercial purposes relating to personal, public service or educational purposes, provided that the publication is only ever accurately reproduced and proper attribution of its source, publication date and authorship is attached to any use or reproduction. This publication must not be used in any way for any commercial purpose without the prior written consent of Auckland Council. Auckland Council does not give any warranty whatsoever, including without limitation, as to the availability, accuracy, completeness, currency or reliability of the information or data (including third party data) made available via the publication and expressly disclaim (to the maximum extent permitted in law) all liability for any damage or loss resulting from your use of, or reliance on the publication or the information and data provided via the publication. The publication, information, and data contained within it are provided on an "as is" basis.

Marine Water Quality Annual Report: 2013

Jarrold Walker
Melanie Vaughan

Research, Investigations and Monitoring Unit
Auckland Council

Table of Contents

1.0	Executive summary.....	1
2.0	Introduction	2
2.1	Report content	4
3.0	Methods	5
3.1	Programme design	5
3.2	Water quality parameters.....	8
3.3	Programme changes	8
3.4	Quality control, data storage and analysis	9
3.5	Reports	9
4.0	Results	11
4.1	Box plots.....	12
4.2	Marine water quality index.....	19
4.3	Data tables	22
5.0	References.....	39
6.0	Acknowledgements.....	40
Appendix A	Physico-chemical measures	41
Appendix B	Water quality indices.....	42

List of Figures

Figure 1-1 The relationship between sediment contaminants, coastal water quality and shellfish contaminant monitoring programmes.....	4
Figure 3-1 Location of the 36 marine quality monitoring sites	7
Figure 4-1 Spatial patterns in conductivity, salinity and pH.	12
Figure 4-2 Spatial patterns in turbidity, suspended sediment, and chlorophyll <i>a</i>	13
Figure 4-3 Spatial patterns in nitrite, nitrate and ammonia.	14
Figure 4-4 Spatial patterns in total kjedahl nitrogen and total nitrogen.	15
Figure 4-5 Spatial patterns in total phosphorous and soluble reactive phosphorous.....	16
Figure 4-6 Spatial patterns in enterococci.	17
Figure 4-7 Spatial patterns in two indices of dissolved oxygen (ppm and % saturation) and sea surface temperature.....	18

List of Tables

Table 3-1	Marine water quality sites sorted from north to south, grouped by location.....	6
Table 4-1	Water quality index and the resultant water quality class..	20
Table 4-2	Electrical conductivity (mS.cm^{-1})	22
Table 4-3	Salinity (ppt)	23
Table 4-4	pH (pH units)	24
Table 4-5	Turbidity (NTU).....	25
Table 4-6	Suspended sediment (mg/L)	26
Table 4-7	Chlorophyll <i>a</i> (mg/L).....	27
Table 4-8	Nitrite (mg N/L).....	28
Table 4-9	Nitrate (mg N/L).....	29
Table 4-10	Ammonia (mg N/L).....	30
Table 4-11	Total kjedahl nitrogen (mg N/L).....	31
Table 4-12	Total nitrogen (by calculation, mg N/L)	32
Table 4-13	Total phosphorus (mg/L).....	33
Table 4-14	Soluble reactive phosphorus (mg/L)	34
Table 4-15	Enterococci (CFU/100ml).....	35
Table 4-16	Dissolve oxygen (% saturation)	36
Table 4-17	Dissolved oxygen (ppm)	37
Table 4-18	Temperature ($^{\circ}\text{C}$)	38
Table A-1	Summary of marine water quality parameters, detection limits, analytical methods and two sources of data collection.	41
Table B-1	The seven water quality parameters, and their objectives, used to produce the water quality indices.....	43

1.0 Executive summary

The Auckland Council operates a long-term saline water quality monitoring programme throughout the region. The objectives of this monitoring include state of the environment reporting, identification of environmental issues and the assessment of the efficiency of Auckland Council policy initiatives and strategies. This report documents any changes made to the monitoring programme and provides a summary of the data collected during the 2013 calendar year.

Water quality is assessed monthly at 36 sites, divided into 6 geographically distinct runs around the region, using a combination of field based and laboratory tested parameters. The results are presented as box plots, which display the variation in the measured parameters at each of the sites, and in tables which provide a statistical summary of each parameter at each site.

The data has been used to produce water quality indices, which allows for sites to be assigned a water quality class and ranked. This is the second year where a three-year average has been used to calculate the water quality indices. This analysis provides a simple form of results to be communicated from complex water quality data. Unchanged from 2012, the 2013 data indicates that Mahurangi Heads has the best water quality in the region, and Brighams Creek has the lowest ranked water quality. Fourteen sites changed water quality class from their 2012 classification.

2.0 Introduction

The marine environment in the Auckland region encompasses two oceans, four major harbours, and numerous estuaries. This wide variety of marine habitats supports a diverse range of plants and animals, including seaweeds, invertebrates (e.g. sponges and kina), mangroves, sea-grass, shellfish, marine mammals, fish and sea birds.

The aesthetics, use, and health of near coastal waters are influenced by the quality of freshwater that runs from the land through streams, rivers and the stormwater system. The microbiological contamination of beaches after heavy rainfall and the sedimentation of harbours and estuaries (ARC, 2009) illustrate the connections between inland and coastal waters, and the sensitivity of these marine ecosystems.

The marine water quality programme is designed to meet the following objectives:

- Satisfy the Auckland Council's Resource Management Act 1991, section 35 obligations with respect to state of the environment reporting.
- Contribute to the need to maintain and enhance the quality of the environment monitoring (Local Government Act 2002).
- Help inform the efficacy and efficiency of policy initiatives and strategies.
- Assist with the identification of large scale and/or cumulative impacts of contaminants associated with varying land uses and disturbance regimes and link these to particular activities.
- Provide baseline, regionally representative data to support the resource consent process and compliance monitoring.
- Answering queries from the public, and promote awareness of water quality issues.

This programme fits under the "Natural Environment and Heritage" component of the Auckland Council's Long-term Plan. A key issue for the region is to manage the effects of growth and development on our natural environment. This includes balancing the needs for environmental protection with Auckland's social, economic and cultural well-being, and aspirations for our coastal resources and marine animal and plant life.

Specific objectives include managing and minimising the effects of present and future urban and rural development, growth, and intensification across the region. The water quality parameters provide information on the condition of the region's marine environment, and feedback on management actions. This is necessary to confirm that Auckland Council's management strategies are effective in sustaining ecosystem functions and uses. By achieving this outcome we are working towards achieving Auckland Council's aspiration of being "The world's most liveable city."

Information from the marine water quality programme is also used to measure the success of several strategic directives in the Auckland Plan including: Directive 7.10 "Manage land to support the values of waterbodies by protecting them where they are high and reviving them where they are degraded" and Directive 7.12 "Protect coastal areas - particularly those with high values - from the impacts of use and development, and enhance degraded areas" (Auckland Council, 2012).

The marine water quality programme monitors water quality across the Auckland region. Information obtained is also used in conjunction with ecological and contaminant data to provide an integrated overview of the physical, chemical, and biological condition of the region's marine environment (Figure 2-1), the four marine monitoring programmes include:

- The marine water quality programme monitors natural occurring parameters, some of which can become elevated in association with natural variations in ocean hydrodynamics, land erosion and biological wastes (organic material and faecal contaminants) in the water column.
- The shellfish contaminant monitoring programme concluded at the end of 2013 with a transition of components of the programme merged into an expanded sediment contamination programme. The shellfish programme indirectly monitored chemical contaminants in the water column. A direct measurement of chemical contaminants in water is unreliable because concentrations are commonly below analytical detection limits, and they vary widely due to water movement and the patchy nature of inputs. However, some plants and animals accumulate contaminants over time, even when ambient levels in the water column are relatively low. The tissues of oysters and mussels therefore provided an integrated measure of ambient chemical contaminant levels in the water column.
- The sediment contaminant monitoring programme monitors chemical contaminant levels in estuarine and harbour sediments. Many contaminants attach to particulate material which settles out of the water column and accumulates in depositional zones. These contaminants can be toxic to the benthic organisms that live in these sediments. Reduced sediment quality may impact on the ecological health of an area by reducing sensitive species and favouring tolerant species.
- The benthic ecology programme monitors temporal changes in specific sediment dwelling, ecological communities in the Mahurangi, Waitemata, Kaipara and Manukau Harbours and East Coast estuaries.

Further details of the programmes can be found in the Marine Monitoring Plan (Carbines et al, 2013).

Collectively, these programmes provide consistent, long-term information on the quality of Auckland's coastal environment. These programmes are strengthened further by the streams and rivers monitoring programme which monitor similar parameters to those in the marine water quality programme. This alignment enables trends in the marine environment and the freshwater environment to be compared allowing the determination (to a certain degree) of the source of some water quality parameters.

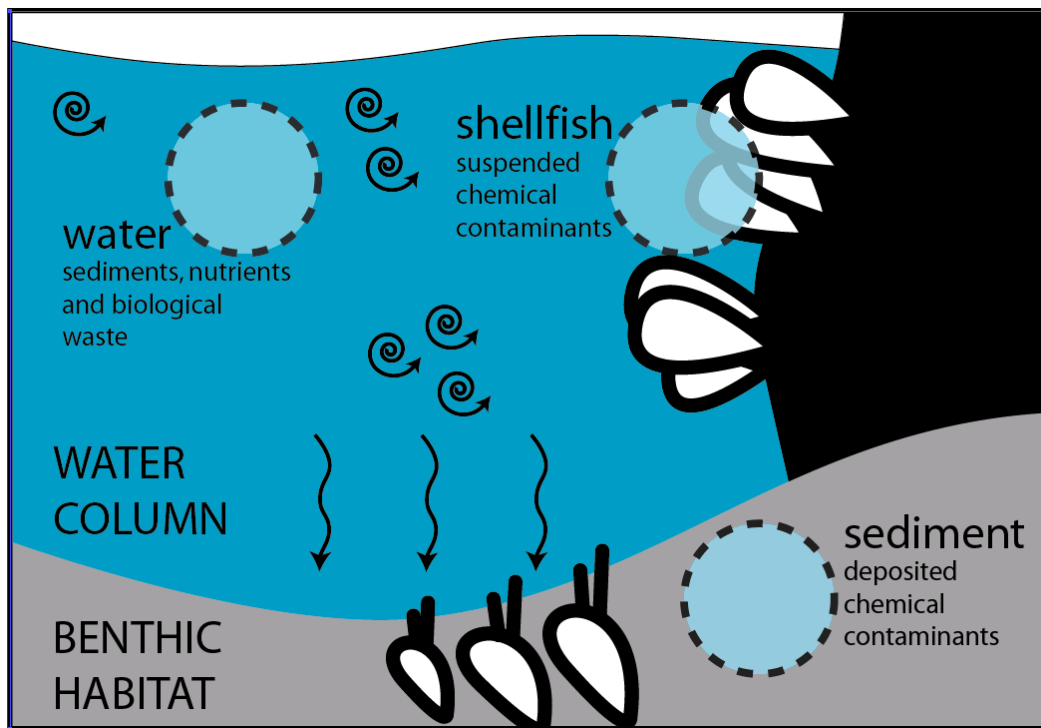


Figure 1-1 The relationship between sediment contaminants, coastal water quality and shellfish contaminant monitoring programmes.

2.1 Report content

This report provides 12 months of summary data from the 2013 calendar year collected from 36 monitoring sites and 17 parameters across the Auckland region (Figure 3-1), and includes summary statistics tabulated by parameter grouped by spatial proximity (Tables 4-2 to 4-18), and results from calculations for water quality indices Table 4-1).

3.0 Methods

3.1 Programme design

Sampling of surface waters for marine water quality monitoring is undertaken monthly by Auckland Council technical officers, predominantly by helicopter. This enables sites spread over a broad area to be collected within a narrow time frame due to tidal constraints (these constraints are described below). Sites where water samples are not collected using a helicopter include, the Upper Waitemata Harbour sites which are sampled by boat, and the Tamaki Estuary sites which are sampled from land. At each site, water samples are collected from the surface waters (the top 1 m) by lowering a 2 litre plastic bottle and 500ml glass bacteria bottle into the water. The 2 litre plastic and glass bacteria bottles are sent to Watercare Laboratory Services (WLS) and analysed for chemical compounds (see Appendix A) and enterococci.

Sampling is divided into 6 geographically distinct runs, summarised below. Routine water quality monitoring locations are summarised in Table 3-1 and illustrated in Figure 3-1.

- 8 sites in Manukau Harbour
- 7 sites in the inner Hauraki Gulf and outer Waitemata Harbour
- 7 sites in Kaipara Harbour
- 3 sites in Mahurangi Harbour
- 2 sites in Tamaki Estuary
- 2 sites in the Tamaki Strait (1 site in Turanga Estuary and 1 site at the mouth of the Wairoa River)
- 8 sites in the Upper Waitemata Harbour

Temporal variation is avoided as much as possible by maintaining a consistent sampling time relative to tidal cycle. Samples are collected approximately 30 minutes–3 hours after high tide for the Kaipara Harbour, Waitemata Harbour and Hauraki Gulf sites and 2.5–4 hours after high tide for the Manukau Harbour. This avoids introducing diurnal variation to the dataset and improves the power of long term trend detection

Table 3-1 Marine water quality sites sorted from north to south, grouped by location. Spatial reference is NZTM coordinates and the year which sampling at each site started are also listed.

Site	Location	Easting	Northing	Start
Goat Island	East Coast	1761835	5984910	1993
Ti Point	East Coast	1760222	5978524	1991
Mahurangi Heads	East Coast	1754382	5959892	1993
Dawsons Creek	East Coast	1753554	5966410	1993
Orewa	East Coast	1753273	5949612	1991
Browns Bay	East Coast	1757934	5935780	1991
Shelly Beach	Kaipara Harbour	1723526	5951872	1991
Kaipara River	Kaipara Harbour	1726372	5946975	2009
Makarau estuary	Kaipara Harbour	1728450	5953472	2009
Omokoiti beacon	Kaipara Harbour	1718659	5961178	2009
Kaipara Heads	Kaipara Harbour	1709351	5970137	2009
Tauhoa Channel	Kaipara Harbour	1717979	5969681	2009
Hoteo River	Kaipara Harbour	1726690	5967497	2009
Chelsea	Waitemata Harbour	1753944	5922872	1991
Whau Creek	Waitemata Harbour	1748289	5920291	1991
Henderson Creek	Waitemata Harbour	1746712	5923648	1991
Hobsonville Jetty	Waitemata Harbour	1749321	5927317	1993
Waimarie Road	Waitemata Harbour	1746213	5929089	1993
Rarawaru Creek	Waitemata Harbour	1744434	5928653	1993
Confluence	Waitemata Harbour	1743962	5929039	1993
Paremoremo Ski Club	Waitemata Harbour	1745746	5930178	1993
Rangitopuni Creek	Waitemata Harbour	1742836	5929868	1993
Brighams Creek	Waitemata Harbour	1742758	5928019	1993
Lucas Creek	Waitemata Harbour	1750045	5932471	1993
Tamaki	Tamaki Estuary	1769372	5917448	1992
Panmure	Tamaki Estuary	1765295	5913934	1992
Turanga Estuary	Tamaki Strait	1774464	5914091	2009
Wairoa River	Tamaki Strait	1786443	5909850	2009
Grahams Beach	Manukau Harbour	1749651	5888082	1987
Clarks Beach	Manukau Harbour	1748630	5897349	1987
Waiuku Town Basin	Manukau Harbour	1753690	5878187	2012
Shag Point	Manukau Harbour	1748379	5908452	1987
Puketutu Point	Manukau Harbour	1753877	5908724	1987
Weymouth	Manukau Harbour	1764925	5897672	1987
Mangere Bridge	Manukau Harbour	1758588	5910714	1987
Manukau Heads	Manukau Harbour	1708915	5970600	2009



Figure 3-1 Location of the 36 marine water quality monitoring sites

Monitoring sites were selected to provide information on:

- Water quality across a disturbance gradient from high to low
- A range of exposure levels including open coast, sheltered coast, harbours, large estuaries and tidal creeks
- The main harbours and large estuaries
- Areas with a variety of adjacent land uses, ranging from urban/industrial to rural

3.2 Water quality parameters

The water quality of the region's coastal environment is determined by measuring 19 parameters. Some parameters are measured in the field but most are analysed in the laboratory (see Table A-1, Appendix A). The number and type of parameters has varied since the programme's inception as new technology became more affordable, instrument sensitivity improved and the programme objectives were modified.

3.3 Programme changes

The monitoring programme was last reviewed in June 2005. Following this review biological oxygen demand (BOD) was dropped in July 2005 from the list of analytical laboratory tests due to laboratory analysis consistently returning results at the laboratory detection limit (<2ppm) and no improved methodology from WaterCare Laboratory Services Ltd being forthcoming upon request. The measurement of water clarity using Secchi disk also ceased in July 2005 due to the difficulty of accurately estimating Secchi disk readings from the helicopter. Turbidity (measured in NTU) was deemed to be a useful approximate surrogate.

In November 2008 a hand held multi-parameter water probe was introduced to the programme. The hand held probe (YSI 556 MPS) is able to take in situ measures of pH, salinity, conductivity, temperature, and two dissolved oxygen readings (% saturation and concentration recorded in mg. L⁻¹). Previous to this, these parameters were measured in the lab by WLS. In July 2013 the hand held probe was updated to a new model, EXO2 YSI.

In January 2009 six new sites in the Kaipara Harbour were added to this programme. In addition, one site at the Manukau Heads, one site at Turanga estuary and one site at the mouth of the Wairoa River were also added. An additional site, Waiuku Town Basin was added to the programme in August 2012. These additional sites allow for greater coverage of the coastal waters of the Auckland region.

Faecal coliforms were deleted from the list of laboratory tests in 2009 as Enterococci is considered a more appropriate bacteria indicator in marine waters. Also, total nitrogen (TN) was added to the list of chemical variables as it can be calculated from the current nitrogen species analysed at the WLS.

3.4 Quality control, data storage and analysis

Quality control is 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 to ensure consistency across the monitoring programme. Samples are analysed under contract to the Auckland Council by Watercare Laboratory Services Ltd (WLS), an IANZ accredited laboratory. Analytical methods follow the "Standard Methods for the Examination of Water and Wastewater" 22nd Edition (APHA, 2012). All field and laboratory data are stored in the Auckland Council's water quality archiving database (HYDSTRA) and complies with ISO 9001:2008 accreditation.

The data is collated and used to produce:

- Box plots which display variation in the measured parameters at each of the sites. The boxplots were produced using the software package SigmaPlot (version 12.0), using the default percentile functions. The boxes represent the inter-quartile range (25th and 75th percentile) and the whiskers represent the 5th and 95th percentiles. The median is shown as a line within each box.
- Summary tables which provide a statistical summary of each parameter at each site. These have been produced using Statistical version 10.
- Water Quality Indices have been produced using the data for seven water quality parameters to allow a water quality class to be assigned to each site. Indices are classed as Poor, Fair, Good and Excellent. These were produced using an MSeExcel workbook produced by the Canadian Council of Ministers of the Environment (2001). The application of this method to the council's water quality data is described in Appendix B.

3.5 Reports

This is the 23rd data report since the inception of the monitoring programme, and it is the seventh time since 2000 that the data has been reported separately from the rivers, streams and lakes water quality monitoring programmes. Previous reports described in the list of references can be obtained by contacting Auckland Council on (09) 301 0101, or in electronic format from Auckland Council's website under 'Technical publications and research':

<http://www.aucklandcouncil.govt.nz/en/planspoliciesprojects/reports/technicalpublications>

A comprehensive trend analysis is conducted approximately every five years and is currently in the process of being written, the last report published prior to this was in 2008 (Scarsbrook, 2008) and a previous report published in 1999 (Vant and Lee, 1998). Auckland Regional Council's State of the Auckland Region Report 2009 briefly summaries water quality issues, including an assessment of the ecological health of the region's marine resources and land use pressures (ARC, 2009).

The marine water quality monitoring programme is also reviewed approximately every five years. Recent reviews were conducted concurrently with the last trend analysis in 2008 (Scarsbrook, 2008), from which a number of recommendations were made along with detailed analysis of long

term changes in water quality for the Auckland region. This report is available on the Auckland Council website.

A specific review of the Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary was last undertaken in 2001 (Wilcock and Kemp, 2001).

4.0 Results

Data from the 2013 calendar year are presented as box plots to display the ranges over which water quality parameter results were recorded. These plots also show the variations in the water quality parameters among sites and locations and the data are summarised in tables in section 4.3. Data tables contain summary statistics (sample sizes, maximum/minimum, means and standard error). For box plots and data tables, sites are grouped by location (e.g. all sites within the Manukau Harbour are grouped) and then listed from north to south. Water indices produced using the data. A more comprehensive state of the environment and trends water quality report is currently being written.

4.1 Box plots

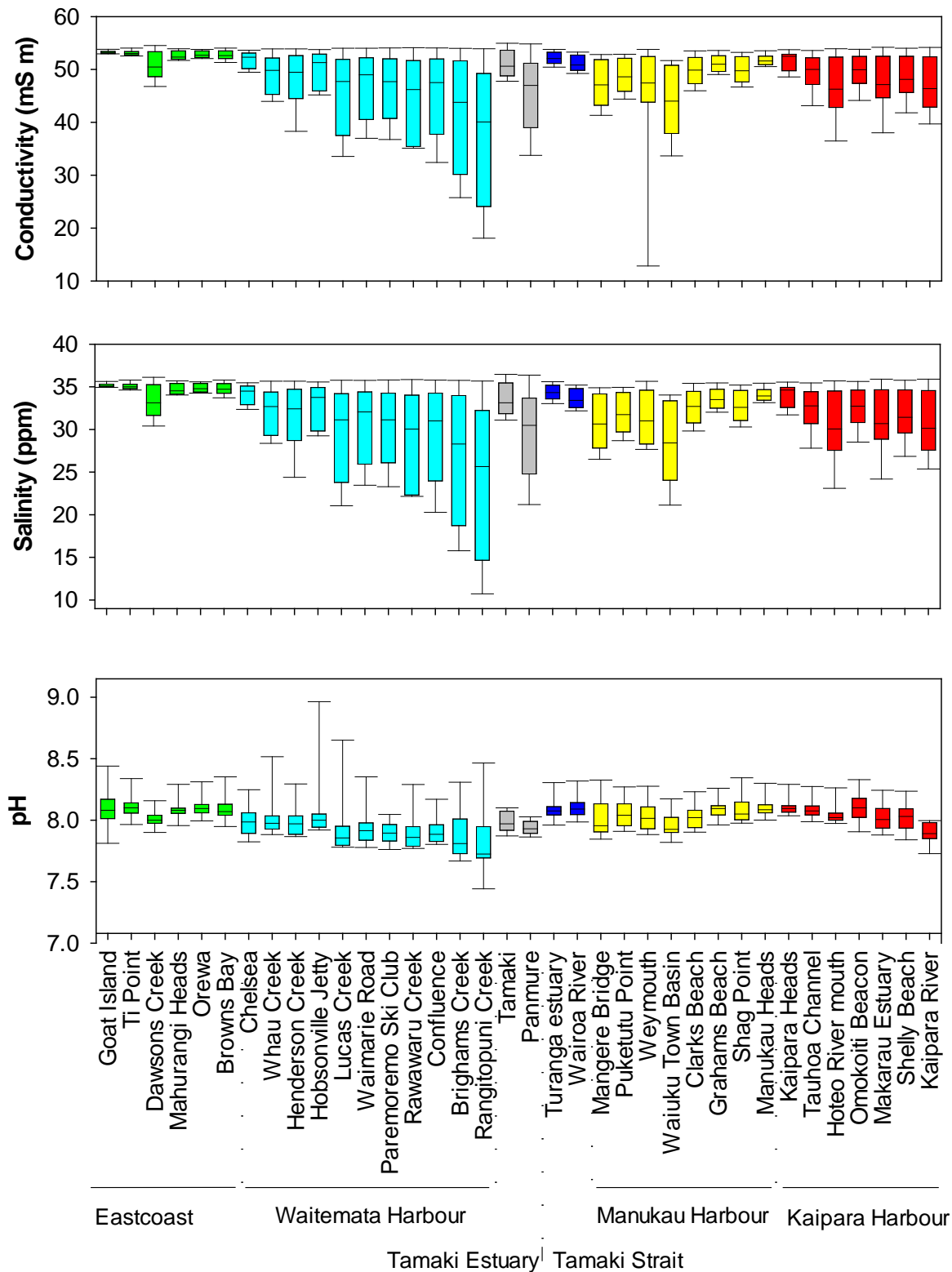


Figure 4-1 Spatial patterns in conductivity, salinity and pH. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentiles values calculated using the standard method in SigmaPlot (v12).

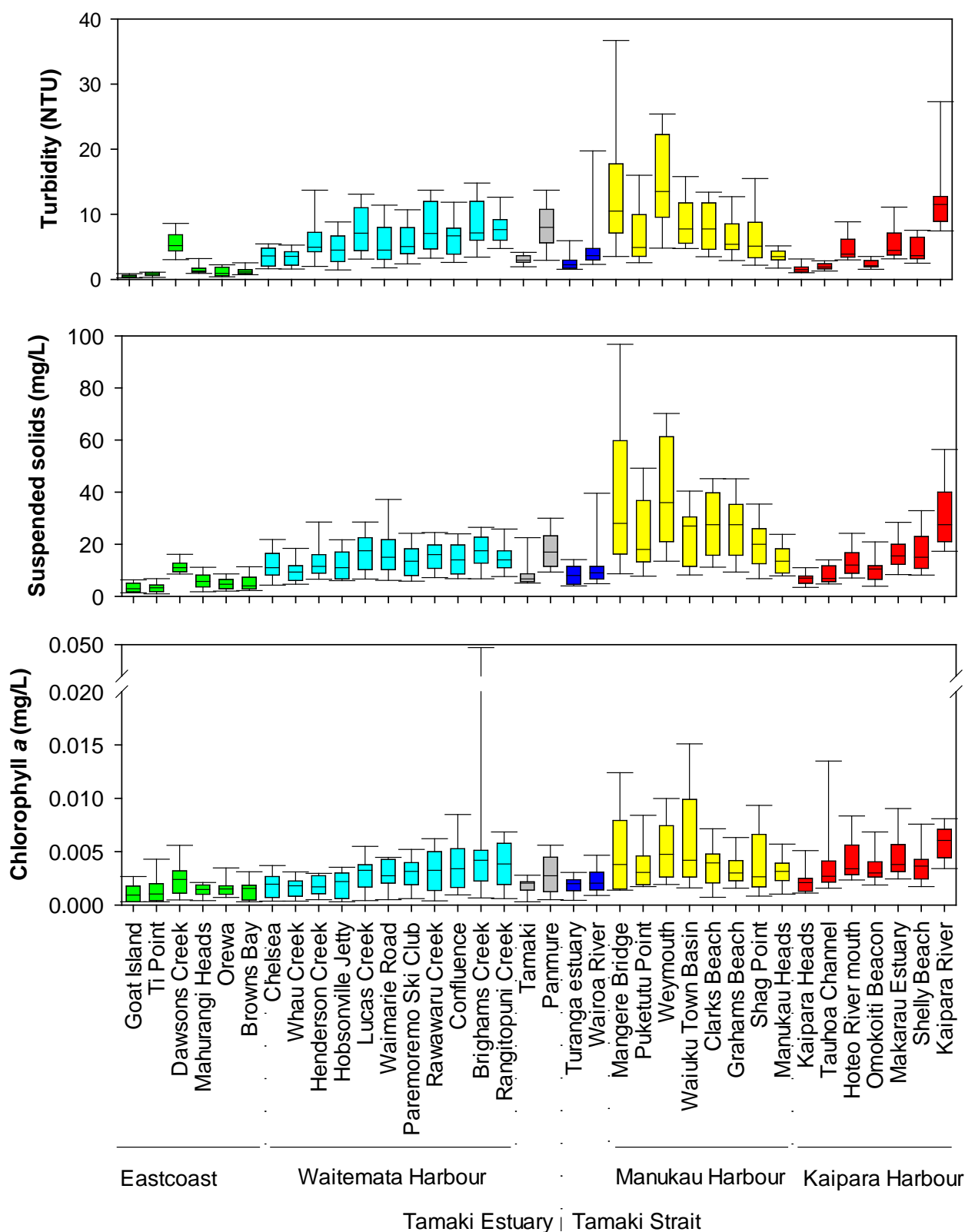


Figure 4-2 Spatial patterns in turbidity, suspended sediment, and chlorophyll a. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentiles values calculated using the standard method in SigmaPlot (v12). Note the scale break in the Chlorophyll a plot.

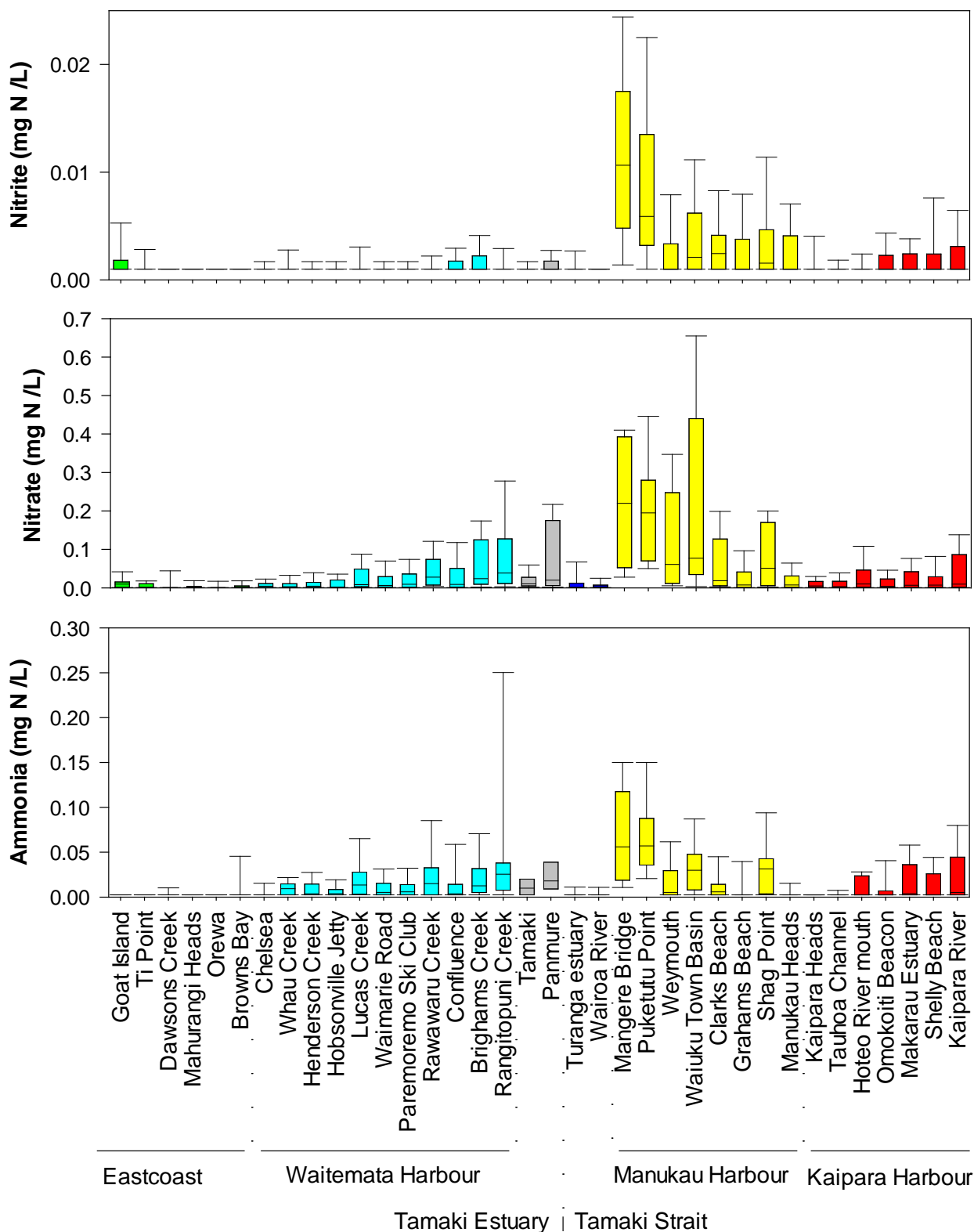


Figure 4-3 Spatial patterns in nitrite, nitrate and ammonia. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentiles values calculated using the standard method in SigmaPlot (v12).

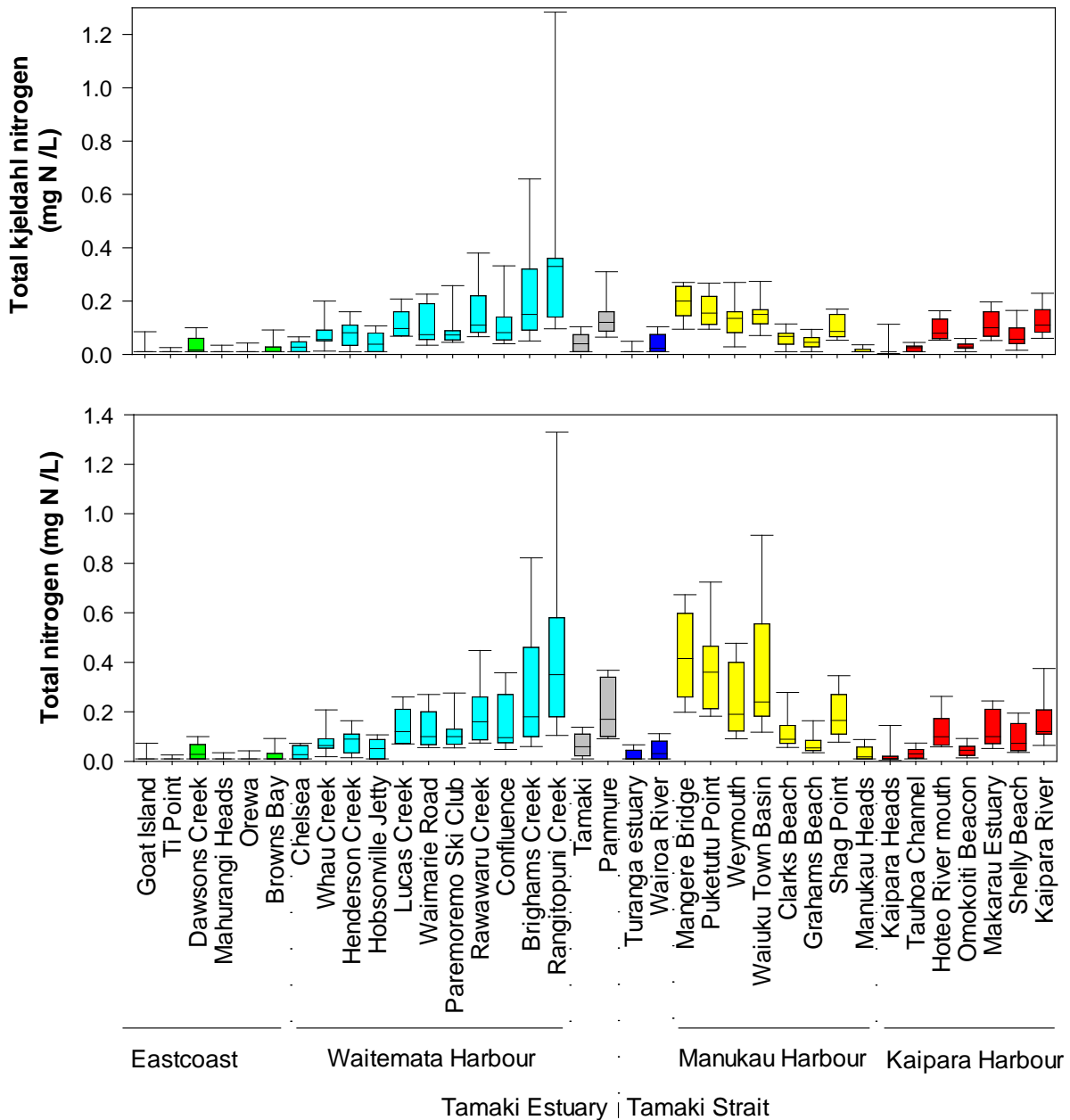


Figure 4-4 Spatial patterns in total kjeldahl nitrogen and total nitrogen. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentiles values calculated using the standard method in SigmaPlot (v12).

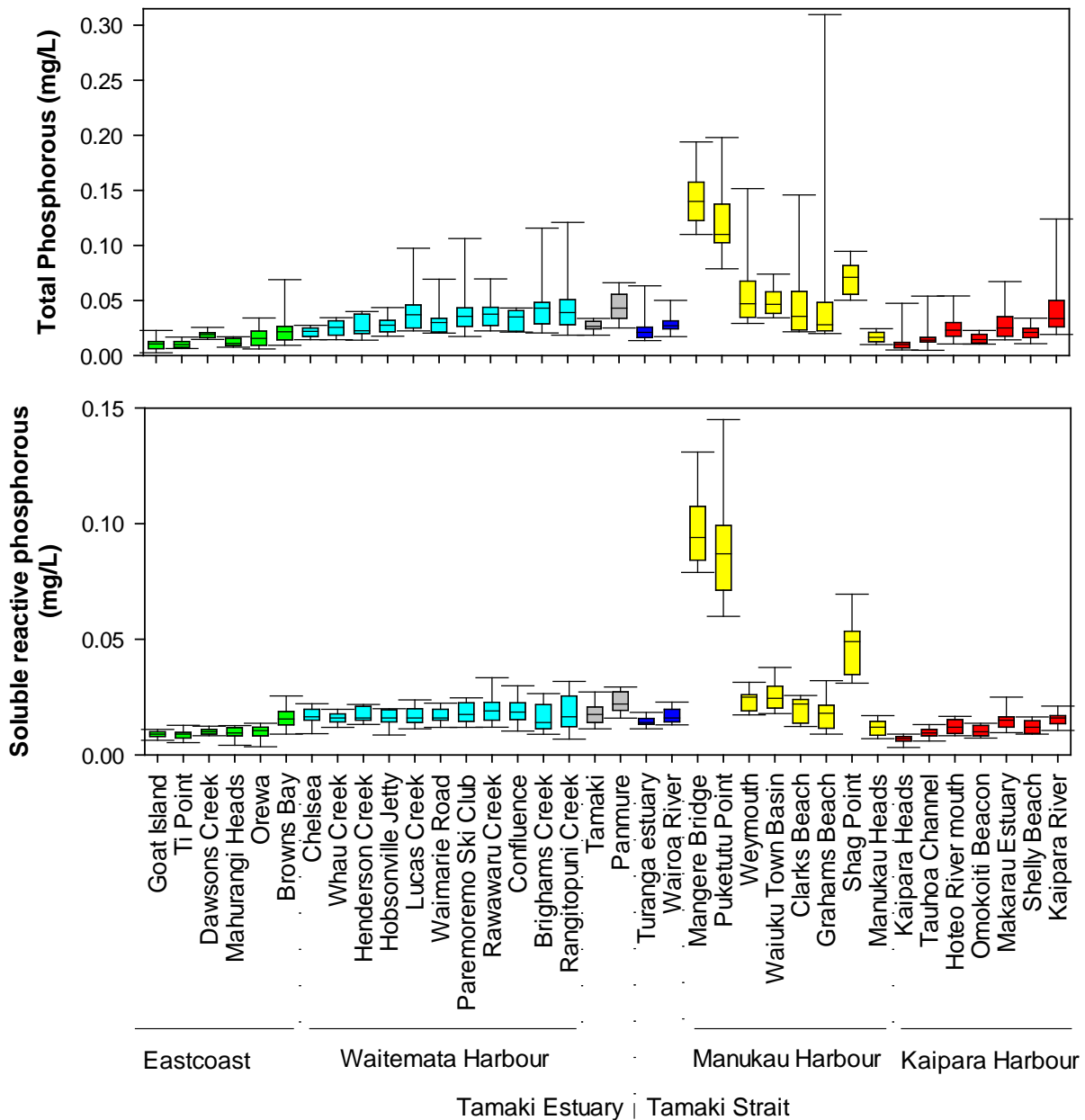


Figure 4-5 Spatial patterns in total phosphorous and soluble reactive phosphorous. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentiles values calculated using the standard method in SigmaPlot (v12).

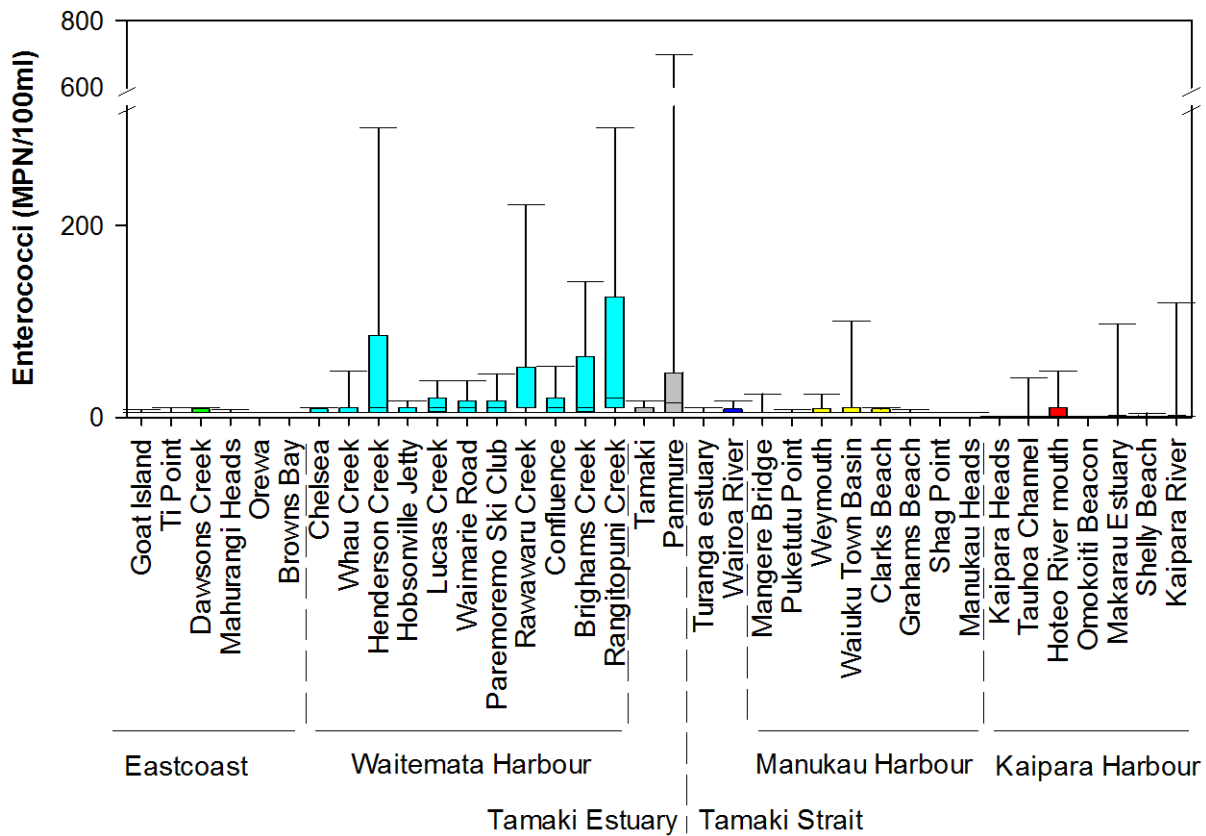


Figure 4-6 Spatial patterns in enterococci. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentiles values calculated using the standard method in SigmaPlot (v12). Note the scale break in the y-axis of the plot.

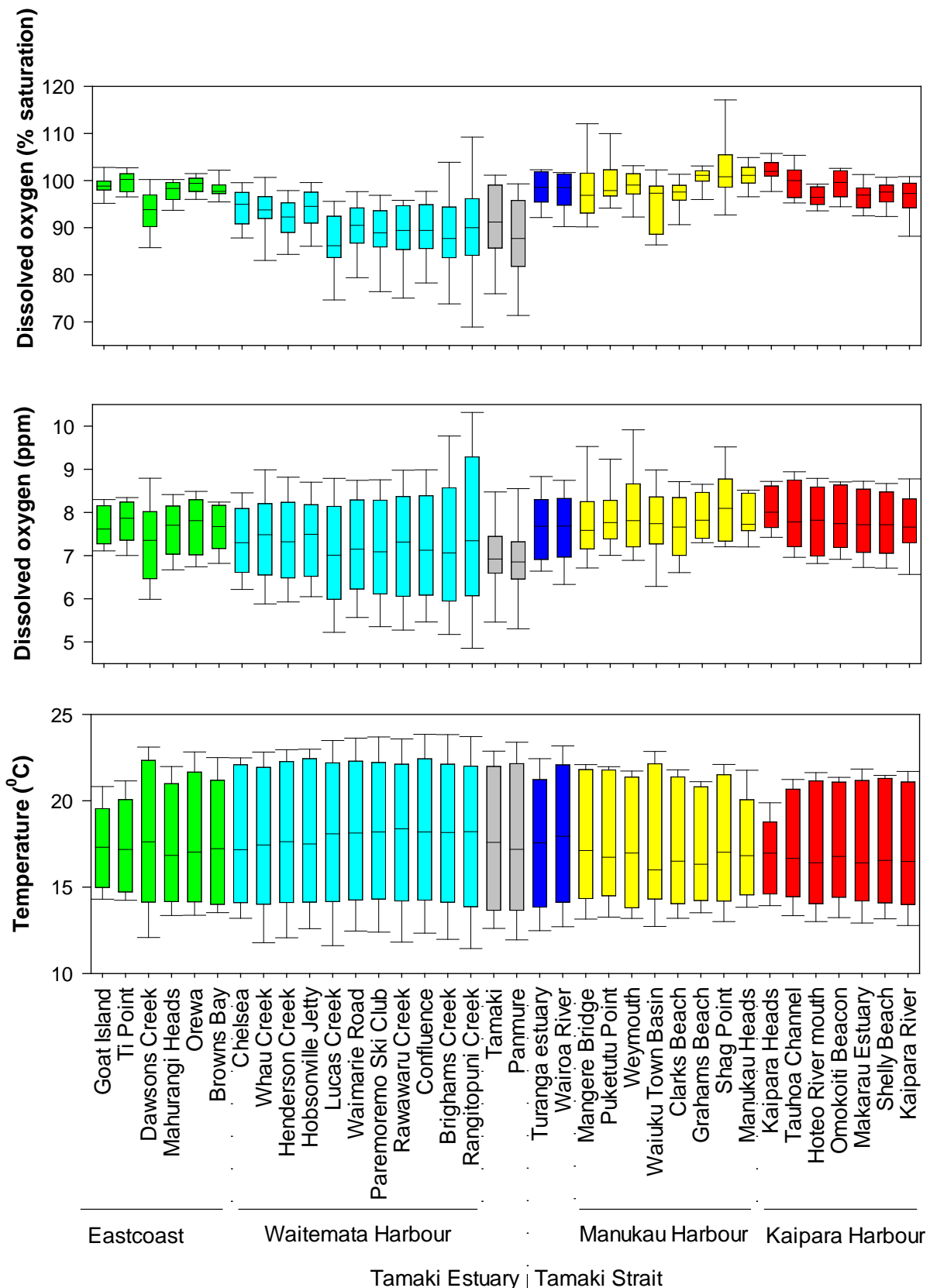


Figure 4-7 Spatial patterns in two indices of dissolved oxygen (ppm and % saturation) and sea surface temperature. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2013 to December 2013. Percentile values calculated using the standard method in SigmaPlot (v12).

4.2 Marine water quality index

Using the methodology described in Appendix B and first applied in the 2009 annual water quality report, water quality indices and classes were generated for each of the 36 sites (Table 4-1, Figure 4-8). The water quality indices for 2013 present an average of three years of data (2011, 2012 and 2013), differing from reports prior to 2012 that present a single year's data. This approach has been adopted to eliminate any inter annual variations from environmental changes such as input from development, heavy rain fall etc.

Mahurangi Heads was the site with the best water quality in 2013, maintaining the same position as it held in 2011 and 2012. The site was classed as excellent, along with four other sites in 2013, compared to one site in 2012 (Walker and Vaughan, 2013c). Brighams Creek had the worst water quality of all monitoring sites in 2013, consistent with 2012, and a position that was previously held by Mangere Bridge in 2010 and 2011 (Walker and Vaughan, 2013a; Walker and Vaughan, 2013b; Walker and Vaughan, 2013c).

Fourteen sites changed water quality class from their 2012 classification (Walker and Vaughan, 2013c). The majority of the changes were increases in water quality with only one site (Clarks beach) decreasing from Fair to Poor. This was a change from 2012, where all sites except one were decreases of water quality (Walker and Vaughan, 2013c). Of the fourteen sites, one site changed by three classes (Chelsea), one site changed by two classes (Kaipara Heads) and twelve sites changed by one class. The most notable change was an increase at Chelsea from Poor to Excellent, this is likely attributable to lower on average results of chlorophyll *a*, total phosphorus, ammonia, dissolve oxygen, turbidity and enterococci.

Poor water quality results were found in 44% of the sites in 2013, this is a decrease from 2012 results of 61% (Walker and Vaughan, 2013c). This result was closer to those found in 2011 of 35%, however comparisons should be made with caution as 2011 results were based on a single year of data and 2012 and 2013 are calculated using three years of data. Lower water quality classes can be attributed to failures to comply with quality thresholds (see Table B-1, Appendix B) for concentrations of suspended sediments, turbidity and typically one of the nutrient tests (e.g. ammoniacal nitrogen, total phosphorus or nitrate + nitrite nitrogen).

Table 4-1 Water quality index and the resultant water quality class for the sites monitored. The 2012 water quality class is also presented for inter-annual comparisons (the four indices scope, frequency, magnitude and index are discussed in Appendix B).

Site	scope	frequency	magnitude	Index	2013 class	2012 class
Mahurangi Heads	11.1	0.9	0	93.6	Excellent	Excellent
Orewa	11.1	0.9	0	93.6	Excellent	Good
Goat Island	11.1	1.9	0	93.5	Excellent	Good
Chelsea	11.1	2	0.2	93.5	Excellent	Poor
Ti Point	22.2	1.9	0.2	87.1	Good	Good
Tamaki	22.2	4.3	0.7	86.9	Good	Fair
Browns Bay	33.3	2.8	1.2	80.7	Good	Good
Turanga Est Mouth	33.3	2.8	1	80.7	Good	Fair
Dawsons Creek	33.3	2.8	0.8	80.7	Good	Fair
Kaipara Heads	33.3	2.9	0.7	80.7	Good	Poor
Shelly Beach	33.3	9.3	3.3	79.9	Good	Fair
Whau Creek	44.4	4	0.3	74.2	Fair	Fair
Manukau Heads	44.4	6.5	1.4	74.1	Fair	Fair
Omokoiti Beacon	44.4	5.6	1.3	74.1	Fair	Poor
Tauhoa Channel	44.4	5.6	4	74	Fair	Fair
Hobsonville Jetty	55.6	6.1	0.7	67.7	Fair	Fair
Wairoa River Mouth	55.6	5.6	4.1	67.7	Fair	Poor
Henderson Creek	55.6	11.1	12.3	66.5	Fair	Poor
Grahams Beach	55.6	19.4	14.7	65	Fair	Poor
Hoteo River mouth	66.7	10.2	4.6	61	Fair	Poor
Clarks Beach	66.7	27.8	16.5	57.2	Poor	Fair
Waimarie Road	77.8	15.2	3.9	54.2	Poor	Poor
Paremoremo Ski Club	77.8	17.2	5	53.9	Poor	Poor
Makarau Estuary	77.8	17.6	7.4	53.8	Poor	Poor
Shag Point	77.8	32.4	18.9	50.1	Poor	Poor
Puketutu Point	66.7	42.6	37.4	49.5	Poor	Poor
Panmure	77.8	29.8	28	49.3	Poor	Poor
Kaipara River	77.8	40.2	23	47.7	Poor	Poor
Waiuku Town Basin	77.8	34.6	32.6	47.4	Poor	Poor
Confluence	88.9	20.2	6.2	47.2	Poor	Poor
Lucas Creek	88.9	24.2	6.7	46.7	Poor	Poor
Weymouth	77.8	40.7	32.3	46	Poor	Poor
Mangere Bridge	77.8	45.4	48	41.1	Poor	Poor
Rarawaru Creek	100	32.3	14.3	38.8	Poor	Poor
Rangitopuni Creek	100	34.3	26.8	37	Poor	Poor
Brighams Creek	100	38.4	26	36.4	Poor	Poor

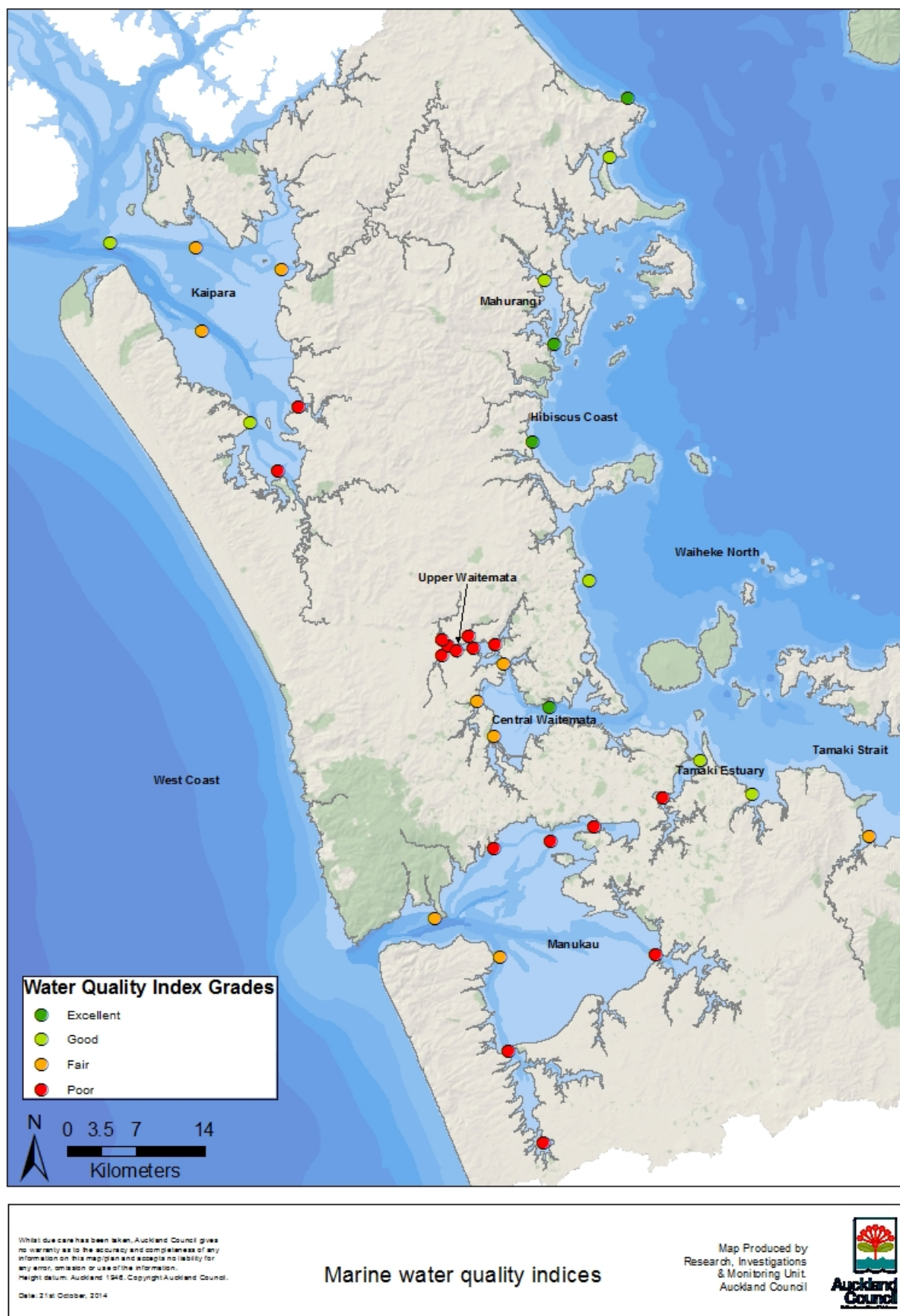


Figure 4-8 Marine water quality indices

4.3 Data tables

Table 4-2 Electrical conductivity ($\text{mS}\cdot\text{cm}^{-1}$) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	52.94	53.84	53.16	53.26	0.09
Ti Point	12	52.53	54.19	53.02	53.11	0.14
Dawsons Creek	12	46.22	54.72	50.45	50.84	0.78
Mahurangi Heads	12	51.65	54.05	52.35	52.68	0.24
Orewa	12	52.05	53.87	52.70	52.87	0.19
Browns Bay	12	51.13	54.24	52.62	52.72	0.26
Chelsea	12	49.41	53.84	52.31	51.70	0.46
Whau Creek	12	43.84	54.27	49.83	48.93	1.05
Henderson Creek	12	36.15	54.22	49.48	48.01	1.52
Hobsonville Jetty	12	45.17	54.02	51.30	49.88	0.96
Lucas Creek	12	33.37	54.47	47.72	44.88	2.19
Waimarie Road	12	36.55	54.46	48.98	46.49	1.80
Paremoremo Ski Club	12	36.20	54.56	47.70	46.04	1.80
Rawawaru Creek	12	35.09	54.67	46.21	44.06	2.23
Confluence	12	31.13	54.53	47.52	44.85	2.23
Brighams Creek	12	24.93	54.49	43.79	41.23	3.06
Rangitopuni Creek	12	16.23	54.60	40.08	37.33	3.76
Tamaki	12	0.00	55.08	50.26	47.01	4.34
Panmure	12	0.00	55.26	45.60	41.69	4.24
Turanga Estuary	12	50.19	53.83	52.07	52.19	0.34
Wairoa River	12	49.20	53.36	50.86	51.13	0.42
Mangere Bridge	12	41.10	52.93	47.08	47.30	1.29
Puketutu Point	12	43.91	53.00	48.60	48.91	0.91
Weymouth	12	0.00	53.94	47.44	44.24	4.19
Waiuku Town Basin	5	0.00	51.76	43.66	40.22	4.08
Clarks Beach	12	45.66	53.71	49.89	49.98	0.78
Grahams Beach	12	49.03	53.94	51.00	51.15	0.48
Shag Point	12	46.64	53.28	49.75	49.96	0.71
Manukau Heads	12	50.50	53.68	51.60	51.77	0.30
Kaipara Heads	12	48.45	54.05	52.49	51.66	0.53
Tauhoa Channel	12	42.20	53.86	50.00	49.44	0.98
Hoteo River mouth	12	33.85	53.94	46.27	46.51	1.71
Omokoiti Beacon	12	43.25	54.05	49.96	49.68	0.93
Makarau Estuary	12	35.60	54.39	47.13	47.53	1.54
Shelly Beach	12	40.32	54.27	48.12	48.63	1.18
Kaipara River	12	38.52	54.31	46.38	47.24	1.47

Table 4-3 Salinity (ppt) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	34.94	35.65	35.12	35.19	0.07
Ti Point	12	34.60	35.90	35.00	35.07	0.11
Dawsons Creek	12	29.99	36.27	33.13	33.39	0.58
Mahurangi Heads	12	34.01	35.80	34.53	34.75	0.18
Orewa	12	34.26	35.64	34.79	34.89	0.15
Browns Bay	12	33.58	35.94	34.73	34.78	0.20
Chelsea	12	32.30	35.62	34.50	34.03	0.34
Whau Creek	12	28.28	35.94	32.68	32.00	0.78
Henderson Creek	12	22.86	35.91	32.42	31.35	1.10
Hobsonville Jetty	12	29.25	35.75	33.75	32.70	0.71
Lucas Creek	12	20.93	36.10	31.13	29.13	1.58
Waimarie Road	12	23.16	36.08	32.06	30.26	1.30
Paremoremo Ski Club	12	22.90	36.16	31.13	29.94	1.30
Rawawaru Creek	12	22.14	36.25	30.04	28.54	1.61
Confluence	12	19.40	36.14	31.00	29.10	1.60
Brighams Creek	12	15.22	36.11	28.30	26.58	2.16
Rangitopuni Creek	12	9.54	36.20	25.66	23.91	2.62
Tamaki	12	0.00	36.54	32.90	30.91	2.86
Panmure	12	0.00	36.68	29.53	27.07	2.82
Turanga Estuary	12	32.87	35.61	34.33	34.38	0.26
Wairoa River	12	32.15	35.25	33.42	33.60	0.32
Mangere Bridge	12	26.33	34.96	30.64	30.83	0.94
Puketutu Point	12	28.34	35.02	31.75	31.99	0.67
Weymouth	12	0.00	35.72	30.94	28.91	2.76
Waiuku Town Basin	5	0.00	34.09	28.17	26.02	2.70
Clarks Beach	12	29.59	35.55	32.70	32.77	0.58
Grahams Beach	12	32.02	35.72	33.50	33.63	0.36
Shag Point	12	30.26	35.23	32.59	32.75	0.53
Manukau Heads	12	33.13	35.53	33.94	34.08	0.23
Kaipara Heads	12	31.60	35.80	34.62	34.01	0.39
Tauhoa Channel	12	27.14	35.66	32.77	32.39	0.72
Hoteo River mouth	12	21.28	35.71	30.06	30.27	1.24
Omokoiti Beacon	12	27.89	35.80	32.74	32.56	0.68
Makarau Estuary	12	22.49	36.06	30.69	31.00	1.12
Shelly Beach	12	25.80	35.97	31.42	31.79	0.87
Kaipara River	12	24.53	36.00	30.14	30.79	1.07

Table 4-4 pH (pH units) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	7.74	8.44	8.08	8.11	0.06
Ti Point	12	7.95	8.41	8.10	8.11	0.03
Dawsons Creek	12	7.90	8.20	8.00	8.01	0.02
Mahurangi Heads	12	7.92	8.36	8.08	8.09	0.03
Orewa	12	7.97	8.36	8.10	8.11	0.03
Browns Bay	12	7.93	8.38	8.08	8.11	0.03
Chelsea	12	7.80	8.29	7.99	8.00	0.04
Whau Creek	12	7.88	8.66	7.98	8.04	0.06
Henderson Creek	12	7.86	8.33	7.97	8.00	0.04
Hobsonville Jetty	12	7.92	9.27	8.00	8.11	0.11
Lucas Creek	12	7.78	8.89	7.86	7.95	0.09
Waimarie Road	12	7.76	8.46	7.92	7.96	0.05
Paremoremo Ski Club	12	7.75	8.05	7.90	7.90	0.03
Rawawaru Creek	12	7.77	8.38	7.86	7.91	0.05
Confluence	12	7.80	8.20	7.89	7.92	0.03
Brighams Creek	12	7.65	8.42	7.81	7.88	0.06
Rangitopuni Creek	12	7.34	8.60	7.73	7.82	0.09
Tamaki	12	7.86	8.10	7.97	7.98	0.02
Panmure	12	7.86	8.03	7.93	7.94	0.02
Turanga Estuary	12	7.93	8.35	8.08	8.09	0.03
Wairoa River	12	7.97	8.37	8.09	8.11	0.03
Mangere Bridge	12	7.84	8.38	7.96	8.01	0.05
Puketutu Point	12	7.90	8.31	8.04	8.06	0.03
Weymouth	12	7.88	8.33	8.02	8.03	0.04
Waiuku Town Basin	5	7.81	8.23	7.93	7.96	0.03
Clarks Beach	12	7.89	8.27	8.02	8.03	0.03
Grahams Beach	12	7.94	8.29	8.10	8.09	0.03
Shag Point	12	7.97	8.39	8.05	8.09	0.04
Manukau Heads	12	7.98	8.36	8.09	8.10	0.03
Kaipara Heads	12	8.03	8.36	8.10	8.11	0.02
Tauhoa Channel	12	7.97	8.34	8.08	8.09	0.03
Hoteo River mouth	12	7.97	8.29	8.02	8.05	0.03
Omokoiti Beacon	12	7.87	8.35	8.10	8.10	0.04
Makarau Estuary	12	7.87	8.30	8.01	8.02	0.03
Shelly Beach	12	7.81	8.29	8.03	8.03	0.03
Kaipara River	12	6.30	8.00	7.89	7.76	0.14

Table 4-5 Turbidity (NTU) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.20	0.95	0.40	0.48	0.06
Ti Point	12	0.30	1.10	0.83	0.78	0.08
Dawsons Creek	12	2.80	9.30	5.20	5.48	0.51
Mahurangi Heads	12	0.90	3.70	1.30	1.54	0.22
Orewa	12	0.35	2.30	0.93	1.16	0.20
Browns Bay	12	0.70	2.90	1.15	1.31	0.17
Chelsea	12	1.60	5.60	3.60	3.49	0.41
Whau Creek	12	1.50	5.60	3.55	3.41	0.35
Henderson Creek	12	1.80	14.00	4.95	6.06	1.09
Hobsonville Jetty	12	1.10	9.40	4.50	4.71	0.71
Lucas Creek	12	2.70	14.00	7.10	7.60	1.01
Waimarie Road	12	1.50	12.00	4.50	5.45	0.93
Paremoremo Ski Club	12	2.00	11.00	5.05	5.88	0.79
Rawawaru Creek	12	3.00	14.00	7.05	7.81	1.10
Confluence	12	2.40	13.00	6.70	6.48	0.84
Brighams Creek	12	3.40	16.00	7.15	8.37	1.12
Rangitopuni Creek	12	4.60	14.00	7.65	7.86	0.72
Tamaki	12	1.90	4.30	2.95	3.03	0.21
Panmure	12	2.10	14.00	8.00	8.10	1.01
Turanga Estuary	12	1.50	6.00	2.25	2.74	0.44
Wairoa River	12	2.10	26.00	3.65	5.50	1.88
Mangere Bridge	12	2.80	40.00	10.50	13.94	3.10
Puketutu Point	12	2.50	16.00	4.90	7.17	1.40
Weymouth	12	4.60	26.00	13.50	14.61	2.08
Waiuku Town Basin	5	4.60	17.00	7.75	8.89	1.12
Clarks Beach	12	3.30	14.00	7.75	8.16	1.01
Grahams Beach	12	2.90	13.00	5.40	6.64	0.94
Shag Point	12	1.70	17.00	5.10	6.32	1.28
Manukau Heads	12	1.40	5.30	3.50	3.59	0.31
Kaipara Heads	12	0.00	3.20	1.35	1.53	0.25
Tauhoa Channel	12	1.30	3.00	1.90	1.99	0.15
Hoteo River mouth	12	3.00	9.80	3.90	4.79	0.58
Omokoiti Beacon	12	1.40	3.70	2.10	2.39	0.19
Makarau Estuary	12	3.10	12.00	4.45	5.57	0.78
Shelly Beach	12	2.40	7.70	3.65	4.63	0.54
Kaipara River	12	7.20	30.00	11.50	13.03	1.85

Table 4-6 Suspended sediment (mg/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	1.30	6.60	2.90	3.29	0.51
Ti Point	12	0.80	7.00	3.30	3.41	0.55
Dawsons Creek	12	8.40	17.00	11.00	11.23	0.71
Mahurangi Heads	12	1.30	12.00	5.70	5.98	0.87
Orewa	12	1.70	9.20	4.65	4.93	0.62
Browns Bay	12	2.10	12.00	4.00	5.20	0.92
Chelsea	12	3.20	23.00	11.00	12.06	1.63
Whau Creek	12	4.50	19.00	9.30	9.75	1.33
Henderson Creek	12	6.00	30.00	11.50	13.94	2.09
Hobsonville Jetty	12	6.00	22.00	11.00	12.23	1.63
Lucas Creek	12	6.50	30.00	17.50	16.71	2.21
Waimarie Road	12	5.80	42.00	15.00	16.72	2.90
Paremoremo Ski Club	12	5.30	26.00	13.50	13.62	1.75
Rawawaru Creek	12	6.00	26.00	16.00	15.58	1.61
Confluence	12	6.50	24.00	14.00	14.73	1.76
Brighams Creek	12	6.00	28.00	17.50	17.28	1.86
Rangitopuni Creek	12	7.50	27.00	14.00	14.78	1.66
Tamaki	12	5.00	27.00	6.70	8.68	1.76
Panmure	12	9.00	30.00	17.00	17.67	2.09
Turanga Estuary	12	3.90	15.00	8.00	8.06	1.05
Wairoa River	12	4.80	51.00	9.00	12.12	3.61
Mangere Bridge	12	6.80	110.00	28.00	39.07	8.61
Puketutu Point	12	7.30	51.00	18.00	23.18	4.21
Weymouth	12	12.00	72.00	36.00	39.75	5.93
Waiuku Town Basin	5	7.00	44.00	27.00	23.25	3.21
Clarks Beach	12	10.00	47.00	27.50	28.08	3.69
Grahams Beach	12	9.00	49.00	27.50	26.08	3.49
Shag Point	12	5.00	39.00	20.00	19.92	2.63
Manukau Heads	12	7.80	25.00	13.50	14.26	1.55
Kaipara Heads	12	0.00	11.00	6.60	6.33	0.90
Tauhoa Channel	12	4.40	14.00	6.85	8.11	1.01
Hoteo River mouth	12	6.40	26.00	12.00	13.48	1.63
Omokoiti Beacon	12	3.00	23.00	10.50	10.39	1.51
Makarau Estuary	12	8.30	29.00	15.50	16.73	1.90
Shelly Beach	12	7.50	35.00	15.00	17.51	2.34
Kaipara River	12	17.00	60.00	27.50	30.58	3.81

Table 4-7 Chlorophyll a (mg/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.000	0.003	0.001	0.001	0.000
Ti Point	12	0.000	0.005	0.001	0.001	0.000
Dawsons Creek	12	0.000	0.007	0.002	0.002	0.000
Mahurangi Heads	12	0.000	0.002	0.001	0.001	0.000
Orewa	12	0.001	0.004	0.002	0.002	0.000
Browns Bay	12	0.000	0.004	0.002	0.001	0.000
Chelsea	12	0.000	0.004	0.002	0.002	0.000
Whau Creek	12	0.000	0.003	0.002	0.002	0.000
Henderson Creek	12	0.000	0.003	0.002	0.002	0.000
Hobsonville Jetty	12	0.000	0.004	0.002	0.002	0.000
Lucas Creek	12	0.000	0.006	0.003	0.003	0.000
Waimarie Road	12	0.000	0.005	0.003	0.003	0.000
Paremoremo Ski Club	12	0.000	0.006	0.003	0.003	0.000
Rawawaru Creek	12	0.000	0.006	0.003	0.003	0.001
Confluence	12	0.001	0.009	0.003	0.004	0.001
Brighams Creek	12	0.000	0.064	0.004	0.009	0.005
Rangitopuni Creek	12	0.000	0.007	0.004	0.004	0.001
Tamaki	12	0.000	0.003	0.002	0.002	0.000
Panmure	12	0.000	0.006	0.003	0.003	0.001
Turanga Estuary	12	0.000	0.003	0.002	0.002	0.000
Wairoa River	12	0.001	0.005	0.002	0.002	0.000
Mangere Bridge	12	0.001	0.013	0.004	0.005	0.001
Puketutu Point	12	0.002	0.010	0.003	0.004	0.001
Weymouth	12	0.002	0.011	0.005	0.005	0.001
Waiuku Town Basin	5	0.001	0.016	0.004	0.006	0.001
Clarks Beach	12	0.000	0.008	0.004	0.004	0.001
Grahams Beach	12	0.001	0.007	0.003	0.003	0.000
Shag Point	12	0.001	0.010	0.003	0.004	0.001
Manukau Heads	12	0.001	0.006	0.003	0.003	0.000
Kaipara Heads	12	0.000	0.006	0.002	0.002	0.000
Tauhoa Channel	12	0.001	0.017	0.003	0.004	0.001
Hoteo River mouth	12	0.002	0.009	0.003	0.004	0.001
Omokoiti Beacon	12	0.002	0.008	0.003	0.003	0.000
Makarau Estuary	12	0.002	0.010	0.004	0.005	0.001
Shelly Beach	12	0.002	0.009	0.004	0.004	0.001
Kaipara River	12	0.003	0.008	0.006	0.006	0.000

Table 4-8 Nitrite (mg N/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.001	0.007	0.001	0.002	0.000
Ti Point	12	0.001	0.004	0.001	0.001	0.000
Dawsons Creek	12	0.001	0.001	0.001	0.001	
Mahurangi Heads	12	0.001	0.001	0.001	0.001	
Orewa	12	0.001	0.001	0.001	0.001	
Browns Bay	12	0.001	0.001	0.001	0.001	
Chelsea	12	0.001	0.002	0.001	0.001	0.000
Whau Creek	12	0.001	0.003	0.001	0.001	0.000
Henderson Creek	12	0.001	0.002	0.001	0.001	0.000
Hobsonville Jetty	12	0.001	0.002	0.001	0.001	0.000
Lucas Creek	12	0.001	0.004	0.001	0.001	0.000
Waimarie Road	12	0.001	0.002	0.001	0.001	0.000
Paremoremo Ski Club	12	0.001	0.002	0.001	0.001	0.000
Rawawaru Creek	12	0.001	0.002	0.001	0.001	0.000
Confluence	12	0.001	0.003	0.001	0.001	0.000
Brighams Creek	12	0.001	0.005	0.001	0.002	0.000
Rangitopuni Creek	12	0.001	0.003	0.001	0.001	0.000
Tamaki	12	0.001	0.002	0.001	0.001	0.000
Panmure	12	0.001	0.220	0.019	0.070	0.026
Turanga Estuary	12	0.001	0.003	0.001	0.001	0.000
Wairoa River	12	0.001	0.001	0.001	0.001	
Mangere Bridge	12	0.001	0.025	0.011	0.012	0.002
Puketutu Point	12	0.001	0.024	0.006	0.009	0.002
Weymouth	12	0.001	0.008	0.001	0.003	0.001
Waiuku Town Basin	5	0.001	0.012	0.002	0.004	0.001
Clarks Beach	12	0.001	0.008	0.002	0.003	0.001
Grahams Beach	12	0.001	0.008	0.001	0.002	0.001
Shag Point	12	0.001	0.012	0.002	0.003	0.001
Manukau Heads	12	0.001	0.008	0.001	0.002	0.001
Kaipara Heads	12	0.000	0.005	0.001	0.001	0.000
Tauhoa Channel	12	0.001	0.002	0.001	0.001	0.000
Hoteo River mouth	12	0.001	0.003	0.001	0.001	0.000
Omokoiti Beacon	12	0.001	0.005	0.001	0.002	0.000
Makarau Estuary	12	0.001	0.004	0.001	0.002	0.000
Shelly Beach	12	0.001	0.009	0.001	0.002	0.001
Kaipara River	12	0.001	0.007	0.001	0.002	0.001

Table 4-9 Nitrate (mg N/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.001	0.050	0.010	0.012	0.004
Ti Point	12	0.001	0.020	0.001	0.005	0.002
Dawsons Creek	12	0.001	0.056	0.001	0.007	0.005
Mahurangi Heads	12	0.001	0.019	0.001	0.004	0.002
Orewa	12	0.001	0.024	0.001	0.003	0.002
Browns Bay	12	0.001	0.022	0.001	0.004	0.002
Chelsea	12	0.001	0.027	0.005	0.007	0.002
Whau Creek	12	0.001	0.033	0.003	0.008	0.003
Henderson Creek	12	0.001	0.041	0.004	0.011	0.004
Hobsonville Jetty	12	0.001	0.038	0.002	0.009	0.004
Lucas Creek	12	0.001	0.100	0.009	0.025	0.009
Waimarie Road	12	0.001	0.070	0.006	0.018	0.007
Paremoremo Ski Club	12	0.001	0.086	0.009	0.019	0.008
Rawawaru Creek	12	0.004	0.130	0.028	0.044	0.012
Confluence	12	0.001	0.130	0.009	0.029	0.012
Brighams Creek	12	0.001	0.180	0.024	0.059	0.019
Rangitopuni Creek	12	0.001	0.290	0.039	0.083	0.028
Tamaki	12	0.001	0.061	0.011	0.019	0.006
Panmure	12	0.001	0.220	0.019	0.070	0.026
Turanga Estuary	12	0.001	0.078	0.001	0.013	0.007
Wairoa River	12	0.001	0.030	0.003	0.006	0.002
Mangere Bridge	12	0.027	0.410	0.220	0.220	0.046
Puketutu Point	12	0.049	0.500	0.195	0.194	0.040
Weymouth	12	0.004	0.380	0.061	0.118	0.038
Waiuku Town Basin	5	0.001	0.700	0.078	0.207	0.070
Clarks Beach	12	0.003	0.220	0.019	0.060	0.021
Grahams Beach	12	0.001	0.110	0.008	0.024	0.010
Shag Point	12	0.001	0.200	0.051	0.077	0.023
Manukau Heads	12	0.001	0.074	0.008	0.018	0.007
Kaipara Heads	12	0.000	0.031	0.004	0.009	0.003
Tauhoa Channel	12	0.001	0.043	0.004	0.011	0.004
Hoteo River mouth	12	0.001	0.130	0.010	0.030	0.011
Omokoiti Beacon	12	0.001	0.048	0.004	0.013	0.005
Makarau Estuary	12	0.001	0.083	0.007	0.023	0.008
Shelly Beach	12	0.001	0.091	0.007	0.022	0.008
Kaipara River	12	0.001	0.150	0.010	0.040	0.015

Table 4-10 Ammonia (mg N/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.003	0.003	0.003	0.003	
Ti Point	12	0.003	0.003	0.003	0.003	
Dawsons Creek	12	0.003	0.011	0.003	0.004	0.001
Mahurangi Heads	12	0.003	0.003	0.003	0.003	
Orewa	12	0.003	0.003	0.003	0.003	
Browns Bay	12	0.003	0.064	0.003	0.008	0.005
Chelsea	12	0.003	0.020	0.003	0.004	0.001
Whau Creek	12	0.003	0.022	0.009	0.010	0.002
Henderson Creek	12	0.003	0.032	0.004	0.009	0.003
Hobsonville Jetty	12	0.003	0.022	0.004	0.006	0.002
Lucas Creek	12	0.003	0.078	0.014	0.019	0.006
Waimarie Road	12	0.003	0.037	0.005	0.009	0.003
Paremoremo Ski Club	12	0.003	0.034	0.006	0.010	0.003
Rawawaru Creek	12	0.003	0.090	0.015	0.024	0.008
Confluence	12	0.003	0.068	0.004	0.014	0.006
Brighams Creek	12	0.003	0.082	0.013	0.022	0.007
Rangitopuni Creek	12	0.003	0.340	0.026	0.048	0.027
Tamaki	12	0.000	0.027	0.003	0.008	0.003
Panmure	12	0.000	0.041	0.006	0.013	0.005
Turanga Estuary	12	0.003	0.012	0.003	0.004	0.001
Wairoa River	12	0.003	0.012	0.003	0.004	0.001
Mangere Bridge	12	0.010	0.150	0.056	0.070	0.016
Puketutu Point	12	0.018	0.150	0.057	0.069	0.013
Weymouth	12	0.003	0.073	0.005	0.017	0.006
Waiuku Town Basin	5	0.003	0.100	0.030	0.032	0.008
Clarks Beach	12	0.003	0.054	0.006	0.012	0.004
Grahams Beach	12	0.003	0.049	0.003	0.008	0.004
Shag Point	12	0.003	0.096	0.032	0.033	0.009
Manukau Heads	12	0.003	0.021	0.003	0.004	0.002
Kaipara Heads	12	0.000	0.003	0.003	0.002	0.000
Tauhoa Channel	12	0.003	0.010	0.003	0.003	0.001
Hoteo River mouth	12	0.003	0.029	0.003	0.010	0.003
Omokoiti Beacon	12	0.003	0.052	0.003	0.008	0.004
Makarau Estuary	12	0.003	0.060	0.004	0.017	0.006
Shelly Beach	12	0.003	0.046	0.003	0.013	0.005
Kaipara River	12	0.003	0.085	0.005	0.023	0.008

Table 4-11 Total kjedahl nitrogen (mg N/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.010	0.100	0.010	0.021	0.008
Ti Point	12	0.010	0.027	0.010	0.012	0.002
Dawsons Creek	12	0.010	0.110	0.017	0.034	0.010
Mahurangi Heads	12	0.010	0.037	0.010	0.014	0.003
Orewa	12	0.010	0.047	0.010	0.015	0.003
Browns Bay	12	0.010	0.100	0.010	0.025	0.009
Chelsea	12	0.010	0.066	0.024	0.030	0.006
Whau Creek	12	0.010	0.210	0.055	0.073	0.017
Henderson Creek	12	0.010	0.170	0.077	0.071	0.014
Hobsonville Jetty	12	0.010	0.110	0.038	0.046	0.010
Lucas Creek	12	0.031	0.220	0.094	0.107	0.015
Waimarie Road	12	0.020	0.230	0.072	0.098	0.021
Paremoremo Ski Club	12	0.024	0.270	0.071	0.094	0.021
Rawawaru Creek	12	0.020	0.420	0.105	0.145	0.031
Confluence	12	0.020	0.370	0.077	0.108	0.027
Brighams Creek	12	0.045	0.670	0.130	0.220	0.061
Rangitopuni Creek	12	0.090	1.500	0.240	0.340	0.111
Tamaki	12	0.010	0.110	0.038	0.044	0.009
Panmure	12	0.063	0.330	0.130	0.141	0.022
Turanga Estuary	12	0.010	0.051	0.010	0.016	0.004
Wairoa River	12	0.010	0.110	0.023	0.038	0.011
Mangere Bridge	12	0.092	0.270	0.200	0.193	0.018
Puketutu Point	12	0.088	0.270	0.155	0.167	0.018
Weymouth	12	0.010	0.300	0.135	0.133	0.021
Waiuku Town Basin	5	0.062	0.280	0.150	0.156	0.018
Clarks Beach	12	0.010	0.120	0.068	0.062	0.010
Grahams Beach	12	0.010	0.100	0.046	0.046	0.008
Shag Point	12	0.052	0.170	0.086	0.103	0.013
Manukau Heads	12	0.010	0.038	0.010	0.015	0.003
Kaipara Heads	12	0.000	0.140	0.010	0.023	0.011
Tauhoa Channel	12	0.010	0.047	0.025	0.024	0.004
Hoteo River mouth	12	0.053	0.170	0.080	0.093	0.012
Omokoiti Beacon	12	0.010	0.062	0.028	0.031	0.005
Makarau Estuary	12	0.050	0.200	0.100	0.112	0.015
Shelly Beach	12	0.010	0.180	0.057	0.072	0.014
Kaipara River	12	0.053	0.250	0.110	0.125	0.016

Table 4-12 Total nitrogen (by calculation, mg N/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.010	0.100	0.010	0.018	0.008
Ti Point	12	0.010	0.027	0.010	0.012	0.002
Dawsons Creek	12	0.010	0.110	0.028	0.039	0.010
Mahurangi Heads	12	0.010	0.037	0.010	0.014	0.003
Orewa	12	0.010	0.047	0.010	0.015	0.003
Browns Bay	12	0.010	0.100	0.010	0.026	0.009
Chelsea	12	0.010	0.074	0.024	0.034	0.007
Whau Creek	12	0.010	0.220	0.064	0.081	0.017
Henderson Creek	12	0.010	0.170	0.089	0.079	0.015
Hobsonville Jetty	12	0.010	0.110	0.046	0.053	0.011
Lucas Creek	12	0.041	0.270	0.109	0.132	0.021
Waimarie Road	12	0.020	0.280	0.095	0.115	0.023
Paremoremo Ski Club	12	0.034	0.280	0.097	0.114	0.023
Rawawaru Creek	12	0.020	0.480	0.155	0.186	0.037
Confluence	12	0.020	0.380	0.089	0.136	0.032
Brighams Creek	12	0.055	0.830	0.170	0.279	0.078
Rangitopuni Creek	12	0.098	1.500	0.285	0.426	0.112
Tamaki	12	0.010	0.140	0.054	0.063	0.013
Panmure	12	0.091	0.370	0.165	0.211	0.032
Turanga Estuary	12	0.010	0.073	0.010	0.024	0.006
Wairoa River	12	0.010	0.120	0.031	0.043	0.011
Mangere Bridge	12	0.180	0.700	0.415	0.423	0.053
Puketutu Point	12	0.170	0.790	0.360	0.373	0.053
Weymouth	12	0.090	0.480	0.190	0.254	0.044
Waiuku Town Basin	5	0.091	1.000	0.240	0.365	0.078
Clarks Beach	12	0.054	0.290	0.090	0.123	0.022
Grahams Beach	12	0.034	0.170	0.054	0.071	0.013
Shag Point	12	0.068	0.370	0.165	0.182	0.027
Manukau Heads	12	0.010	0.095	0.018	0.033	0.008
Kaipara Heads	12	0.000	0.170	0.010	0.030	0.014
Tauhoa Channel	12	0.010	0.076	0.030	0.034	0.006
Hoteo River mouth	12	0.058	0.280	0.100	0.122	0.020
Omokoiti Beacon	12	0.010	0.099	0.045	0.045	0.007
Makarau Estuary	12	0.050	0.250	0.100	0.134	0.021
Shelly Beach	12	0.034	0.210	0.073	0.093	0.017
Kaipara River	12	0.053	0.420	0.120	0.168	0.029

Table 4-13 Total phosphorus (mg/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.003	0.026	0.011	0.010	0.002
Ti Point	12	0.006	0.018	0.010	0.011	0.001
Dawsons Creek	12	0.014	0.027	0.019	0.019	0.001
Mahurangi Heads	12	0.007	0.017	0.011	0.012	0.001
Orewa	12	0.005	0.038	0.016	0.017	0.003
Browns Bay	12	0.009	0.086	0.022	0.025	0.006
Chelsea	12	0.014	0.028	0.022	0.021	0.001
Whau Creek	12	0.014	0.035	0.026	0.025	0.002
Henderson Creek	12	0.013	0.040	0.023	0.026	0.003
Hobsonville Jetty	12	0.017	0.046	0.028	0.028	0.002
Lucas Creek	12	0.022	0.110	0.037	0.043	0.007
Waimarie Road	12	0.020	0.084	0.030	0.032	0.005
Paremoremo Ski Club	12	0.017	0.120	0.036	0.042	0.008
Rawawaru Creek	12	0.022	0.075	0.038	0.040	0.004
Confluence	12	0.021	0.044	0.035	0.032	0.003
Brighams Creek	12	0.019	0.140	0.043	0.047	0.009
Rangitopuni Creek	12	0.017	0.150	0.039	0.047	0.010
Tamaki	12	0.017	0.034	0.027	0.027	0.001
Panmure	12	0.025	0.067	0.043	0.045	0.004
Turanga Estuary	12	0.013	0.078	0.021	0.025	0.005
Wairoa River	12	0.016	0.054	0.027	0.029	0.003
Mangere Bridge	12	0.110	0.200	0.140	0.143	0.008
Puketutu Point	12	0.073	0.210	0.110	0.123	0.011
Weymouth	12	0.027	0.180	0.047	0.060	0.012
Waiuku Town Basin	5	0.033	0.079	0.047	0.049	0.004
Clarks Beach	12	0.021	0.180	0.036	0.049	0.013
Grahams Beach	12	0.020	0.420	0.028	0.064	0.033
Shag Point	12	0.049	0.100	0.071	0.070	0.004
Manukau Heads	12	0.010	0.025	0.017	0.017	0.001
Kaipara Heads	12	0.000	0.052	0.010	0.013	0.004
Tauhoa Channel	12	0.003	0.068	0.014	0.018	0.005
Hoteo River mouth	12	0.009	0.061	0.023	0.026	0.004
Omokoiti Beacon	12	0.010	0.023	0.015	0.015	0.001
Makarau Estuary	12	0.013	0.075	0.025	0.030	0.005
Shelly Beach	12	0.009	0.037	0.021	0.021	0.002
Kaipara River	12	0.018	0.150	0.034	0.046	0.010

Table 4-14 Soluble reactive phosphorus (mg/L) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.006	0.011	0.009	0.009	0.000
Ti Point	12	0.005	0.014	0.009	0.009	0.001
Dawsons Creek	12	0.008	0.013	0.010	0.010	0.000
Mahurangi Heads	12	0.003	0.013	0.010	0.009	0.001
Orewa	12	0.003	0.014	0.011	0.010	0.001
Browns Bay	12	0.009	0.027	0.016	0.016	0.001
Chelsea	12	0.008	0.023	0.017	0.017	0.001
Whau Creek	12	0.011	0.020	0.016	0.016	0.001
Henderson Creek	12	0.000	0.022	0.016	0.016	0.002
Hobsonville Jetty	12	0.008	0.020	0.016	0.016	0.001
Lucas Creek	12	0.011	0.025	0.016	0.017	0.001
Waimarie Road	12	0.011	0.023	0.016	0.017	0.001
Paremoremo Ski Club	12	0.011	0.025	0.018	0.018	0.001
Rawawaru Creek	12	0.012	0.037	0.019	0.020	0.002
Confluence	12	0.010	0.032	0.019	0.019	0.002
Brighams Creek	12	0.008	0.028	0.014	0.016	0.002
Rangitopuni Creek	12	0.005	0.033	0.017	0.018	0.002
Tamaki	12	0.011	0.029	0.018	0.018	0.001
Panmure	12	0.015	0.030	0.022	0.023	0.001
Turanga Estuary	12	0.011	0.019	0.014	0.015	0.001
Wairoa River	12	0.013	0.024	0.016	0.017	0.001
Mangere Bridge	12	0.078	0.140	0.094	0.097	0.005
Puketutu Point	12	0.059	0.160	0.087	0.089	0.008
Weymouth	12	0.017	0.032	0.025	0.024	0.001
Waiuku Town Basin	5	0.017	0.039	0.025	0.026	0.002
Clarks Beach	12	0.012	0.026	0.022	0.020	0.001
Grahams Beach	12	0.009	0.036	0.018	0.018	0.002
Shag Point	12	0.031	0.071	0.049	0.047	0.004
Manukau Heads	12	0.007	0.017	0.012	0.012	0.001
Kaipara Heads	12	0.000	0.009	0.007	0.006	0.001
Tauhoa Channel	12	0.006	0.014	0.010	0.010	0.001
Hoteo River mouth	12	0.008	0.017	0.012	0.012	0.001
Omokoiti Beacon	12	0.007	0.014	0.010	0.010	0.001
Makarau Estuary	12	0.009	0.028	0.015	0.015	0.001
Shelly Beach	12	0.009	0.017	0.012	0.012	0.001
Kaipara River	12	0.010	0.022	0.016	0.016	0.001

Table 4-15 Enterococci (MPN/100ml) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	5.00	10.00	5.00	5.42	0.42
Ti Point	12	5.00	10.00	5.00	5.83	0.56
Dawsons Creek	12	5.00	10.00	5.00	6.25	0.65
Mahurangi Heads	12	5.00	10.00	5.00	5.42	0.42
Orewa	12	5.00	5.00	5.00	5.00	
Browns Bay	12	5.00	5.00	5.00	5.00	
Chelsea	12	5.00	10.00	5.00	6.25	0.65
Whau Creek	12	5.00	52.00	5.00	12.75	4.63
Henderson Creek	12	5.00	380.00	10.00	59.50	31.28
Hobsonville Jetty	12	5.00	20.00	10.00	8.75	1.25
Lucas Creek	12	5.00	41.00	10.00	15.58	3.26
Waimarie Road	12	5.00	41.00	10.00	13.08	3.39
Paremoremo Ski Club	12	5.00	52.00	10.00	14.42	4.06
Rawawaru Creek	12	5.00	270.00	10.00	45.25	22.32
Confluence	12	5.00	63.00	10.00	15.75	4.91
Brighams Creek	12	5.00	160.00	10.00	35.50	14.26
Rangitopuni Creek	12	5.00	350.00	20.00	73.67	30.51
Tamaki	12	5.00	20.00	5.00	7.50	1.31
Panmure	12	5.00	960.00	15.00	101.08	78.40
Turanga Estuary	12	5.00	10.00	5.00	5.83	0.56
Wairoa River	12	5.00	20.00	5.00	7.08	1.30
Mangere Bridge	12	5.00	31.00	5.00	7.58	2.17
Puketutu Point	12	5.00	10.00	5.00	5.42	0.42
Weymouth	12	5.00	31.00	5.00	8.00	2.16
Waiuku Town Basin	5	5.00	130.00	5.00	18.42	10.37
Clarks Beach	12	5.00	10.00	5.00	6.25	0.65
Grahams Beach	12	5.00	10.00	5.00	5.42	0.42
Shag Point	12	5.00	5.00	5.00	5.00	
Manukau Heads	12	5.00	5.00	5.00	5.00	
Kaipara Heads	12	0.80	0.85	0.85	0.85	0.00
Tauhoa Channel	12	0.80	50.00	0.85	6.54	4.26
Hoteo River mouth	12	0.80	58.00	1.28	9.04	4.91
Omokoiti Beacon	12	0.80	0.85	0.85	0.85	0.00
Makarau Estuary	12	0.80	130.00	0.85	13.60	10.74
Shelly Beach	12	0.80	5.00	0.85	1.47	0.38
Kaipara River	12	0.80	140.00	0.85	18.58	12.51

Table 4-16 Dissolve oxygen (% saturation) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	95.10	103.80	98.80	98.79	0.66
Ti Point	12	96.50	103.00	100.25	99.81	0.61
Dawsons Creek	12	85.50	100.20	93.80	93.38	1.38
Mahurangi Heads	12	92.80	100.30	98.30	97.67	0.64
Orewa	12	95.80	101.50	99.40	99.09	0.53
Browns Bay	12	94.90	102.60	97.70	98.22	0.59
Chelsea	12	86.70	99.60	94.95	94.43	1.14
Whau Creek	12	81.40	101.90	93.75	93.23	1.52
Henderson Creek	12	83.60	98.70	92.25	91.93	1.24
Hobsonville Jetty	12	84.90	100.00	94.50	93.99	1.26
Lucas Creek	12	72.80	96.10	86.15	86.57	1.92
Waimarie Road	12	78.50	97.90	90.50	90.07	1.71
Paremoremo Ski Club	12	74.60	97.30	88.90	88.63	1.86
Rawawaru Creek	12	72.30	95.80	89.40	88.61	2.03
Confluence	12	76.90	98.30	89.40	89.49	1.81
Brighams Creek	12	72.20	107.00	87.70	88.12	2.64
Rangitopuni Creek	12	66.30	114.00	90.00	89.12	3.45
Tamaki	12	73.50	101.40	91.20	90.72	2.37
Panmure	12	68.50	99.70	87.70	87.43	2.59
Turanga Estuary	12	91.60	102.40	98.55	98.25	1.06
Wairoa River	12	89.90	101.70	98.50	97.54	1.19
Mangere Bridge	12	89.70	115.80	96.85	97.97	2.03
Puketutu Point	12	93.50	113.10	97.85	99.60	1.47
Weymouth	12	91.20	103.40	99.05	98.59	0.98
Waiuku Town Basin	5	0.00	102.30	96.50	87.46	8.10
Clarks Beach	12	90.20	101.80	97.55	96.90	0.95
Grahams Beach	12	94.60	103.20	101.10	100.59	0.65
Shag Point	12	91.20	117.50	100.80	102.93	2.19
Manukau Heads	12	96.00	105.30	101.10	101.04	0.75
Kaipara Heads	12	97.50	106.00	101.95	102.03	0.72
Tauhoa Channel	12	95.10	106.10	100.00	99.71	1.00
Hoteo River mouth	12	93.40	99.30	96.45	96.58	0.58
Omokoiti Beacon	12	94.00	102.60	99.60	99.03	0.86
Makarau Estuary	12	92.30	101.60	96.90	96.78	0.82
Shelly Beach	12	92.10	100.90	97.55	97.00	0.79
Kaipara River	12	87.50	101.30	97.25	96.25	1.21

Table 4-17 Dissolved oxygen (ppm) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	7.11	8.34	7.62	7.68	0.13
Ti Point	12	6.96	8.35	7.87	7.76	0.15
Dawsons Creek	12	5.96	8.98	7.36	7.33	0.27
Mahurangi Heads	12	6.60	8.47	7.71	7.61	0.18
Orewa	12	6.73	8.49	7.81	7.68	0.19
Browns Bay	12	6.80	8.26	7.68	7.63	0.16
Chelsea	12	6.15	8.54	7.30	7.36	0.23
Whau Creek	12	5.78	9.30	7.49	7.44	0.30
Henderson Creek	12	5.87	9.01	7.32	7.33	0.28
Hobsonville Jetty	12	5.97	8.86	7.50	7.40	0.26
Lucas Creek	12	5.07	8.97	7.01	7.01	0.34
Waimarie Road	12	5.50	8.86	7.15	7.20	0.32
Paremoremo Ski Club	12	5.21	8.93	7.09	7.11	0.34
Rawawaru Creek	12	5.07	9.20	7.32	7.19	0.37
Confluence	12	5.36	9.12	7.13	7.22	0.36
Brighams Creek	12	5.04	10.02	7.06	7.27	0.45
Rangitopuni Creek	12	4.65	10.44	7.35	7.54	0.54
Tamaki	12	5.15	8.70	6.92	6.97	0.25
Panmure	12	5.02	8.71	6.86	6.90	0.28
Turanga Estuary	12	6.60	8.96	7.68	7.69	0.22
Wairoa River	12	6.31	8.90	7.69	7.63	0.24
Mangere Bridge	12	6.56	9.81	7.59	7.81	0.25
Puketutu Point	12	6.99	9.44	7.77	7.88	0.21
Weymouth	12	6.82	10.41	7.81	8.02	0.29
Waiuku Town Basin	5	0.00	9.05	7.65	7.10	0.69
Clarks Beach	12	6.50	8.73	7.66	7.67	0.21
Grahams Beach	12	7.28	8.67	7.82	7.93	0.15
Shag Point	12	7.19	9.79	8.10	8.12	0.24
Manukau Heads	12	7.06	8.52	7.73	7.92	0.14
Kaipara Heads	12	7.41	8.73	8.01	8.07	0.14
Tauhoa Channel	12	6.91	8.99	7.78	7.92	0.22
Hoteo River mouth	12	6.75	8.83	7.82	7.80	0.23
Omokoiti Beacon	12	6.87	8.71	7.74	7.84	0.20
Makarau Estuary	12	6.70	8.74	7.72	7.77	0.22
Shelly Beach	12	6.62	8.68	7.72	7.73	0.21
Kaipara River	12	6.31	8.90	7.66	7.74	0.20

Table 4-18 Summary table of temperature (°C) for data collected from January 2013 to December 2013.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	14.25	21.01	17.31	17.39	0.69
Ti Point	12	14.21	21.32	17.18	17.45	0.76
Dawsons Creek	12	11.37	23.19	17.63	17.77	1.17
Mahurangi Heads	12	13.18	22.04	16.84	17.55	0.95
Orewa	12	13.20	22.99	17.03	17.76	1.03
Browns Bay	12	13.51	22.56	17.23	17.65	0.99
Chelsea	12	12.93	22.54	17.17	17.85	1.06
Whau Creek	12	11.03	23.02	17.44	17.45	1.16
Henderson Creek	12	11.32	22.96	17.63	17.74	1.16
Hobsonville Jetty	12	12.04	23.07	17.50	17.87	1.14
Lucas Creek	12	10.59	23.51	18.08	17.81	1.24
Waimarie Road	12	11.75	23.89	18.13	18.00	1.18
Paremoremo Ski Club	12	11.66	23.87	18.19	18.02	1.19
Rawawaru Creek	12	10.88	23.80	18.37	17.94	1.21
Confluence	12	11.56	24.06	18.20	18.04	1.21
Brighams Creek	12	11.08	24.05	18.16	17.91	1.23
Rangitopuni Creek	12	10.51	23.99	18.21	17.72	1.27
Tamaki	12	12.53	22.93	17.59	17.72	1.17
Panmure	12	11.85	23.72	17.19	17.62	1.26
Turanga Estuary	12	11.92	22.45	17.56	17.46	1.07
Wairoa River	12	12.20	23.42	17.94	17.86	1.12
Mangere Bridge	12	12.84	22.11	17.12	17.62	1.04
Puketutu Point	12	12.79	22.01	16.73	17.63	1.01
Weymouth	12	13.03	21.74	16.98	17.35	1.03
Waiuku Town Basin	5	0.00	22.88	15.50	16.07	1.83
Clarks Beach	12	13.01	21.87	16.50	17.36	1.01
Grahams Beach	12	13.38	21.14	16.33	17.22	0.90
Shag Point	12	12.72	22.15	17.02	17.49	1.03
Manukau Heads	12	13.80	21.97	16.82	17.34	0.85
Kaipara Heads	12	13.78	19.94	16.97	16.90	0.64
Tauhoa Channel	12	13.12	21.26	16.66	17.34	0.91
Hoteo River mouth	12	12.67	21.75	16.41	17.22	1.01
Omokoiti Beacon	12	13.04	21.40	16.78	17.40	0.95
Makarau Estuary	12	12.58	22.00	16.41	17.26	1.01
Shelly Beach	12	12.88	21.48	16.54	17.36	1.00
Kaipara River	12	12.30	21.82	16.49	17.19	1.03

5.0 References

- APHA (2005). Standard methods for the examination of water and wastewater 21st edition. American Public Health Association, American Waterworks Association, Water Environment Federation.
- APHA (2012). Standard methods for the examination of water and wastewater 22nd edition. American Public Health Association, American Waterworks Association, Water Environment Federation.
- Auckland Council, (2012). The Auckland Plan. Auckland Council.
- Auckland Regional Council, (2009). State of the Auckland Region-2009. Auckland Regional Council, 21 Pitt Street, Auckland. 300 pages.
- Canadian Council of Ministers of the Environment (2001). Canadian water quality guidelines for the protection of aquatic life: CCME water quality index 1.0, Technical Report. In *Canadian Environmental Quality Guidelines*, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
- Carbines, M.J., Walker, J.W., Cameron, M.J. and Vaughan, M (2013). Marine monitoring plan. Auckland Council technical report, TR2013/025
- Scarsbrook, M. (2008). Saline Water Quality State and Trends in the Auckland Region. Prepared for the Auckland Regional Council by the National Institute of Water and Atmospheric Research, Hamilton. ARC Technical Report (TR2008/005), 21 Pitt Street, Auckland. 54 pages.
- Vant, W.N., Lee, D.E. (1998). Review of Auckland Regional Council's saline long term baseline programme. Prepared for the ARC by the National Institute of Water and Atmospheric Research, Hamilton. NIWA Client Report No. ARC80239
- Walker, J and Vaughan, M (2013a). Marine water quality annual report: 2010. Auckland Council technical report, TR2013/030
- Walker, J and Vaughan, M (2013b). Marine water quality annual report: 2011. Auckland Council technical report, TR2013/031
- Walker, J and Vaughan, M (2013c). Marine water quality annual report: 2012. Auckland Council technical report, TR2013/051
- Wilcock, R. J., Kemp, C.L.S. (2001). Water Quality Surveys of Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary 1992-2001. Prepared for the ARC by the National Institute of Water and Atmospheric Research, Hamilton. ARC Technical Publication 191 (TP191), 21 Pitt Street, Auckland. 211 pages.

6.0 Acknowledgements

The Auckland Council saline water quality monitoring programme has benefitted from the efforts of numerous people since it began in 1987.

During the 2013 sampling season, thanks to Peter Williams for organising the sampling and to other members of the RIMU Environmental Science and Monitoring teams. Laboratory analyses were carried out by Watercare Laboratory Services Ltd.

Appendix A Physico-chemical measures

Table A-1 Summary of marine water quality parameters, detection limits, analytical methods and two sources of data collection.

Parameter	Unit	Detection Limit	Method	Source
Dissolved oxygen	ppm	0.1	Handheld meter (YSI-556)	Field
Dissolved oxygen saturation	% sat	0.01	Handheld meter (YSI-556)	Field
Temperature	°C	0.1	Handheld meter (YSI-556)	Field
Conductivity	(mS cm)	0.1	Handheld meter (YSI-556)	Field
Salinity	ppt	0.01	Handheld meter (YSI-556)	Field
pH	pH units	0.01	Handheld meter (YSI-556)	Field
Suspended sediment	mg/L	0.2	APHA (2012) 2540 D	Lab
Turbidity	NTU	0.1	APHA (2012) 2130 B (modified)	Lab
Chlorophyll <i>a</i>	mg/L	0.0006	APHA (2012) 10200 H (modified)	Lab
Nitrate nitrogen (NO ₃)	mgN/L	0.002	Calculation (NNN - NO ₂)	Lab
Nitrite nitrogen (NO ₂)	mgN/L	0.002	APHA (2012) 4500-NO ₂ B (modified)	Lab
Ammoniacal nitrogen (NH ₄ -N)	mgN/L	0.005	APHA (2012) 4500-NH ₃ G (modified)	Lab
Total kjeldahl nitrogen (TKN)	mgN/L	0.02	APHA (2012) 4500-org A, D Modified	Lab
Total nitrogen (TN)	mgN/L	0.02	APHA (2012) 4500-P J, 4500-NO ₃ F (modified)	Lab
Soluble reactive phosphorus	mg/L	0.0006	APHA (2012) 4500-P B, F Mod	Lab
Total phosphorus	mg/L	0.005	APHA (2012) 4500-P B,J (modified)	Lab
Enterococci	MPN/100ml	10	APHA (2005) 9230A & 9230D	Lab

Appendix B Water quality indices

The communication of water quality data is often hampered by the volume of results and the complexity of the information. In this report, a water quality index developed by the Canadian Council of Ministers for the Environment (CCME) (2001) was applied to the marine water quality data collected by Auckland Council to enable improved understanding and communication of the work.

The CCME approach uses water quality results to produce four water quality indices, and these indices can be used to assign a water quality class to each monitoring site. The four indices are;

- Scope – This represents the percentage of parameters that failed to meet the objective at least once during the time period under consideration (the lower this index, the better).
- Frequency – This represents the percentage of all individual tests that failed to meet the objective during the time period under consideration (the lower this index, the better).
- Magnitude – This represents the amount by which failed tests exceeded the objective (the lower this index, the better). This is based on the collective amount by which individual tests are out of compliance with the objectives and is scaled to be between 1 and 100. This is the most complex part of the index derivation and the reader is referred to CCME (2001) for full details.
- WQI – This represents an overall water quality index based on a combination of the three indices described above. It is calculated thus;

$$WQI = 100 - \left[\sqrt{(Scope^2 + Frequency^2 + Magnitude^2)} \div 1.732 \right]$$

The divisor 1.732 normalises the resultant values to a range between 0 and 100, where 0 represents the “worst” water quality and 100 represents the “best” water quality.

The WQI index is used by Auckland Council to assign a water quality class to each site using the following ranges;

- Greater than 90 = excellent water quality
- Between 75 and 90 = good water quality
- Between 60 and 75 = fair water quality
- Lower than 60 = poor water quality

The above indices are calculated for each site based on seven water quality parameters presented in Table B-1. The objectives against which the water quality data are tested (Table B-1) are derived from the ranges observed at six reference sites (Goat Island, Ti Point, Mahurangi Heads, Orewa, Browns Bay and Hobsonville) over the five year preceding this report (2009 to 2013). It was considered thresholds based on a fixed period, whilst providing consistency, would not capture longer term trends in water quality, nor account for improvements in the measurement of parameters (for example, improved meter performance or improvements in detection limits).

The ranges at these reference sites were used, as this represents the best achievable water quality in the Auckland region. Therefore, the index represents the deviation from “natural” conditions in the Auckland region, rather than indicating whether the water quality is suitable for a particular purpose.

Table B-1 The seven water quality parameters, and their objectives, used to produce the water quality indices.

Dissolved oxygen (% saturation)	greater than 78%
pH	Between 7.6 and 8.3
Turbidity	Less than 7.7 NTU
Ammoniacal nitrogen	Less than 0.089 mg N l ⁻¹
Total suspended sediment	Less than 25 mg l ⁻¹
Total phosphorus	Less than 0.062 mg P l ⁻¹
Nitrate + nitrite nitrogen	Less than 0.105 mg N l ⁻¹