



Marine Water Quality Annual Report: 2014

December 2015

Technical Report 2015/032

Auckland Council
Technical Report 2015/032
ISSN 2230-4525 (Print)
ISSN 2230-4533 (PDF)

ISBN 978-0-908320-75-2 (Print)
ISBN 978-0-908320-76-9 (PDF)

This report has been peer reviewed by the Peer Review Panel.

Review completed on 21 December 2015
Reviewed by one reviewer

Approved for Auckland Council publication by:



Name: Dr Lucy Baragwanath

Position: Manager, Research and Evaluation Unit (RIMU)

Date: 21 December 2015

Recommended citation:

Vaughan, M and Walker, J (2015). Marine water quality annual report: 2014.
Auckland Council technical report, TR2015/032

© 2015 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: 2014

Melanie Vaughan

Jarrold Walker

Research and Evaluation Unit

Auckland Council

Table of Contents

1.0	Executive summary.....	1
2.0	Introduction.....	2
2.1	Report content.....	3
3.0	Methods.....	4
3.1	Programme design.....	4
3.2	Water quality parameters.....	7
3.3	Programme changes.....	7
3.4	Quality control, data storage and analysis.....	8
3.5	Reports.....	8
4.0	Results and discussion.....	10
4.1	Box plots.....	11
4.2	Marine Water Quality Index.....	17
4.3	Data tables.....	19
5.0	References.....	35
6.0	Acknowledgements.....	36
	Appendix A: Physico-chemical measures.....	37
	Appendix B: Water quality indices.....	38

List of figures

Figure 3-1	Location of the 35 marine quality monitoring sites	6
Figure 4-1	Spatial patterns in conductivity, salinity and pH.	11
Figure 4-2	Spatial patterns in turbidity, suspended sediment, and chlorophyll a.	12
Figure 4-3	Spatial patterns in nitrite, nitrate and ammonia.	13
Figure 4-4	Spatial patterns in total kjedahl nitrogen and total nitrogen.	14
Figure 4-5	Spatial patterns in total phosphorous and soluble reactive phosphorous.....	15
Figure 4-7	Spatial patterns in two indices of dissolved oxygen (ppm and % saturation) and sea surface temperature.	16

List of tables

Table 3-1	Marine water quality sites sorted from north to south, grouped by location.....	5
Table 4-1	Percentage of sites per water quality class.....	17
Table 4-2	Water quality index and the resultant water quality class for monitored sites.	18
Table 4-3	Electrical conductivity ($\text{mS}\cdot\text{cm}^{-1}$)	19
Table 4-4	Salinity (ppt)	20
Table 4-5	pH (pH units).....	21
Table 4-6	Turbidity (NTU).....	22
Table 4-7	Suspended sediment (mg/L).	23
Table 4-8	Chlorophyll <i>a</i> (mg/L).....	24
Table 4-9	Nitrite (mg N/L).....	25
Table 4-10	Nitrate (mg N/L).....	26
Table 4-11	Ammonia (mg N/L).	27
Table 4-12	Total kjedahl nitrogen (mg N/L)	28
Table 4-13	Total nitrogen (by calculation, mg N/L)	29
Table 4-14	Total phosphorus (mg/L)	30
Table 4-15	Soluble reactive phosphorus (mg/L)	31
Table 4-17	Dissolve oxygen (% saturation)	32
Table 4-18	Dissolved oxygen (ppm)	33
Table 4-19	Summary table of temperature ($^{\circ}\text{C}$).....	34

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 council policy initiatives and strategies. This report documents any changes made to the monitoring programmes and provides a summary of the data collected during 2014.

Water quality is assessed monthly at 35 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 analysis provides a simple form of results to be communicated from complex water quality data. For the first time since the water quality index (WQI) has been calculated, Kaipara Heads has the best water quality in the Auckland region. Mangere Bridge has the lowest ranking water quality, a position that it also held in 2010 (Walker and Vaughan, 2013). Sixteen sites changed water quality class from their 2013 classification (Walker and Vaughan, 2014) and for the majority of these, an increase in quality.

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, seagrass, 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 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 3-1). The three 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 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, Waitematā, Kaipara and Manukau Harbours and East Coast estuaries.

Historically the council also used to run a further programme, the shellfish contaminant monitoring programme which indirectly monitors chemical contaminants in the water column. This was dropped in 2013. 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.

2.1 Report content

This report provides 12-months of summary data from the 2014 calendar year collected from 35 monitoring sites across the Auckland region (Figure 3-1), and includes summary statistics tabulated by parameter grouped by spatial proximity, and water quality indices.

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 Waitematā 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 500ml glass bacteria bottles are sent to Watercare Laboratory Services (WLS) and analysed for chemical compounds (see Appendix A).

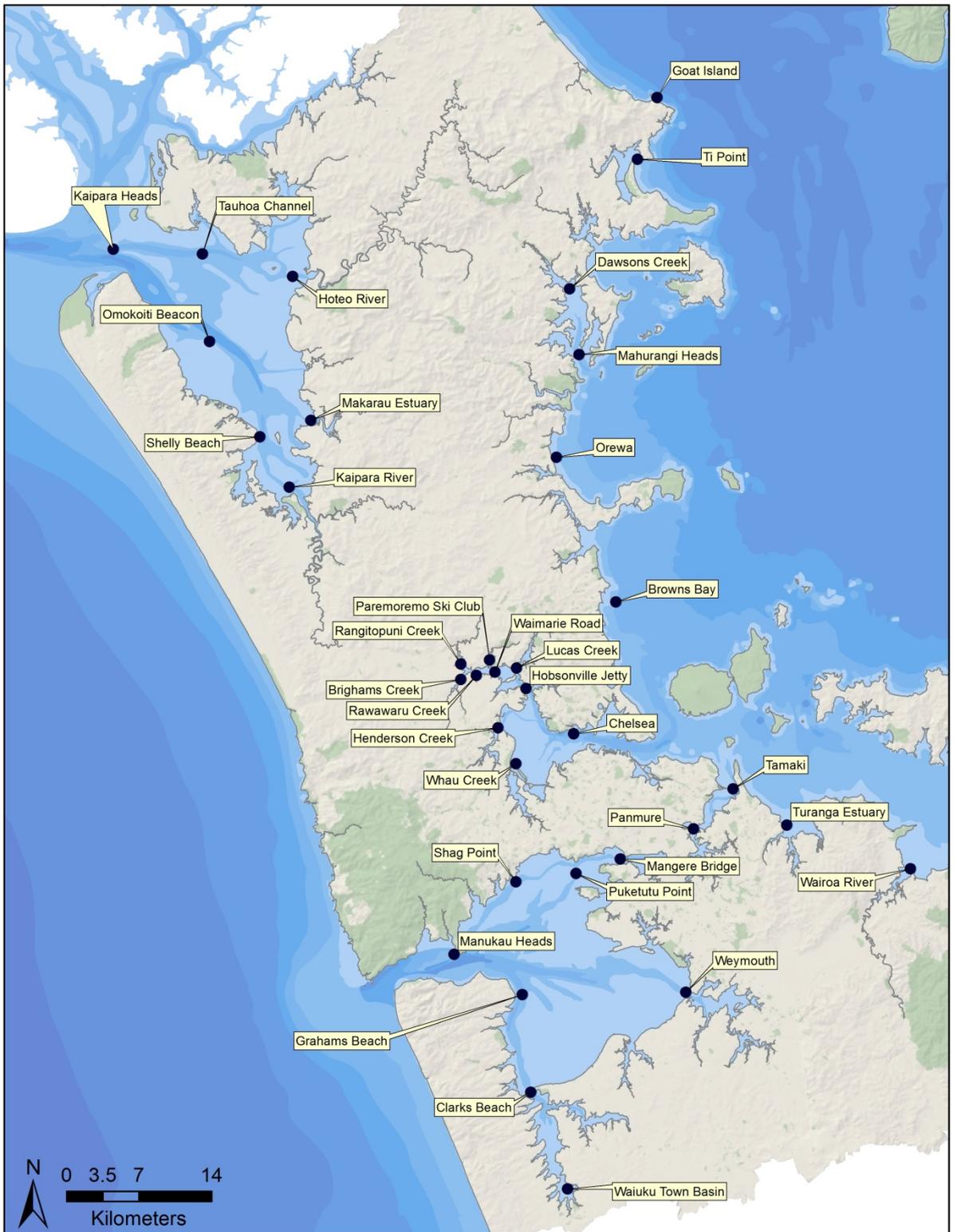
Sampling is divided into 6 geographically distinct runs, summarised below. Routine water quality monitoring locations are summarised in Table 3-1 and illustrated in Figure 3-1.

- 8 sites in Manukau Harbour;
- 7 sites in the inner Hauraki Gulf and outer Waitematā 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).
- 7 sites in the Upper Waitematā Harbour.

Temporal variation is avoided as much as possible by maintaining a consistent sampling time relative to tidal cycle. Samples are collected approximately 30mins–3hrs hours after high tide for the Kaipara Harbour, Waitematā 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 is 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	Waitematā Harbour	1753944	5922872	1991
Whau Creek	Waitematā Harbour	1748289	5920291	1991
Henderson Creek	Waitematā Harbour	1746712	5923648	1991
Hobsonville Jetty	Waitematā Harbour	1749321	5927317	1993
Waimarie Road	Waitematā Harbour	1746213	5929089	1993
Rawawaru Creek	Waitematā Harbour	1744434	5928653	1993
Paremoremo Ski Club	Waitematā Harbour	1745746	5930178	1993
Rangitopuni Creek	Waitematā Harbour	1742836	5929868	1993
Brighams Creek	Waitematā Harbour	1742758	5928019	1993
Lucas Creek	Waitematā 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



Whilst due care has been taken, Auckland Council gives no warranty as to the accuracy and completeness of any information on this map/plan and accepts no liability for any error, omission or use of the information.
 Height datum: Auckland 1946. Copyright Auckland Council.
 Date: 27th August, 2015

Map Produced by
 Research and Evaluation
 Unit, Auckland Council

Auckland Council
 Te Kaitiaki o Te Whanganui-a-Tara

Marine water quality monitoring sites

Figure 3-1 Location of the 35 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 18 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 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 were considered a more appropriate bacteria indicator in marine waters. However, Enterococci was removed from the sampling parameters in 2014 because analysis is showing that the temporal variability requires a much more focused programme such as the Safeswim programme run over summer at Auckland's beaches (www.aucklandcouncil.govt.nz/safeswim). Total nitrogen (TN) was added to the list of chemical variables in 2009 as a result of WLS having the capability to calculate the result from the current nitrogen species analysed.

In June 2014 the site Confluence in the Upper Waitematā Harbour was dropped from the sampling programme. This was a site that was historically included and following assessment of sites and their contributions the decision was made to drop the site as the surrounding sites provide adequate data.

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 excel 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 0.

3.5 Reports

This is the 24th data report since the inception of the monitoring programme, and it is the eighth 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, TP2008/005) 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, TP2008/005). A number of recommendations were made in this report 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 Waitematā Harbour and Tamaki Estuary was last undertaken in 2001 (Wilcock and Kemp, 2001).

4.0 Results and discussion

Data from the 2014 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 quality indices are produced using a select few parameters and the data available.

4.1 Box plots

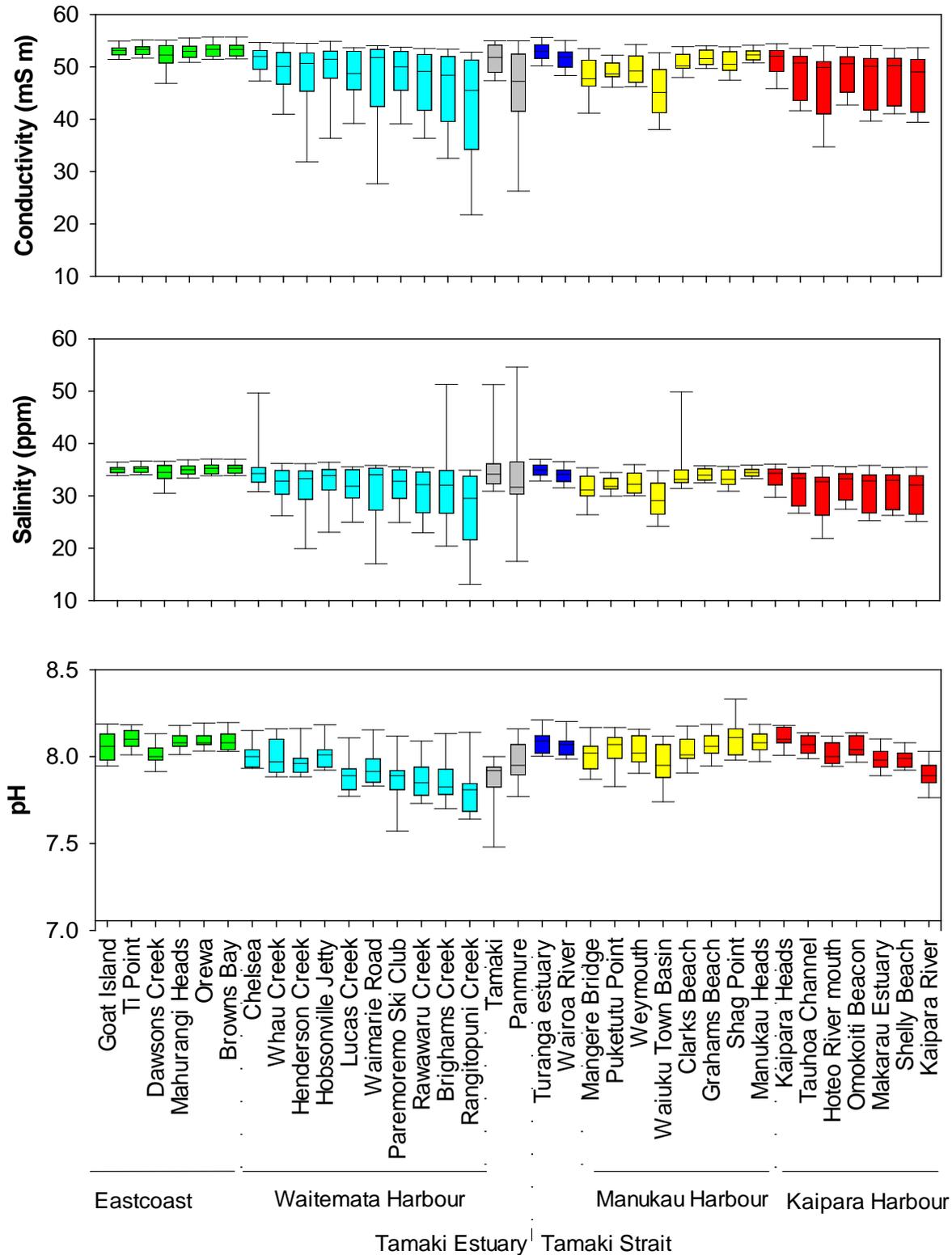


Figure 4-1 Spatial patterns in conductivity, salinity and pH. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2014 to December 2014. Percentiles values calculated using the standard method in SigmaPlot (v12).

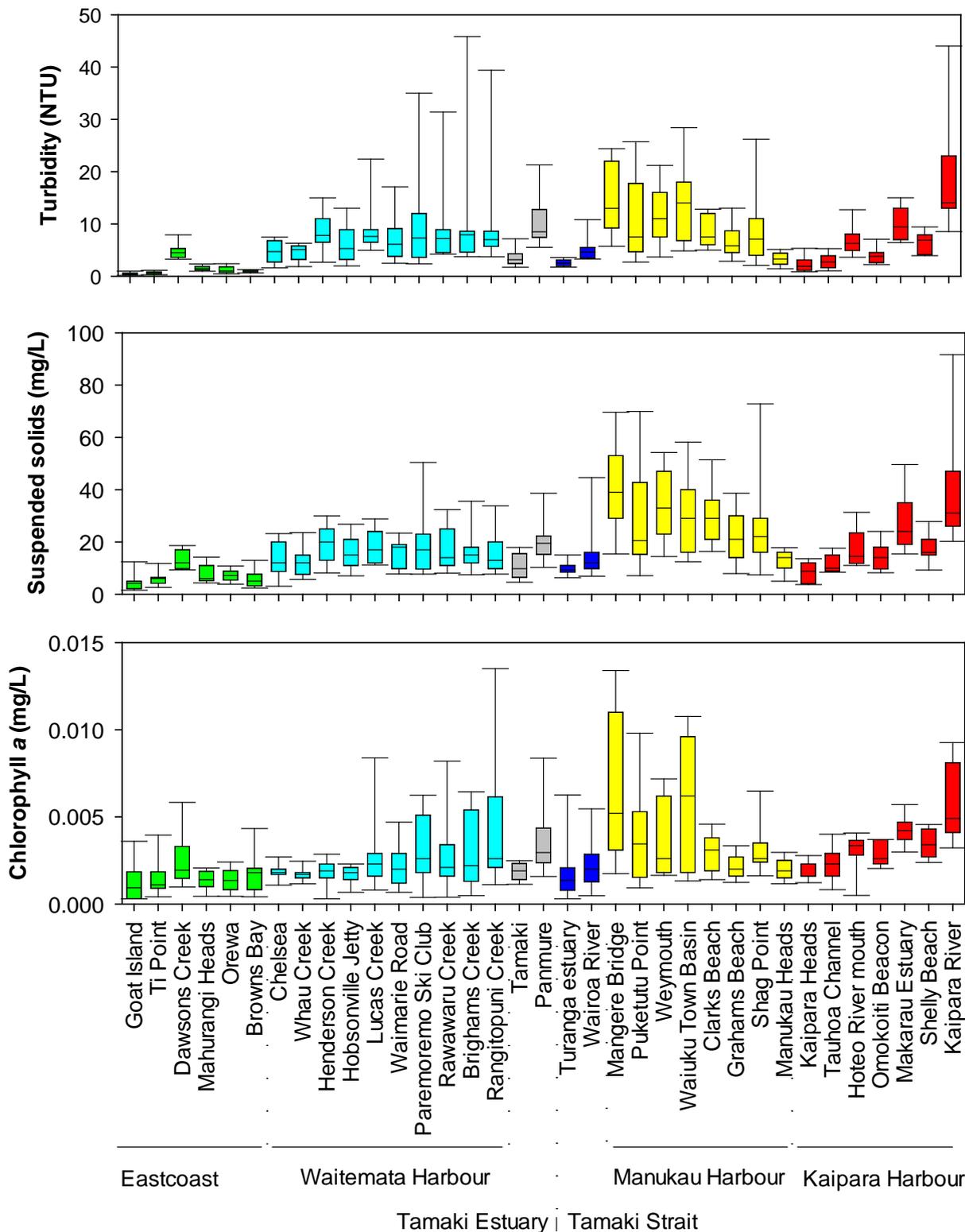


Figure 4-2 Spatial patterns in turbidity, suspended sediment, and chlorophyll a. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2014 to December 2014. Percentiles values calculated using the standard method in SigmaPlot (v12).

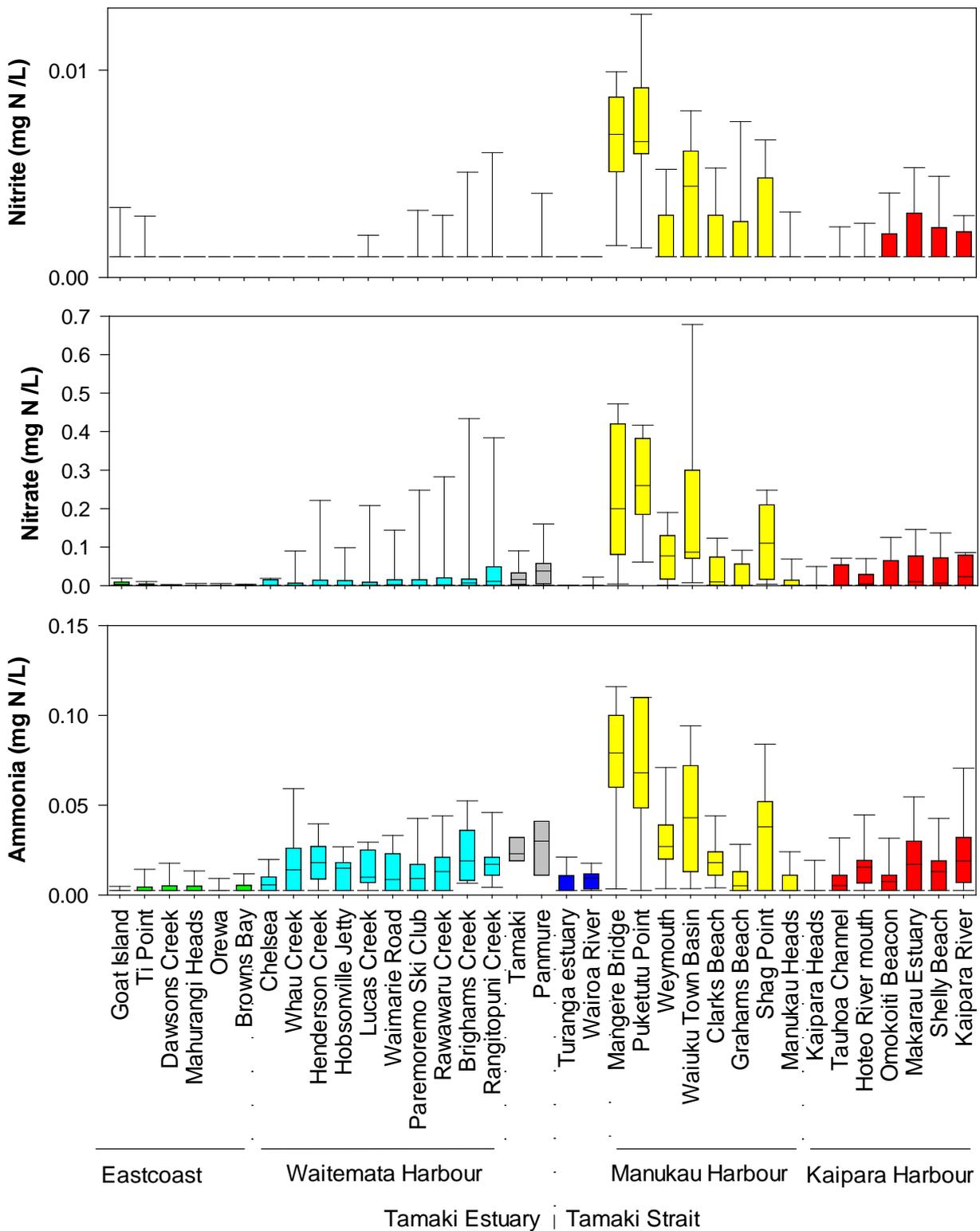


Figure 4-3 Spatial patterns in nitrite, nitrate and ammonia. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2014 to December 2014. Percentiles values calculated using the standard method in SigmaPlot (v12).

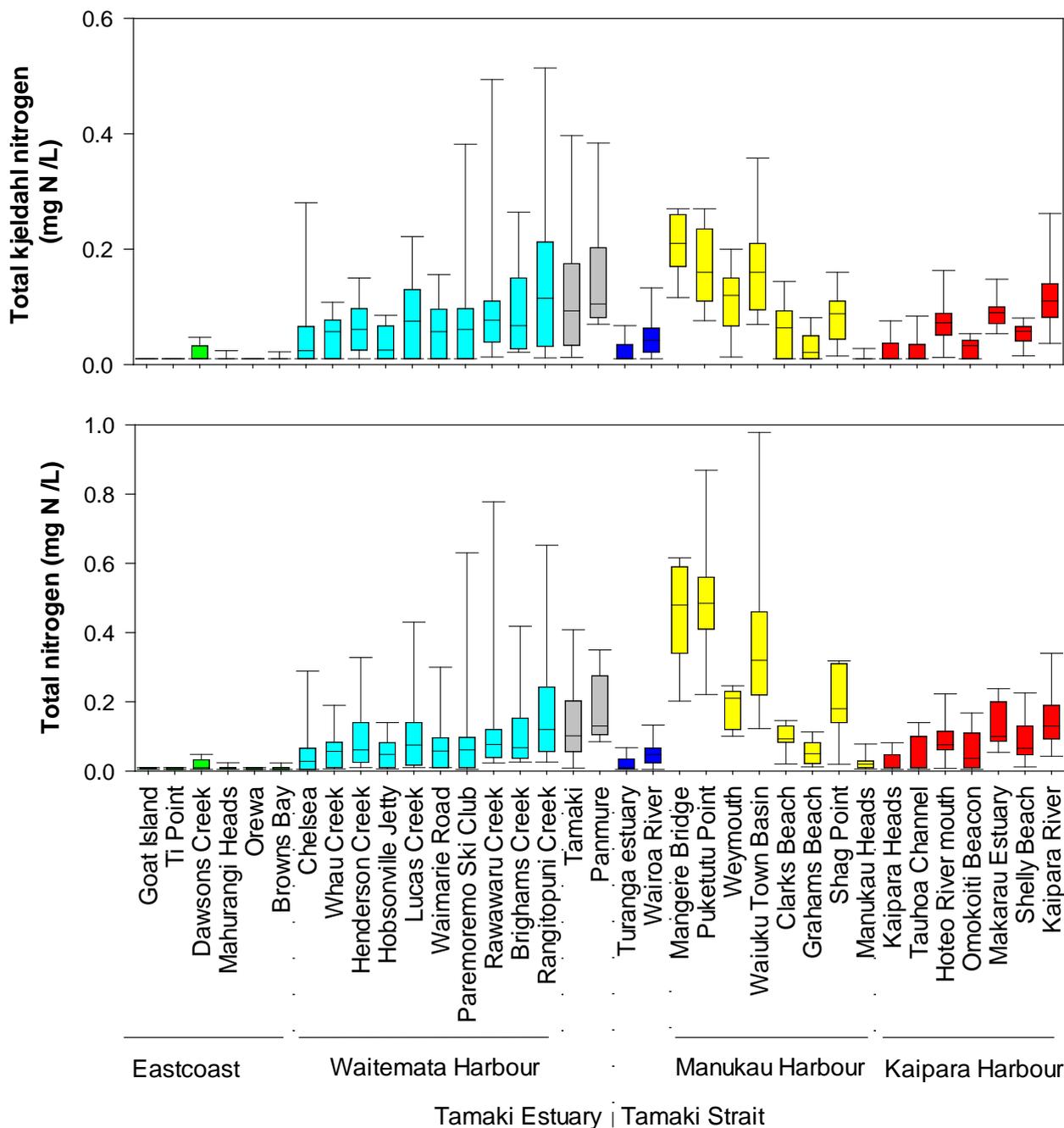


Figure 4-4 Spatial patterns in total kjeldahl nitrogen and total nitrogen. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2014 to December 2014. Percentiles values calculated using the standard method in SigmaPlot (v12).

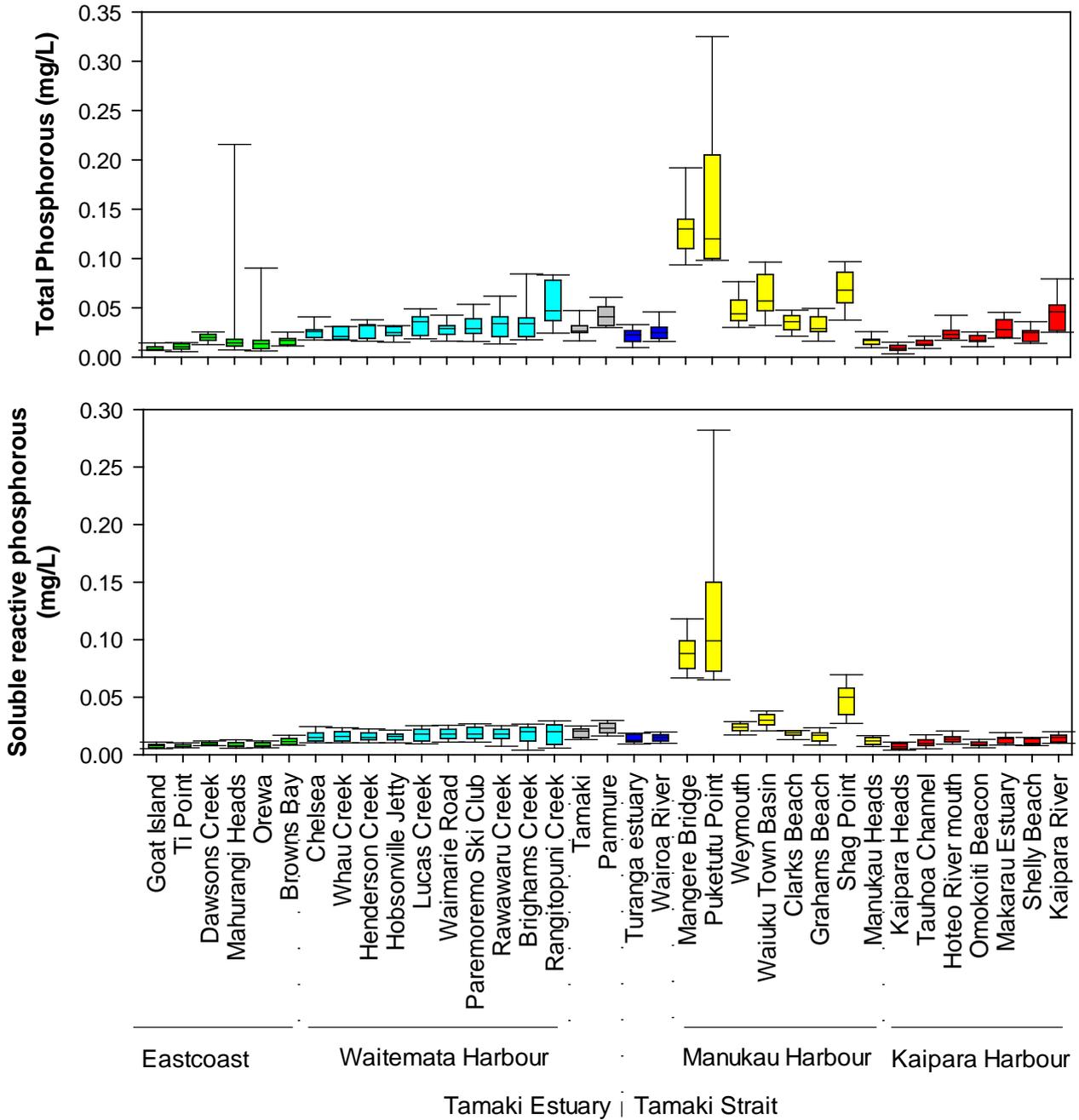


Figure 4-5 Spatial patterns in total phosphorous and soluble reactive phosphorous. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2014 to December 2014. Percentiles values calculated using the standard method in SigmaPlot (v12).

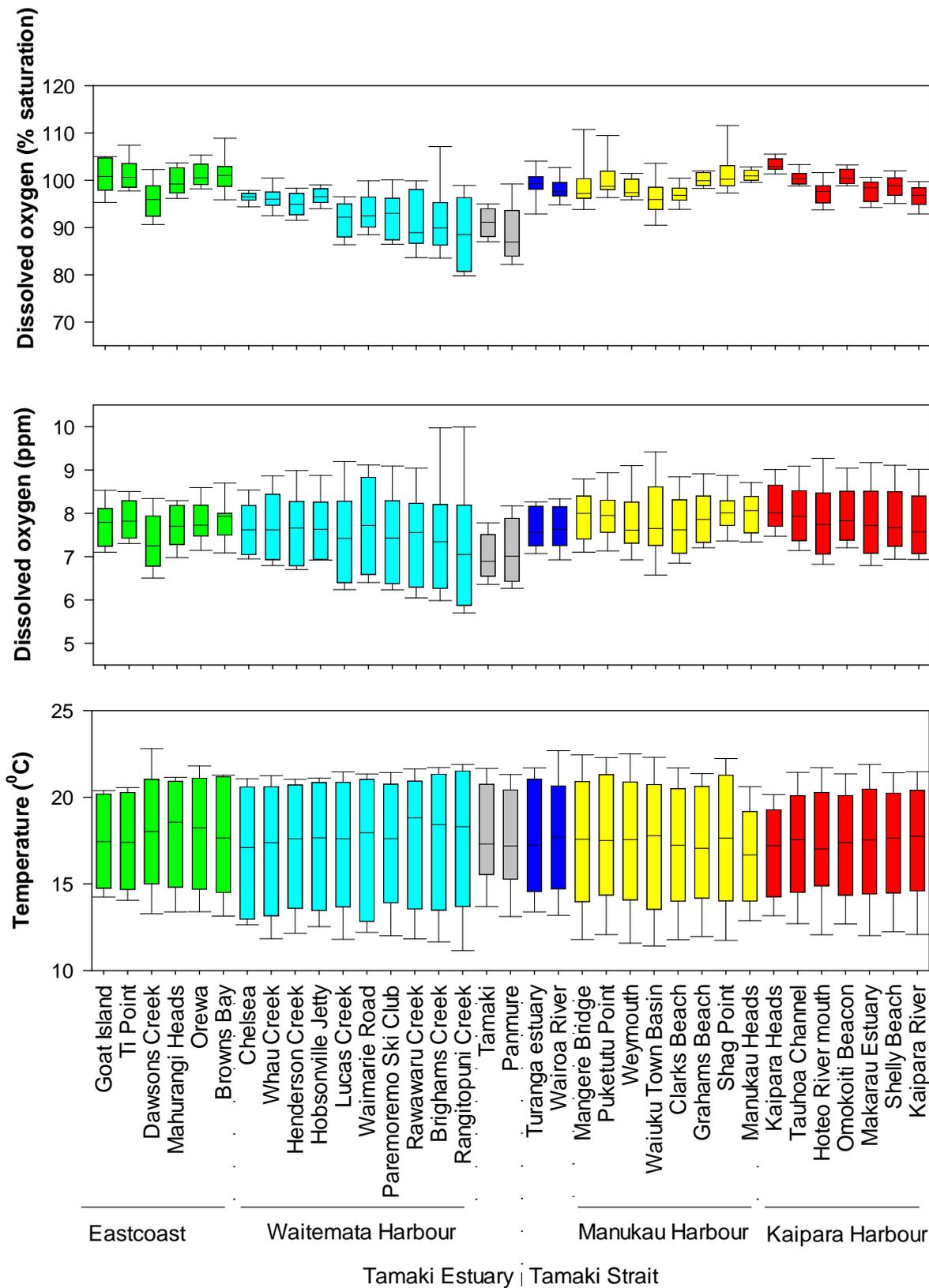


Figure 4-6 Spatial patterns in two indices of dissolved oxygen (ppm and % saturation) and sea surface temperature. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2014 to December 2014. Percentile values calculated using the standard method in SigmaPlot (v12).

4.2 Marine Water Quality Index

Using the methodology described in 0 and first applied in the 2009 annual water quality report, water quality indices and classes were generated for each of the 35 sites (Table 4-2). The water quality indices for 2014 present the result for a single year, as does the table for the preceding years. Average water quality indices can be used to calculate a result to eliminate any inter annual variations from environmental changes such as input from development, heavy rain fall etc. The decision has been made to present the raw data for each year in the data reports and present averages when discussing general trends for the sites.

Kaipara Heads was the site that had the best water quality in 2014, the first time this site has reached a 100 WQI and the second time in the past five years that the site has been classed as Excellent. Mangere Bridge had the worst water quality in 2014, a position it has previously held in 2010.

Sixteen sites changed water quality class from their 2013 classification (Walker and Vaughan, 2014). The majority of the changes were increases in water quality with only two sites decreasing in water quality (Chelsea-Excellent to Good and Shelly Beach-Good to Fair). This remains relatively constant with the 2013 water class changes where was only one decrease at Clarks beach from 2012 (Walker and Vaughan, 2014). Of the sixteen sites, one site changed by two classes (Manukau Heads) and all other sites changed by one class. When considering the results over the past five years, 2 sites have maintained excellent water quality (Orewa and Mahurangi Heads), 1 site has maintained good water quality (Dawsons Creek), no sites have stayed as fair water quality and seven sites have remained as poor water quality (Rangitopuni Creek, Weymouth, Brighams Creek, Kaipara River, Panmure, Puketutu Point and Mangere Bridge).

Interestingly the divide of water quality classes over the region are split evenly between Excellent, Good and Fair all with 23% of sites, and then Poor has slightly more sites with 31%. Over the past five years the poor water quality class has held the most number of sites with the exception of 2012 where the Excellent water quality class had the most number of sites (Table 4-1).

Table 4-1 Percentage of sites per water quality class. Note there are 35 sites in 2010, 2011 and 2014 and 36 sites in 2012 and 2013

Water Quality Class	2010	2011	2012	2013	2014
Excellent	11	20	36	11	23
Good	17	17	17	19	23
Fair	31	29	14	25	23
Poor	40	34	33	44	31

Table 4-2 Water quality index and the resultant water quality class for the current monitored sites. Sites are ordered according to WQI. Previous years water quality classes are also presented for inter-annual comparisons and reference. The water quality index is discussed in 0.

Site	2010 class	2011 class	2012 class	2013 class	2014 class	2014 WQI
Kaipara Heads	Fair	Fair	Excellent	Good	Excellent	100
Browns Bay	Good	Excellent	Excellent	Good	Excellent	92.8
Goat Island	Excellent	Good	Excellent	Excellent	Excellent	92.8
Manukau Heads	Fair	Fair	Excellent	Fair	Excellent	92.8
Ti Point	Excellent	Excellent	Excellent	Good	Excellent	92.8
Orewa	Excellent	Excellent	Excellent	Excellent	Excellent	92.7
Turanga Est Mouth	Good	Excellent	Excellent	Good	Excellent	92.7
Mahurangi Heads	Excellent	Excellent	Excellent	Excellent	Excellent	91.9
Tauhoa Channel	Fair	Good	Excellent	Fair	Good	85.4
Chelsea	Good	Poor	Excellent	Excellent	Good	85.3
Omokoiti Beacon	Fair	Good	Excellent	Fair	Good	85.2
Tamaki	Good	Poor	Excellent	Good	Good	78.2
Whau Creek	Good	Excellent	Poor	Fair	Good	78.2
Dawsons Creek	Good	Good	Good	Good	Good	78.1
Hobsonville Jetty	Fair	Excellent	Good	Fair	Good	77.7
Henderson Creek	Poor	Fair	Good	Fair	Good	76.5
Wairoa River Mouth	Fair	Poor	Good	Fair	Fair	70.8
Shelly Beach	Fair	Fair	Good	Good	Fair	69.6
Grahams Beach	Poor	Fair	Excellent	Fair	Fair	69.5
Hoteo River mouth	Fair	Fair	Good	Fair	Fair	63.4
Waimarie Road	Fair	Good	Fair	Poor	Fair	63.1
Lucas Creek	Poor	Fair	Poor	Poor	Fair	62.2
Paremoremo Ski Club	Fair	Good	Poor	Poor	Fair	61.6
Clarks Beach	Poor	Fair	Fair	Poor	Fair	60.6
Rarawaru Creek	Poor	Poor	Fair	Poor	Poor	54.9
Rangitopuni Creek	Poor	Poor	Poor	Poor	Poor	52.4
Makarau Estuary	Fair	Fair	Poor	Poor	Poor	52.2
Weymouth	Poor	Poor	Poor	Poor	Poor	49.1
Brighams Creek	Poor	Poor	Poor	Poor	Poor	47.1
Kaipara River	Poor	Poor	Poor	Poor	Poor	45.8
Panmure	Poor	Poor	Poor	Poor	Poor	45.7
Waiuku Town Basin	NA	NA	Poor	Poor	Poor	43.1
Shag Point	Poor	Poor	Fair	Poor	Poor	43.0
Puketutu Point	Poor	Poor	Poor	Poor	Poor	40.8
Mangere Bridge	Poor	Poor	Poor	Poor	Poor	36.1

4.3 Data tables

Table 4-3 Electrical conductivity ($\text{mS}\cdot\text{cm}^{-1}$) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	51.41	55.25	53.16	53.03	0.33
Ti Point	11	51.68	55.49	53.36	53.20	0.33
Dawsons Creek	11	46.32	55.31	52.27	51.86	0.78
Mahurangi Heads	11	50.72	55.86	52.97	52.93	0.43
Orewa	11	51.34	56.00	53.35	53.24	0.41
Browns Bay	11	51.49	56.02	53.33	53.24	0.40
Chelsea	11	47.10	54.89	51.99	51.47	0.72
Whau Creek	11	40.19	54.69	50.09	49.74	1.34
Henderson Creek	11	28.76	54.63	50.67	48.61	2.22
Hobsonville Jetty	11	33.88	55.05	51.45	49.96	1.79
Lucas Creek	10	38.96	53.69	48.73	48.47	1.60
Waimarie Road	9	27.66	54.05	51.79	47.43	2.89
Paremoremo Ski Club	10	38.79	53.78	50.01	48.80	1.58
Rawawaru Creek	10	36.15	53.60	49.14	47.12	1.97
Brighams Creek	10	32.41	53.44	48.41	45.82	2.45
Rangitopuni Creek	10	21.57	52.88	45.50	42.36	3.63
Tamaki	9	47.37	54.99	51.80	51.34	0.92
Panmure	9	26.26	54.98	47.25	45.76	3.01
Turanga Estuary	11	49.99	55.97	52.94	52.91	0.50
Wairoa River	11	48.01	55.37	51.89	51.72	0.60
Mangere Bridge	11	40.88	53.86	47.73	47.77	1.19
Puketutu Point	11	45.65	52.59	48.66	49.04	0.56
Weymouth	11	46.17	54.60	49.21	49.56	0.88
Waiuku Town Basin	11	37.58	53.06	45.10	45.32	1.42
Clarks Beach	11	47.56	54.07	50.18	50.87	0.57
Grahams Beach	11	49.51	54.12	51.57	51.75	0.44
Shag Point	11	47.04	54.05	50.49	50.78	0.63
Manukau Heads	11	50.68	54.27	52.29	52.31	0.32
Kaipara Heads	11	45.32	54.60	52.05	51.36	0.84
Tauhoa Channel	11	41.29	53.71	50.74	48.85	1.30
Hoteo River mouth	11	33.15	54.37	49.89	46.89	1.91
Omokoiti Beacon	11	42.28	53.98	50.62	49.33	1.14
Makarau Estuary	11	39.33	54.35	50.10	47.69	1.54
Shelly Beach	11	40.69	53.73	50.21	48.23	1.36
Kaipara River	11	38.98	53.89	49.05	47.22	1.54

Table 4-4 Salinity (ppt) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	33.84	36.69	35.14	35.02	0.25
Ti Point	11	34.04	36.86	35.26	35.14	0.25
Dawsons Creek	11	30.10	36.74	34.47	34.15	0.58
Mahurangi Heads	11	33.28	37.15	35.00	34.94	0.33
Orewa	11	33.74	37.26	35.26	35.17	0.31
Browns Bay	11	33.83	37.26	35.25	35.16	0.30
Chelsea	11	30.59	36.43	34.27	33.85	0.54
Whau Creek	11	25.67	36.27	32.82	32.60	0.98
Henderson Creek	11	17.78	36.23	33.30	31.82	1.58
Hobsonville Jetty	11	21.28	36.55	33.87	32.78	1.29
Lucas Creek	10	24.76	35.53	31.84	31.69	1.17
Waimarie Road	9	17.03	35.80	34.04	30.98	2.07
Paremoremo Ski Club	10	24.65	35.59	32.78	31.93	1.16
Rawawaru Creek	10	22.81	35.46	32.14	30.72	1.43
Brighams Creek	10	20.25	35.33	31.61	29.81	1.76
Rangitopuni Creek	10	12.99	34.92	29.51	27.41	2.55
Tamaki	9	30.84	36.50	34.12	33.78	0.68
Panmure	9	16.10	36.49	30.79	29.80	2.14
Turanga Estuary	11	32.69	37.23	34.91	34.92	0.38
Wairoa River	11	31.26	36.79	34.10	34.04	0.45
Mangere Bridge	11	26.18	35.65	31.14	31.16	0.87
Puketutu Point	11	29.60	34.70	31.81	32.07	0.42
Weymouth	11	29.97	36.21	32.22	32.46	0.65
Waiuku Town Basin	11	23.84	35.05	29.09	29.39	1.03
Clarks Beach	11	30.97	35.82	32.93	33.41	0.43
Grahams Beach	11	32.38	35.85	33.95	34.05	0.34
Shag Point	11	30.60	35.79	33.17	33.34	0.47
Manukau Heads	11	33.23	35.96	34.45	34.48	0.25
Kaipara Heads	11	29.32	36.20	34.29	33.79	0.63
Tauhoa Channel	11	26.44	35.55	33.35	31.97	0.96
Hoteo River mouth	11	20.74	36.03	32.71	30.56	1.38
Omokoiti Beacon	11	27.14	35.75	33.25	32.31	0.84
Makarau Estuary	11	25.03	36.02	32.87	31.12	1.13
Shelly Beach	11	25.99	35.56	32.95	31.51	1.00
Kaipara River	11	24.78	35.68	32.09	30.78	1.12

Table 4-5 pH (pH units) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	7.94	8.19	8.06	8.06	0.03
Ti Point	11	8.00	8.19	8.10	8.10	0.02
Dawsons Creek	11	7.90	8.14	8.00	8.01	0.02
Mahurangi Heads	11	8.01	8.19	8.08	8.09	0.02
Orewa	11	8.03	8.21	8.08	8.10	0.02
Browns Bay	11	8.03	8.20	8.08	8.10	0.02
Chelsea	11	7.93	8.16	8.00	8.01	0.02
Whau Creek	11	7.88	8.17	7.97	7.99	0.03
Henderson Creek	11	7.88	8.18	7.96	7.98	0.03
Hobsonville Jetty	11	7.92	8.20	8.01	8.02	0.03
Lucas Creek	11	7.77	8.12	7.89	7.90	0.03
Waimarie Road	10	7.83	8.16	7.92	7.94	0.03
Paremoremo Ski Club	11	7.52	8.12	7.89	7.88	0.05
Rawawaru Creek	10	7.73	8.09	7.85	7.87	0.04
Brighams Creek	10	7.70	8.14	7.83	7.86	0.04
Rangitopuni Creek	9	7.64	8.14	7.81	7.81	0.05
Tamaki	9	7.48	8.00	7.92	7.86	0.05
Panmure	9	7.77	8.16	7.95	7.97	0.04
Turanga Estuary	11	8.00	8.22	8.09	8.09	0.02
Wairoa River	11	7.98	8.21	8.07	8.07	0.02
Mangere Bridge	11	7.87	8.17	8.02	8.02	0.03
Puketutu Point	11	7.80	8.18	8.07	8.04	0.03
Weymouth	11	7.89	8.16	8.02	8.04	0.03
Waiuku Town Basin	11	7.71	8.12	7.95	7.95	0.04
Clarks Beach	11	7.89	8.18	8.01	8.03	0.03
Grahams Beach	11	7.93	8.19	8.06	8.08	0.02
Shag Point	11	7.98	8.36	8.11	8.11	0.03
Manukau Heads	11	7.96	8.19	8.08	8.09	0.02
Kaipara Heads	11	8.00	8.18	8.10	8.11	0.02
Tauhoa Channel	11	7.98	8.14	8.07	8.07	0.02
Hoteo River mouth	11	7.94	8.12	8.00	8.01	0.02
Omokoiti Beacon	11	7.96	8.14	8.04	8.05	0.02
Makarau Estuary	11	7.88	8.11	7.98	7.99	0.02
Shelly Beach	11	7.92	8.08	7.99	7.99	0.02
Kaipara River	11	7.76	8.04	7.89	7.89	0.02

Table 4-6 Turbidity (NTU) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	0.15	1.00	0.35	0.46	0.08
Ti Point	11	0.30	1.20	0.70	0.66	0.08
Dawsons Creek	11	3.20	7.90	4.50	4.91	0.49
Mahurangi Heads	11	0.90	2.40	1.50	1.56	0.14
Orewa	11	0.40	2.50	1.00	1.19	0.20
Browns Bay	11	0.60	1.30	0.90	0.91	0.06
Chelsea	11	1.50	7.60	4.70	4.64	0.63
Whau Creek	11	1.60	6.40	5.10	4.45	0.47
Henderson Creek	11	2.50	16.00	7.80	8.22	1.12
Hobsonville Jetty	11	1.90	14.00	5.30	6.30	1.06
Lucas Creek	11	4.90	25.00	7.60	9.11	1.69
Waimarie Road	11	2.20	19.00	6.10	7.20	1.38
Paremoremo Ski Club	11	2.10	36.00	7.30	11.18	3.44
Rawawaru Creek	11	4.20	36.00	7.20	9.55	2.76
Brighams Creek	11	3.60	55.00	7.90	11.08	4.43
Rangitopuni Creek	11	3.40	45.00	7.00	10.98	3.56
Tamaki	10	1.70	7.40	3.15	3.57	0.52
Panmure	10	5.40	22.00	8.50	10.28	1.57
Turanga Estuary	11	1.70	3.60	2.50	2.61	0.19
Wairoa River	11	3.30	11.00	4.60	5.31	0.81
Mangere Bridge	11	5.10	25.00	13.00	14.68	2.04
Puketutu Point	10	2.50	26.00	7.50	10.73	2.58
Weymouth	11	3.30	22.00	11.00	11.71	1.67
Waiuku Town Basin	11	4.60	29.00	14.00	14.32	2.40
Clarks Beach	11	4.90	13.00	7.50	8.43	0.85
Grahams Beach	11	2.60	14.00	5.80	6.60	0.95
Shag Point	11	1.90	28.00	7.10	9.31	2.36
Manukau Heads	11	1.30	5.20	3.30	3.28	0.37
Kaipara Heads	11	0.85	5.80	1.90	2.20	0.44
Tauhoa Channel	11	0.90	5.50	2.70	2.97	0.41
Hoteo River mouth	10	3.60	13.00	6.25	6.86	0.90
Omokoiti Beacon	11	2.20	7.70	3.80	3.85	0.46
Makarau Estuary	11	6.40	15.00	9.40	10.10	0.99
Shelly Beach	11	3.90	9.60	6.90	6.39	0.59
Kaipara River	11	7.90	45.00	14.00	19.81	3.62

Table 4-7 Suspended sediment (mg/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	1.50	13.00	4.20	5.00	1.06
Ti Point	11	2.40	13.00	6.00	5.85	0.84
Dawsons Creek	11	9.30	19.00	12.00	12.77	1.04
Mahurangi Heads	11	4.20	15.00	6.00	7.56	1.05
Orewa	11	3.70	11.00	7.20	7.27	0.70
Browns Bay	11	2.30	14.00	5.00	5.92	1.02
Chelsea	11	2.40	24.00	12.00	13.30	1.99
Whau Creek	11	5.40	24.00	12.00	12.42	1.85
Henderson Creek	11	7.20	31.00	20.00	19.47	2.21
Hobsonville Jetty	11	6.80	28.00	15.00	15.98	1.93
Lucas Creek	11	11.00	30.00	17.00	18.18	1.96
Waimarie Road	11	7.60	24.00	18.00	15.78	1.62
Paremoremo Ski Club	11	7.20	53.00	17.00	20.31	4.27
Rawawaru Creek	11	7.80	34.00	14.00	16.89	2.48
Brighams Creek	11	7.20	38.00	15.00	16.78	2.61
Rangitopuni Creek	11	7.40	35.00	13.00	16.36	2.62
Tamaki	10	4.60	18.00	9.80	10.50	1.51
Panmure	10	10.00	40.00	19.50	20.40	2.60
Turanga Estuary	11	6.00	16.00	9.20	9.72	0.78
Wairoa River	11	6.80	50.00	12.00	15.90	3.66
Mangere Bridge	11	13.00	72.00	39.00	40.82	5.07
Puketutu Point	10	6.40	72.00	20.50	28.44	6.38
Weymouth	11	13.00	55.00	33.00	34.18	4.01
Waiuku Town Basin	11	12.00	62.00	29.00	30.55	4.64
Clarks Beach	11	16.00	55.00	29.00	29.64	3.37
Grahams Beach	11	6.60	40.00	21.00	22.33	2.96
Shag Point	11	6.00	76.00	22.00	28.00	6.39
Manukau Heads	11	4.00	18.00	14.00	12.89	1.25
Kaipara Heads	11	3.60	14.00	8.80	8.32	1.05
Tauhoa Channel	11	8.30	18.00	10.00	11.59	1.02
Hoteo River mouth	10	11.00	32.00	14.50	17.40	2.24
Omokoiti Beacon	11	8.00	25.00	14.00	14.24	1.61
Makarau Estuary	11	15.00	53.00	24.00	27.09	3.27
Shelly Beach	11	8.30	29.00	16.00	17.66	1.66
Kaipara River	11	20.00	94.00	31.00	41.18	7.42

Table 4-8 Chlorophyll a (mg/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.000	0.004	0.001	0.001	0.000
Ti Point	12	0.000	0.005	0.001	0.002	0.000
Dawsons Creek	12	0.001	0.006	0.002	0.002	0.000
Mahurangi Heads	12	0.000	0.002	0.001	0.001	0.000
Orewa	12	0.000	0.003	0.001	0.001	0.000
Browns Bay	12	0.000	0.005	0.002	0.002	0.000
Chelsea	11	0.001	0.003	0.002	0.002	0.000
Whau Creek	11	0.001	0.003	0.002	0.002	0.000
Henderson Creek	11	0.000	0.003	0.002	0.002	0.000
Hobsonville Jetty	11	0.001	0.002	0.002	0.002	0.000
Lucas Creek	11	0.001	0.009	0.002	0.003	0.001
Waimarie Road	11	0.001	0.005	0.002	0.002	0.000
Paremoremo Ski Club	11	0.000	0.006	0.003	0.003	0.001
Rawawaru Creek	11	0.000	0.009	0.002	0.003	0.001
Brighams Creek	11	0.000	0.007	0.002	0.003	0.001
Rangitopuni Creek	10	0.001	0.014	0.003	0.004	0.001
Tamaki	10	0.001	0.003	0.002	0.002	0.000
Panmure	10	0.002	0.009	0.003	0.004	0.001
Turanga Estuary	12	0.000	0.008	0.001	0.002	0.001
Wairoa River	12	0.000	0.006	0.002	0.002	0.000
Mangere Bridge	11	0.002	0.014	0.005	0.006	0.001
Puketutu Point	10	0.001	0.010	0.003	0.004	0.001
Weymouth	11	0.002	0.007	0.003	0.004	0.001
Waiuku Town Basin	11	0.001	0.011	0.006	0.006	0.001
Clarks Beach	11	0.001	0.005	0.003	0.003	0.000
Grahams Beach	11	0.001	0.004	0.002	0.002	0.000
Shag Point	11	0.002	0.007	0.003	0.003	0.000
Manukau Heads	11	0.001	0.003	0.002	0.002	0.000
Kaipara Heads	11	0.001	0.003	0.002	0.002	0.000
Tauhoa Channel	11	0.001	0.004	0.002	0.002	0.000
Hoteo River mouth	10	0.000	0.004	0.003	0.003	0.000
Omokoiti Beacon	11	0.002	0.004	0.003	0.003	0.000
Makarau Estuary	11	0.003	0.006	0.004	0.004	0.000
Shelly Beach	11	0.002	0.005	0.003	0.003	0.000
Kaipara River	11	0.003	0.010	0.005	0.006	0.001

Table 4-9 Nitrite (mg N/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.001	0.004	0.001	0.001	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	NA
Mahurangi Heads	12	0.001	0.001	0.001	0.001	NA
Orewa	12	0.001	0.001	0.001	0.001	NA
Browns Bay	12	0.001	0.001	0.001	0.001	NA
Chelsea	11	0.001	0.001	0.001	0.001	NA
Whau Creek	11	0.001	0.001	0.001	0.001	NA
Henderson Creek	11	0.001	0.001	0.001	0.001	NA
Hobsonville Jetty	11	0.001	0.001	0.001	0.001	NA
Lucas Creek	11	0.001	0.002	0.001	0.001	0.000
Waimarie Road	11	0.001	0.001	0.001	0.001	NA
Paremoremo Ski Club	11	0.001	0.004	0.001	0.001	0.000
Rawawaru Creek	11	0.001	0.004	0.001	0.001	0.000
Brighams Creek	11	0.001	0.006	0.001	0.001	0.000
Rangitopuni Creek	11	0.001	0.006	0.001	0.002	0.001
Tamaki	10	0.001	0.001	0.001	0.001	NA
Panmure	10	0.001	0.004	0.001	0.001	0.000
Turanga Estuary	12	0.001	0.001	0.001	0.001	NA
Wairoa River	12	0.001	0.001	0.001	0.001	NA
Mangere Bridge	11	0.001	0.010	0.007	0.007	0.001
Puketutu Point	10	0.001	0.013	0.007	0.007	0.001
Weymouth	11	0.001	0.005	0.001	0.002	0.000
Waiuku Town Basin	11	0.001	0.009	0.004	0.004	0.001
Clarks Beach	11	0.001	0.006	0.001	0.002	0.000
Grahams Beach	11	0.001	0.008	0.001	0.002	0.001
Shag Point	11	0.001	0.007	0.001	0.003	0.001
Manukau Heads	11	0.001	0.003	0.001	0.001	0.000
Kaipara Heads	11	0.001	0.001	0.001	0.001	NA
Tauhoa Channel	11	0.001	0.003	0.001	0.001	0.000
Hoteo River mouth	10	0.001	0.003	0.001	0.001	0.000
Omokoiti Beacon	11	0.001	0.004	0.001	0.002	0.000
Makarau Estuary	11	0.001	0.006	0.001	0.002	0.000
Shelly Beach	11	0.001	0.005	0.001	0.002	0.000
Kaipara River	11	0.001	0.003	0.001	0.001	0.000

Table 4-10 Nitrate (mg N/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.001	0.021	0.003	0.006	0.002
Ti Point	12	0.001	0.012	0.001	0.003	0.001
Dawsons Creek	12	0.001	0.003	0.001	0.001	0.000
Mahurangi Heads	12	0.001	0.006	0.001	0.002	0.000
Orewa	12	0.001	0.007	0.001	0.002	0.001
Browns Bay	12	0.001	0.004	0.001	0.002	0.000
Chelsea	11	0.001	0.019	0.001	0.006	0.002
Whau Creek	11	0.001	0.110	0.001	0.012	0.010
Henderson Creek	11	0.001	0.270	0.001	0.030	0.024
Hobsonville Jetty	11	0.001	0.120	0.001	0.014	0.011
Lucas Creek	11	0.001	0.250	0.001	0.029	0.022
Waimarie Road	11	0.001	0.170	0.002	0.023	0.015
Paremoremo Ski Club	11	0.001	0.300	0.001	0.034	0.027
Rawawaru Creek	11	0.001	0.330	0.002	0.044	0.030
Brighams Creek	11	0.001	0.500	0.006	0.066	0.046
Rangitopuni Creek	11	0.001	0.430	0.011	0.070	0.040
Tamaki	10	0.001	0.096	0.016	0.024	0.009
Panmure	9	0.001	0.160	0.038	0.044	0.016
Turanga Estuary	12	0.001	0.001	0.001	0.001	
Wairoa River	12	0.001	0.030	0.001	0.004	0.002
Mangere Bridge	11	0.001	0.480	0.200	0.231	0.052
Puketutu Point	10	0.049	0.420	0.260	0.266	0.038
Weymouth	11	0.001	0.200	0.077	0.081	0.020
Waiuku Town Basin	11	0.004	0.760	0.087	0.203	0.066
Clarks Beach	11	0.001	0.130	0.010	0.037	0.014
Grahams Beach	11	0.001	0.098	0.001	0.022	0.010
Shag Point	11	0.001	0.250	0.110	0.107	0.028
Manukau Heads	11	0.001	0.072	0.001	0.014	0.008
Kaipara Heads	11	0.001	0.061	0.001	0.007	0.005
Tauhoa Channel	11	0.001	0.071	0.001	0.019	0.009
Hoteo River mouth	10	0.001	0.071	0.004	0.017	0.008
Omokoiti Beacon	11	0.001	0.140	0.001	0.026	0.014
Makarau Estuary	11	0.001	0.160	0.010	0.035	0.016
Shelly Beach	11	0.001	0.150	0.006	0.032	0.015
Kaipara River	11	0.001	0.087	0.023	0.030	0.011

Table 4-11 Ammonia (mg N/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.003	0.006	0.003	0.003	0.000
Ti Point	12	0.003	0.017	0.003	0.004	0.001
Dawsons Creek	12	0.003	0.021	0.003	0.005	0.002
Mahurangi Heads	12	0.003	0.014	0.003	0.005	0.001
Orewa	12	0.003	0.010	0.003	0.004	0.001
Browns Bay	12	0.003	0.013	0.003	0.004	0.001
Chelsea	11	0.003	0.022	0.006	0.007	0.002
Whau Creek	11	0.003	0.067	0.014	0.018	0.006
Henderson Creek	11	0.003	0.042	0.018	0.019	0.004
Hobsonville Jetty	11	0.003	0.028	0.015	0.012	0.003
Lucas Creek	11	0.003	0.030	0.010	0.014	0.003
Waimarie Road	11	0.003	0.034	0.009	0.013	0.003
Paremoremo Ski Club	11	0.003	0.046	0.009	0.014	0.004
Rawawaru Creek	11	0.003	0.047	0.013	0.016	0.004
Brighams Creek	11	0.007	0.054	0.019	0.022	0.005
Rangitopuni Creek	11	0.003	0.048	0.017	0.020	0.004
Tamaki	7	0.011	0.038	0.023	0.025	0.003
Panmure	7	0.011	0.077	0.030	0.032	0.009
Turanga Estuary	12	0.003	0.025	0.003	0.007	0.002
Wairoa River	12	0.003	0.018	0.009	0.009	0.002
Mangere Bridge	11	0.003	0.120	0.079	0.073	0.011
Puketutu Point	9	0.003	0.110	0.068	0.072	0.012
Weymouth	11	0.003	0.076	0.027	0.031	0.006
Waiuku Town Basin	11	0.003	0.095	0.043	0.045	0.010
Clarks Beach	11	0.003	0.048	0.018	0.020	0.004
Grahams Beach	11	0.003	0.030	0.005	0.009	0.003
Shag Point	11	0.003	0.091	0.038	0.035	0.008
Manukau Heads	11	0.003	0.027	0.003	0.007	0.002
Kaipara Heads	11	0.003	0.021	0.003	0.005	0.002
Tauhoa Channel	11	0.003	0.037	0.005	0.009	0.003
Hoteo River mouth	10	0.003	0.047	0.016	0.016	0.004
Omokoiti Beacon	11	0.003	0.034	0.008	0.010	0.003
Makarau Estuary	11	0.003	0.057	0.017	0.021	0.005
Shelly Beach	11	0.003	0.045	0.013	0.015	0.004
Kaipara River	11	0.003	0.076	0.019	0.024	0.007

Table 4-12 Total kjedahl nitrogen (mg N/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.010	0.010	0.010	0.010	
Ti Point	12	0.010	0.010	0.010	0.010	
Dawsons Creek	12	0.010	0.052	0.010	0.019	0.004
Mahurangi Heads	12	0.010	0.030	0.010	0.012	0.002
Orewa	12	0.010	0.010	0.010	0.010	
Browns Bay	12	0.010	0.027	0.010	0.011	0.001
Chelsea	11	0.010	0.330	0.024	0.056	0.028
Whau Creek	11	0.010	0.110	0.057	0.050	0.012
Henderson Creek	11	0.010	0.160	0.061	0.061	0.014
Hobsonville Jetty	11	0.010	0.086	0.025	0.038	0.009
Lucas Creek	11	0.010	0.230	0.075	0.083	0.022
Waimarie Road	11	0.010	0.160	0.057	0.060	0.016
Paremoremo Ski Club	11	0.010	0.430	0.061	0.092	0.037
Rawawaru Creek	11	0.010	0.560	0.077	0.123	0.047
Brighams Creek	10	0.021	0.270	0.068	0.099	0.026
Rangitopuni Creek	10	0.010	0.520	0.115	0.159	0.057
Tamaki	10	0.010	0.420	0.093	0.119	0.038
Panmure	10	0.070	0.400	0.105	0.155	0.033
Turanga Estuary	12	0.010	0.074	0.010	0.024	0.006
Wairoa River	12	0.010	0.150	0.042	0.049	0.012
Mangere Bridge	11	0.110	0.270	0.210	0.208	0.017
Puketutu Point	9	0.076	0.270	0.160	0.173	0.023
Weymouth	11	0.010	0.210	0.120	0.105	0.018
Waiuku Town Basin	11	0.066	0.360	0.160	0.181	0.030
Clarks Beach	11	0.010	0.150	0.064	0.061	0.015
Grahams Beach	11	0.010	0.082	0.021	0.033	0.008
Shag Point	11	0.010	0.170	0.088	0.082	0.014
Manukau Heads	11	0.010	0.029	0.010	0.013	0.002
Kaipara Heads	11	0.010	0.083	0.010	0.022	0.007
Tauhoa Channel	11	0.010	0.095	0.010	0.026	0.008
Hoteo River mouth	10	0.010	0.170	0.073	0.074	0.013
Omokoiti Beacon	11	0.010	0.055	0.033	0.029	0.005
Makarau Estuary	11	0.051	0.150	0.090	0.093	0.009
Shelly Beach	11	0.010	0.081	0.058	0.054	0.006
Kaipara River	11	0.033	0.280	0.110	0.120	0.021

Table 4-13 Total nitrogen (by calculation, mg N/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.005	0.010	0.010	0.009	0.001
Ti Point	12	0.005	0.010	0.010	0.008	0.001
Dawsons Creek	12	0.005	0.052	0.010	0.019	0.005
Mahurangi Heads	12	0.005	0.030	0.010	0.010	0.002
Orewa	12	0.005	0.010	0.010	0.008	0.001
Browns Bay	12	0.005	0.029	0.010	0.010	0.002
Chelsea	11	0.005	0.340	0.028	0.057	0.029
Whau Creek	11	0.005	0.210	0.057	0.061	0.019
Henderson Creek	11	0.010	0.370	0.061	0.089	0.032
Hobsonville Jetty	11	0.005	0.150	0.048	0.051	0.014
Lucas Creek	11	0.010	0.480	0.075	0.111	0.042
Waimarie Road	11	0.010	0.330	0.058	0.081	0.029
Paremoremo Ski Club	11	0.005	0.730	0.061	0.123	0.064
Rawawaru Creek	11	0.023	0.890	0.077	0.167	0.077
Brighams Creek	10	0.025	0.440	0.068	0.120	0.040
Rangitopuni Creek	10	0.025	0.660	0.120	0.194	0.072
Tamaki	10	0.005	0.430	0.102	0.142	0.039
Panmure	9	0.085	0.350	0.130	0.174	0.033
Turanga Estuary	12	0.005	0.074	0.010	0.022	0.006
Wairoa River	12	0.005	0.150	0.048	0.051	0.012
Mangere Bridge	11	0.200	0.620	0.480	0.446	0.047
Puketutu Point	10	0.200	0.900	0.485	0.501	0.056
Weymouth	11	0.098	0.250	0.210	0.184	0.016
Waiuku Town Basin	11	0.098	1.100	0.320	0.386	0.080
Clarks Beach	11	0.010	0.150	0.093	0.096	0.012
Grahams Beach	11	0.010	0.120	0.050	0.055	0.010
Shag Point	11	0.010	0.320	0.180	0.193	0.032
Manukau Heads	11	0.005	0.080	0.020	0.026	0.008
Kaipara Heads	11	0.005	0.083	0.010	0.028	0.009
Tauhoa Channel	11	0.005	0.150	0.010	0.043	0.015
Hoteo River mouth	10	0.005	0.230	0.076	0.090	0.020
Omokoiti Beacon	11	0.005	0.180	0.037	0.055	0.017
Makarau Estuary	11	0.051	0.240	0.100	0.129	0.020
Shelly Beach	11	0.005	0.240	0.066	0.086	0.020
Kaipara River	11	0.033	0.370	0.130	0.150	0.027

Table 4-14 Total phosphorus (mg/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.007	0.015	0.008	0.009	0.001
Ti Point	12	0.005	0.015	0.011	0.011	0.001
Dawsons Creek	11	0.012	0.026	0.020	0.020	0.001
Mahurangi Heads	12	0.007	0.300	0.015	0.038	0.024
Orewa	12	0.006	0.120	0.014	0.022	0.009
Browns Bay	12	0.011	0.026	0.017	0.017	0.001
Chelsea	11	0.017	0.043	0.026	0.026	0.002
Whau Creek	11	0.017	0.031	0.021	0.024	0.002
Henderson Creek	11	0.016	0.039	0.032	0.028	0.002
Hobsonville Jetty	11	0.015	0.032	0.025	0.025	0.002
Lucas Creek	11	0.018	0.049	0.036	0.034	0.003
Waimarie Road	11	0.015	0.043	0.029	0.029	0.002
Paremoremo Ski Club	11	0.014	0.056	0.029	0.032	0.003
Rawawaru Creek	11	0.012	0.066	0.034	0.034	0.004
Brighams Creek	11	0.017	0.094	0.034	0.037	0.006
Rangitopuni Creek	11	0.024	0.084	0.047	0.052	0.006
Tamaki	10	0.016	0.048	0.027	0.029	0.003
Panmure	10	0.030	0.061	0.041	0.043	0.004
Turanga Estuary	12	0.008	0.033	0.023	0.022	0.002
Wairoa River	12	0.015	0.050	0.025	0.026	0.003
Mangere Bridge	11	0.092	0.200	0.130	0.129	0.009
Puketutu Point	10	0.098	0.330	0.120	0.158	0.026
Weymouth	11	0.030	0.079	0.044	0.047	0.005
Waiuku Town Basin	11	0.032	0.097	0.057	0.062	0.007
Clarks Beach	11	0.020	0.049	0.036	0.035	0.003
Grahams Beach	11	0.014	0.051	0.029	0.032	0.003
Shag Point	11	0.034	0.098	0.068	0.069	0.006
Manukau Heads	11	0.009	0.026	0.017	0.017	0.002
Kaipara Heads	11	0.003	0.016	0.009	0.009	0.001
Tauhoa Channel	11	0.008	0.022	0.013	0.014	0.001
Hoteo River mouth	10	0.017	0.044	0.023	0.025	0.002
Omokoiti Beacon	11	0.010	0.026	0.017	0.018	0.001
Makarau Estuary	11	0.019	0.046	0.028	0.030	0.003
Shelly Beach	11	0.014	0.038	0.025	0.024	0.002
Kaipara River	11	0.025	0.082	0.046	0.045	0.006

Table 4-15 Soluble reactive phosphorus (mg/L) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.005	0.011	0.008	0.008	0.001
Ti Point	12	0.006	0.011	0.007	0.008	0.000
Dawsons Creek	12	0.008	0.012	0.009	0.009	0.000
Mahurangi Heads	12	0.005	0.013	0.008	0.009	0.001
Orewa	12	0.006	0.012	0.008	0.009	0.001
Browns Bay	12	0.008	0.017	0.012	0.012	0.001
Chelsea	11	0.010	0.025	0.015	0.016	0.001
Whau Creek	11	0.010	0.024	0.016	0.016	0.001
Henderson Creek	11	0.010	0.023	0.015	0.016	0.001
Hobsonville Jetty	11	0.010	0.022	0.016	0.015	0.001
Lucas Creek	11	0.009	0.026	0.018	0.017	0.002
Waimarie Road	11	0.011	0.026	0.018	0.018	0.001
Paremoremo Ski Club	11	0.011	0.027	0.018	0.019	0.002
Rawawaru Creek	11	0.007	0.026	0.018	0.017	0.002
Brighams Creek	11	0.003	0.027	0.020	0.018	0.002
Rangitopuni Creek	11	0.005	0.030	0.020	0.019	0.002
Tamaki	10	0.013	0.025	0.021	0.019	0.001
Panmure	10	0.016	0.030	0.023	0.023	0.001
Turanga Estuary	12	0.009	0.019	0.013	0.014	0.001
Wairoa River	12	0.010	0.020	0.015	0.015	0.001
Mangere Bridge	11	0.065	0.120	0.088	0.089	0.005
Puketutu Point	10	0.065	0.290	0.099	0.123	0.023
Weymouth	11	0.017	0.029	0.024	0.023	0.001
Waiuku Town Basin	11	0.020	0.038	0.030	0.030	0.002
Clarks Beach	11	0.013	0.021	0.019	0.018	0.001
Grahams Beach	11	0.008	0.024	0.017	0.016	0.001
Shag Point	11	0.027	0.072	0.050	0.047	0.004
Manukau Heads	11	0.007	0.017	0.012	0.012	0.001
Kaipara Heads	11	0.004	0.011	0.007	0.007	0.001
Tauhoa Channel	11	0.005	0.018	0.010	0.010	0.001
Hoteo River mouth	10	0.009	0.021	0.014	0.014	0.001
Omokoiti Beacon	11	0.006	0.014	0.009	0.009	0.001
Makarau Estuary	11	0.008	0.020	0.014	0.013	0.001
Shelly Beach	11	0.008	0.015	0.010	0.011	0.001
Kaipara River	11	0.010	0.020	0.015	0.014	0.001

Table 4-16 Dissolve oxygen (% saturation) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	95.20	105.00	100.80	100.43	1.06
Ti Point	11	97.60	107.90	100.60	101.59	0.99
Dawsons Creek	11	90.30	103.00	95.90	95.84	1.13
Mahurangi Heads	11	96.00	103.90	99.20	99.65	0.80
Orewa	11	98.00	105.80	100.50	101.15	0.74
Browns Bay	11	95.40	110.20	101.00	100.97	1.17
Chelsea	11	94.30	98.00	96.50	96.36	0.33
Whau Creek	11	92.40	100.90	96.00	96.15	0.74
Henderson Creek	11	91.40	98.40	94.90	94.94	0.76
Hobsonville Jetty	11	93.70	99.10	96.50	96.68	0.50
Lucas Creek	11	86.00	96.60	92.20	91.75	1.08
Waimarie Road	10	88.40	100.10	92.45	93.28	1.20
Paremoremo Ski Club	11	86.40	101.00	93.00	92.46	1.41
Rawawaru Creek	10	83.40	100.00	88.90	91.61	1.93
Brighams Creek	10	83.50	108.40	89.90	91.28	2.30
Rangitopuni Creek	9	79.80	98.90	88.50	89.17	2.50
Tamaki	9	87.00	95.00	91.10	90.96	1.04
Panmure	9	82.20	99.20	86.90	88.84	1.89
Turanga Estuary	11	92.20	104.80	99.30	99.00	0.96
Wairoa River	11	94.40	103.10	97.50	98.16	0.72
Mangere Bridge	11	93.30	111.20	97.20	99.45	1.69
Puketutu Point	11	96.10	109.60	98.70	100.83	1.36
Weymouth	11	95.70	101.60	97.40	98.14	0.60
Waiuku Town Basin	11	90.00	104.40	95.90	96.30	1.18
Clarks Beach	11	93.70	100.50	96.80	96.99	0.63
Grahams Beach	11	98.20	102.00	99.90	100.07	0.41
Shag Point	11	97.10	111.80	100.20	102.05	1.45
Manukau Heads	11	99.50	102.90	100.90	100.96	0.34
Kaipara Heads	11	101.20	105.60	102.90	103.28	0.42
Tauhoa Channel	11	98.70	103.50	100.30	100.63	0.44
Hoteo River mouth	11	93.60	102.00	97.60	97.42	0.75
Omokoiti Beacon	11	98.70	103.40	100.40	100.80	0.48
Makarau Estuary	11	94.00	100.70	98.40	97.74	0.69
Shelly Beach	11	94.70	102.30	98.80	98.64	0.64
Kaipara River	11	92.50	99.80	96.80	96.68	0.67

Table 4-17 Dissolved oxygen (ppm) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	7.07	8.56	7.79	7.79	0.15
Ti Point	11	7.28	8.52	7.82	7.86	0.13
Dawsons Creek	11	6.45	8.38	7.25	7.41	0.19
Mahurangi Heads	11	6.94	8.30	7.70	7.68	0.15
Orewa	11	7.13	8.66	7.73	7.79	0.14
Browns Bay	11	7.04	8.80	7.93	7.80	0.15
Chelsea	11	6.93	8.56	7.62	7.66	0.18
Whau Creek	11	6.77	8.87	7.62	7.73	0.23
Henderson Creek	11	6.69	9.06	7.66	7.65	0.25
Hobsonville Jetty	11	6.92	8.92	7.63	7.73	0.22
Lucas Creek	11	6.21	9.31	7.42	7.49	0.31
Waimarie Road	10	6.40	9.14	7.72	7.67	0.34
Paremoremo Ski Club	11	6.23	9.11	7.43	7.51	0.32
Rawawaru Creek	10	6.04	9.12	7.56	7.35	0.33
Brighams Creek	10	5.98	10.13	7.35	7.39	0.41
Rangitopuni Creek	9	5.70	9.99	7.05	7.21	0.48
Tamaki	9	6.36	7.78	6.89	7.05	0.17
Panmure	9	6.27	8.17	7.01	7.10	0.24
Turanga Estuary	11	7.05	8.28	7.56	7.67	0.14
Wairoa River	11	6.90	8.37	7.63	7.62	0.15
Mangere Bridge	11	7.04	8.81	8.00	7.97	0.17
Puketutu Point	11	7.04	8.95	7.95	8.03	0.17
Weymouth	11	6.87	9.14	7.61	7.83	0.22
Waiuku Town Basin	11	6.50	9.53	7.65	7.84	0.27
Clarks Beach	11	6.85	8.86	7.62	7.72	0.21
Grahams Beach	11	7.20	8.94	7.86	7.93	0.18
Shag Point	11	7.30	8.89	8.01	8.07	0.14
Manukau Heads	11	7.32	8.71	8.06	7.99	0.15
Kaipara Heads	11	7.44	9.01	8.01	8.17	0.16
Tauhoa Channel	11	7.13	9.09	7.93	8.00	0.20
Hoteo River mouth	11	6.79	9.27	7.74	7.85	0.25
Omokoiti Beacon	11	7.19	9.05	7.83	8.00	0.19
Makarau Estuary	11	6.73	9.19	7.72	7.85	0.24
Shelly Beach	11	6.90	9.13	7.67	7.88	0.22
Kaipara River	11	6.93	9.03	7.57	7.78	0.22

Table 4-18 Summary table of temperature (°C) for data collected from January 2014 to December 2014.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	11	14.24	20.42	17.44	17.56	0.75
Ti Point	11	13.93	20.56	17.39	17.62	0.76
Dawsons Creek	11	13.08	22.84	18.03	18.14	1.05
Mahurangi Heads	11	13.05	21.17	18.57	17.93	0.89
Orewa	11	13.10	21.90	18.24	17.93	0.94
Browns Bay	11	12.86	21.28	17.65	17.73	0.95
Chelsea	11	12.59	21.10	17.10	16.75	1.01
Whau Creek	11	11.64	21.30	17.38	16.69	1.11
Henderson Creek	11	12.08	21.07	17.61	16.83	1.08
Hobsonville Jetty	11	12.52	21.13	17.66	16.88	1.05
Lucas Creek	11	11.69	21.53	17.61	17.01	1.15
Waimarie Road	10	12.15	21.35	17.95	17.17	1.22
Paremoremo Ski Club	11	11.80	21.44	17.62	17.16	1.10
Rawawaru Creek	10	11.74	21.65	18.81	17.54	1.22
Brighams Creek	10	11.53	21.72	18.42	17.58	1.25
Rangitopuni Creek	10	10.94	21.91	18.30	17.53	1.28
Tamaki	9	13.70	21.66	17.30	18.08	0.97
Panmure	9	13.12	21.31	17.19	17.76	0.98
Turanga Estuary	11	13.11	21.76	17.23	17.69	0.96
Wairoa River	11	13.07	22.73	17.70	17.87	1.08
Mangere Bridge	11	11.73	22.71	17.58	17.12	1.11
Puketutu Point	11	12.04	22.50	17.50	17.22	1.10
Weymouth	11	11.44	22.88	17.56	17.06	1.13
Waiuku Town Basin	11	11.21	22.56	17.78	17.06	1.14
Clarks Beach	11	11.64	21.84	17.23	16.88	1.05
Grahams Beach	11	11.81	21.52	17.06	16.88	1.01
Shag Point	11	11.69	22.40	17.65	17.13	1.13
Manukau Heads	11	12.77	20.69	16.67	16.74	0.83
Kaipara Heads	11	13.06	20.36	17.20	16.94	0.75
Tauhoa Channel	11	12.67	21.54	17.55	17.37	0.90
Hoteo River mouth	11	11.99	21.85	17.02	17.22	0.98
Omokoiti Beacon	11	12.58	21.39	17.39	17.33	0.90
Makarau Estuary	11	11.92	21.99	17.54	17.20	1.01
Shelly Beach	11	12.10	21.48	17.63	17.31	0.94
Kaipara River	11	11.95	21.65	17.75	17.18	0.96

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.
- 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 (TR 2008/005), 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
- Walker, J and Vaughan, M (2014). Marine water quality report 2013. Auckland Council technical report, TR2014/030
- 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 its inception in 1987.

During the 2014 sampling season, Peter Williams and Ebrahim Hussain for organising the sampling and efforts from other members of the RIMU Environmental Science and Monitoring team. 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 (EXO 2-YSI)	Field
Dissolved oxygen saturation	% sat	0.01	Handheld meter (EXO 2-YSI)	Field
Temperature	°C	0.1	Handheld meter (EXO 2-YSI)	Field
Conductivity	(mS cm)	0.1	Handheld meter (EXO 2-YSI)	Field
Salinity	ppt	0.01	Handheld meter (EXO 2-YSI)	Field
pH	pH units	0.01	Handheld meter (EXO 2-YSI)	Field
Suspended sediment	mg/L	0.2	APHA (2012) 2540 D	Lab
Turbidity	NTU	0.1	APHA (2012) 2130 B (modified)	Lab
Chlorophyll a	mg/L	0.0006	APHA (2012) 10200 H (modified)	Lab
Nitrate nitrogen (NO ₃)	mg/L	0.002	Calculation (NNN - NO ₂)	Lab
Nitrite nitrogen (NO ₂)	mg/L	0.002	APHA (2012) 4500-NO ₂ B (modified)	Lab
Ammoniacal nitrogen (NH ₄ -N)	mg/L	0.005	APHA (2012) 4500-NH ₃ G (modified)	Lab
Total kjeldahl nitrogen (TKN)	mg N /L	0.02	APHA (2012) 4500-org A, D Modified	Lab
Total nitrogen (TN)	mg N /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

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 as shown in Table B-1 below. The objectives against which the water quality data are tested 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 (2010 to 2014). It was considered thresholds based on a fixed period, while 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.

Parameter	Objective (acceptable if)
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