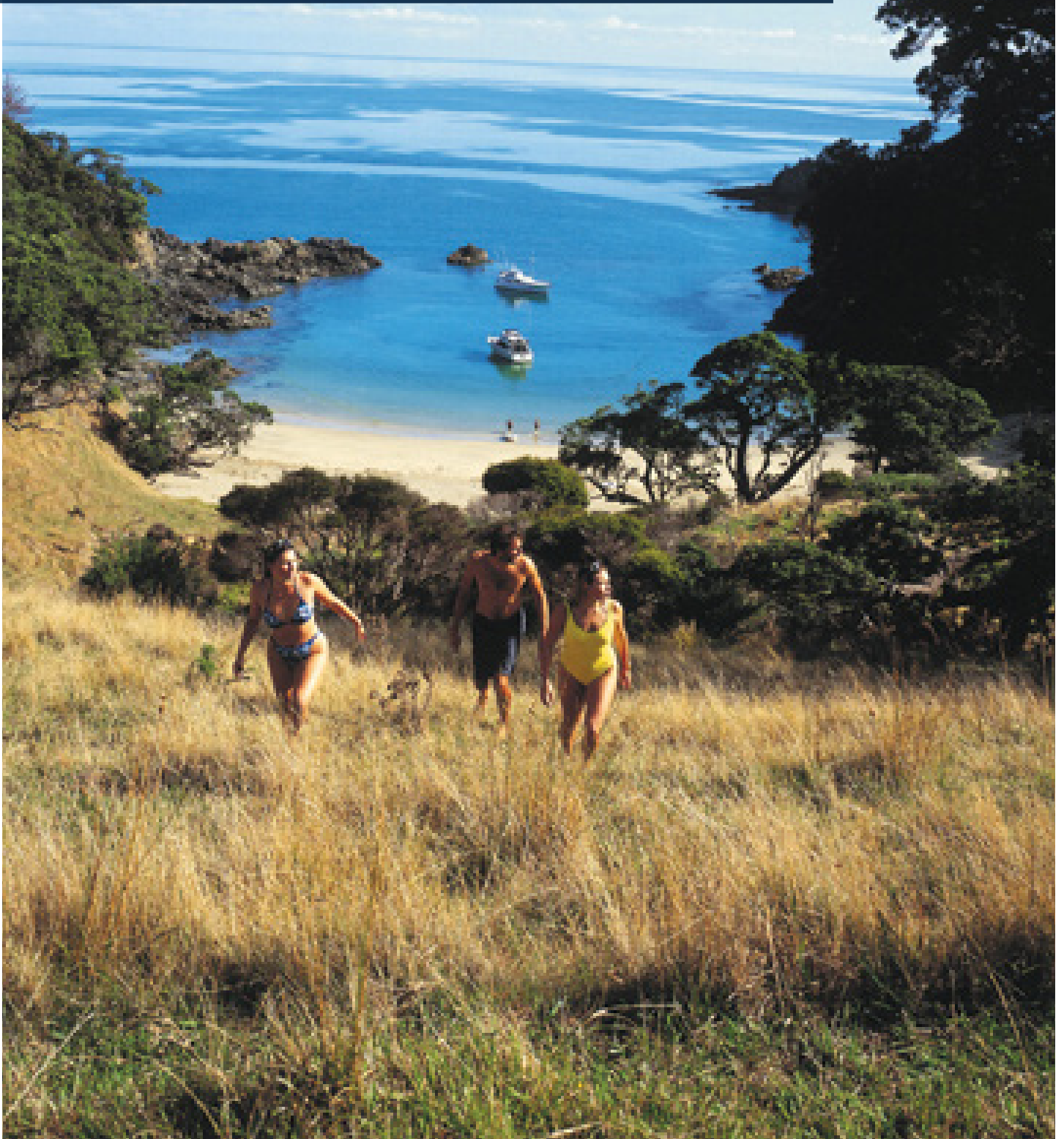


Marine Water Quality Annual Report 2015

June 2017

Technical Report 2017/015



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Auckland Council
Technical Report 2017/015
ISSN 2230-4525 (Print)
ISSN 2230-4533 (Online)

ISBN 978-1-98-852924-0 (Print)
ISBN 978-1-98-852925-7 (PDF)

This report has been peer reviewed by the Peer Review Panel.
Submitted for review on 24 March 2017 Review completed on 15 June 2017 Reviewed by two reviewers
Approved for Auckland Council publication by: Name: Dr Lucy Baragwanath Position: Manager, Research and Evaluation (RIMU) Name: Jacqueline Anthony Position: Manager, Environmental Monitoring, Research and Evaluation (RIMU)
Date: 15 June 2017

Recommended citation

Williams, P., Vaughan, M and Walker, J (2017). Marine water quality annual report 2015.
Auckland Council technical report, 2017/015

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Marine Water Quality Annual Report 2015

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Auckland Council

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1.0 Executive summary

The Auckland Council operates a long-term, region-wide saline water quality monitoring programme. The main objective of this programme is to gather information for State of the Environment reporting under section 35 of the Resource Management Act 1991; to identify and monitor environmental issues and to assess the efficiency of council initiatives, policies and strategies. This report documents changes made to the monitoring programme since the last report and provides a summary of the data collected in 2015.

Water quality is assessed monthly using a combination of field based and laboratory tested parameters at 35 sites which are distributed across six geographically distinct sampling runs around the region. The results are presented as box plots, which display the variation in the measured parameters at each site, and in tables which provide a statistical summary of each parameter at each site.

The data has been used to produce water quality indices (WQI) which allows for sites to be assigned a water quality class and ranked. The analysis combines all water quality measures to provide a general and readily understood description of the water quality.

Before an index can be calculated, appropriate objectives need to be defined. Variables from reference sites are used to summarize water quality from Auckland's harbours to create objectives to be tested against. Prior to 2015, only east coast sites had been included as reference sites due to the lack of sufficient data from west coast harbours. However, two sites, Kaipara Heads and Manukau Harbour Mouth, have now reached five years of data and have been included with the reference sites to calculate objectives. Including the west coast sites' data has resulted in the objective values now being slightly lower than previously reported.

When comparing the WQI calculations with and without the new reference sites, 10 sites (29%) resulted in a different class. The adjustment has resulted in fewer sites with poor water quality and more excellent ranked sites. These changes have come about as a result of the addition of new reference sites to the programme and a lowering of the objective values, rather than an actual change in water quality between 2014 and 2015.

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 (Auckland Council, 2015) 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 (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 2009-19. 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 two other programmes – sediment contaminants and benthic ecology to provide an integrated overview of the physical, chemical, and biological condition of the region's marine environment (Table A- 1, Appendix A). The three marine monitoring programmes are outlined as follows:

- The marine water quality programme monitors naturally 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 Auckland Council also ran a shellfish contaminant monitoring programme which indirectly monitors chemical contaminants in the water column. This program ceased 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 monitors 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 2015 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 grouped into four main categories (Excellent, Good, Fair and Poor).

3.0 Methods

3.1 Programme design

Sampling of surface waters for marine water quality monitoring is undertaken monthly by Auckland Council environmental monitoring specialists, predominantly by helicopter. This enables sites spread over a broad area to be collected within a narrow time frame created by 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 into the water. The 2 litre plastic 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.

- 9 sites in the inner Hauraki Gulf and outer Waitematā Harbour (including 2 sites in Mahurangi Harbour;
- 7 sites in Kaipara Harbour;
- 7 sites in the Upper Waitematā 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); and
- 8 sites in Manukau Harbour.

Temporal variation is avoided as much as possible by maintaining a consistent sampling time relative to tidal cycle. Samples are collected approximately 10 mins–2.5 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



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; and
- 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 16 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 has become more affordable, instrument sensitivity improved and the programme objectives modified.

3.3 Programme changes

In June 2014, the monitoring site at the confluence in the Upper Waitematā Harbour was dropped from the sampling programme. In July 2015 a further four sites were dropped from the sampling programme due to budget constraints; Omokoti Beacon in the Kaipara, Turanga Estuary in the Tamaki Straight, Rarawaru and Waimarie in the Upper Waitematā Harbour.

In January 2009, six new sites in the Kaipara Harbour were added to the 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. In August 2012 an additional site, Waiuku Town Basin was also added to the programme. 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 has showed 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 it can be calculated from the current nitrogen species analysed.

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 Dec 2014, the YSI 556 MPS multi-parameter meter was upgraded to the EXO 2 multi-parameter sonde (Xylem Analytics).

A 2005 review of this program resulted in the removal of biological oxygen demand (BOD) parameter from the list of analytical laboratory tests. This was due to laboratory analysis

consistently returning results at the laboratory detection limit (<2ppm) and no improved methodology was forthcoming or available from WLS. 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.

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 WLS, an International Accreditation New Zealand (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 certification.

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 Statistica version 13.
- 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 Appendix A.

3.5 Reports

This is the 25th data report since the inception of the monitoring programme, and it is the ninth 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 periodically, the last report was published in 2008 (Scarsbrook 2008, TP2008/005) and a previous report published in 1999 (Vant and Lee, 1998). The most recent trends analysis is currently being written. Auckland Council's *The health of*

Auckland's natural environment in 2015 report briefly summarises water quality issues and the pressures facing the Auckland region and its ecological health (Auckland Council, 2015).

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 web site.

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

4.0 Results and discussion

Data from the 2015 calendar year are presented as box plots (section 4.1) 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 4.4. 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 were produced using the data and summarised in section 4.2. Data for the four sites removed in July 2015 (see section 3.3 above) are captured in this report but caution must be exercised in their interpretation as only 6 months of data in the 2015 calendar year was collected.

4.1 Box plots

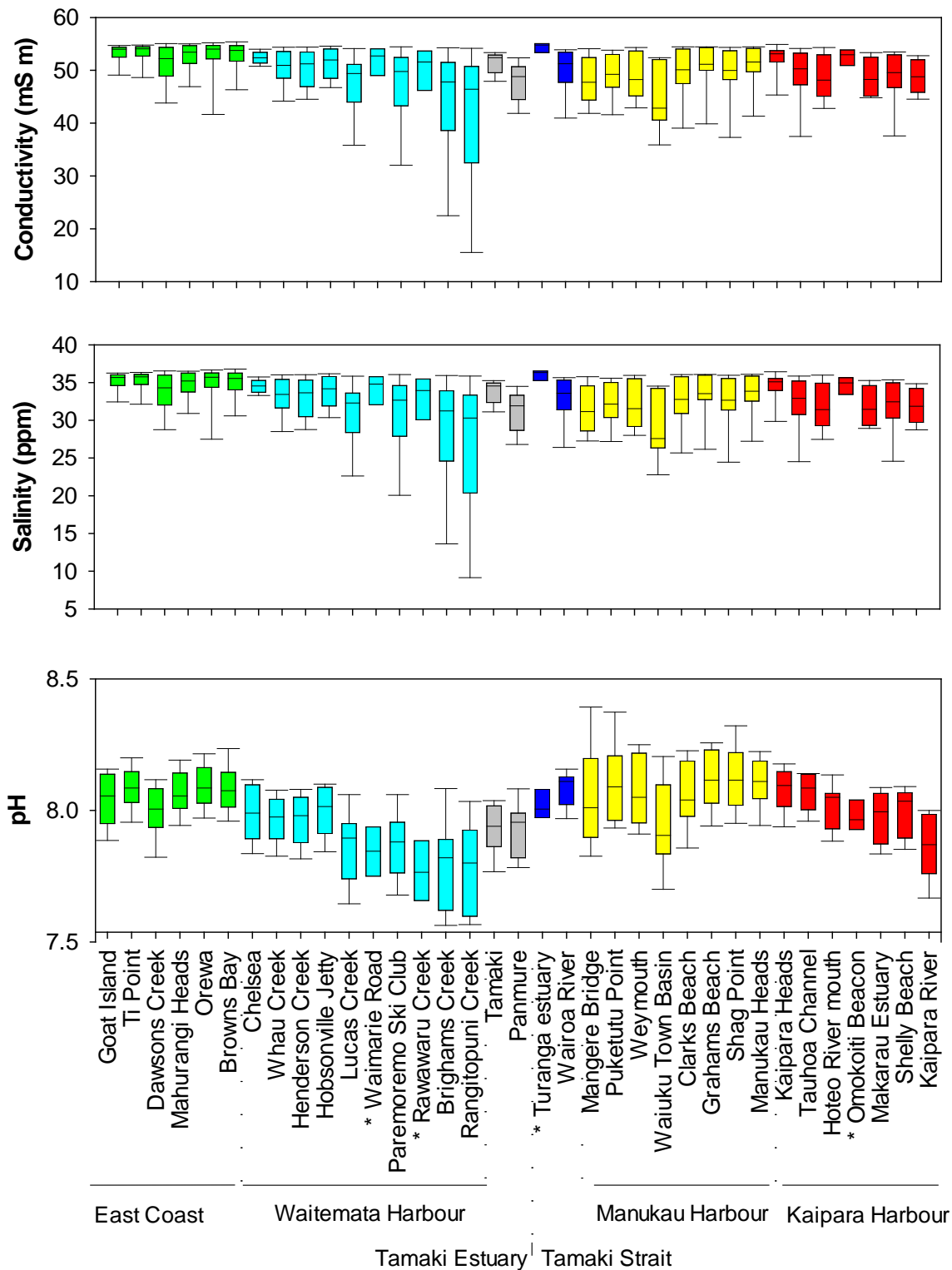


Figure 4-1 Spatial patterns in conductivity, salinity and pH. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2015 to December 2015. Percentile values calculated using the standard method in SigmaPlot (v12). * = sites with only 6 months of data.

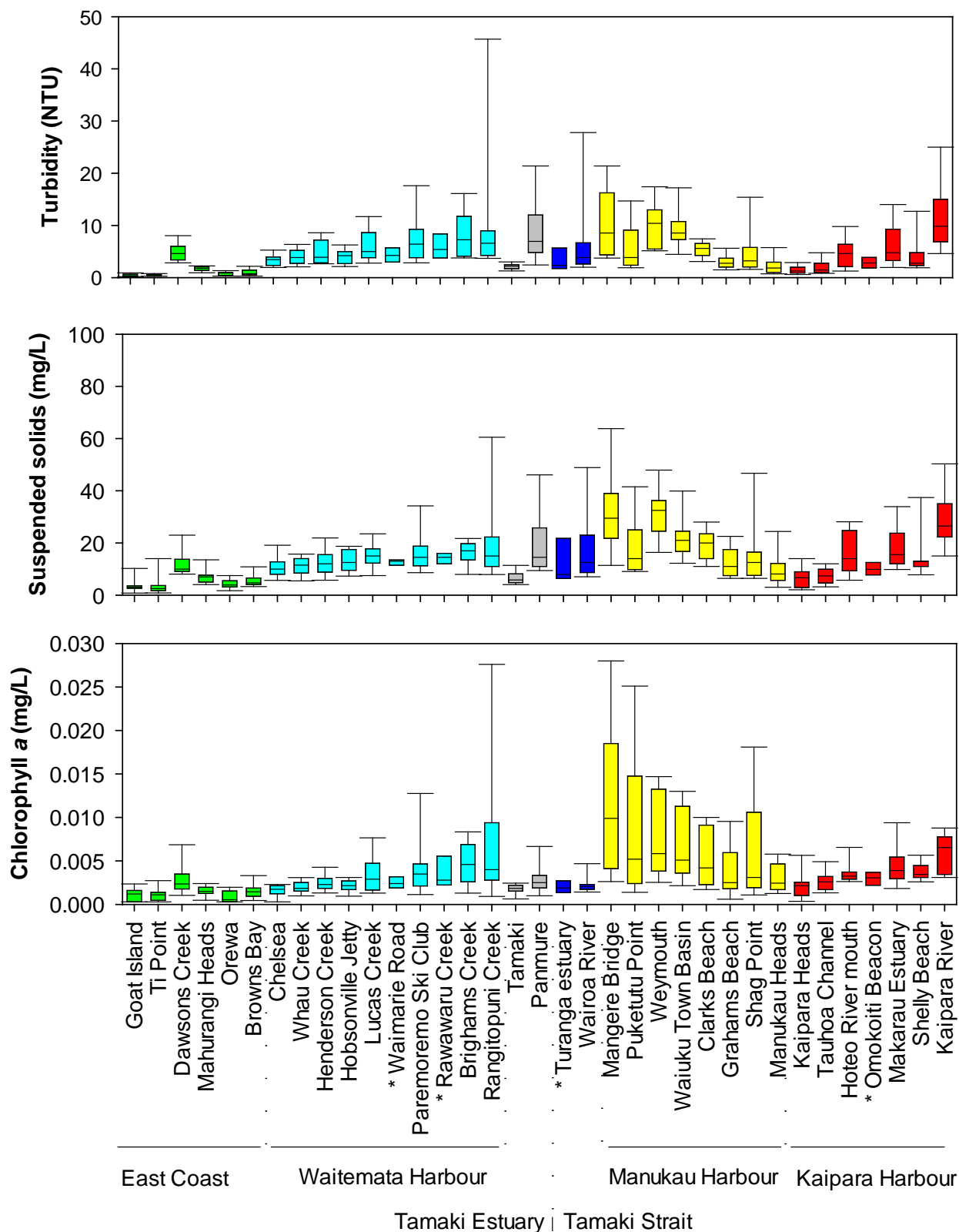


Figure 4-2 Spatial patterns in turbidity, suspended sediment, and chlorophyll a. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2015 to December 2015. Percentile values calculated using the standard method in SigmaPlot (v12). * = sites with only 6 months of data.

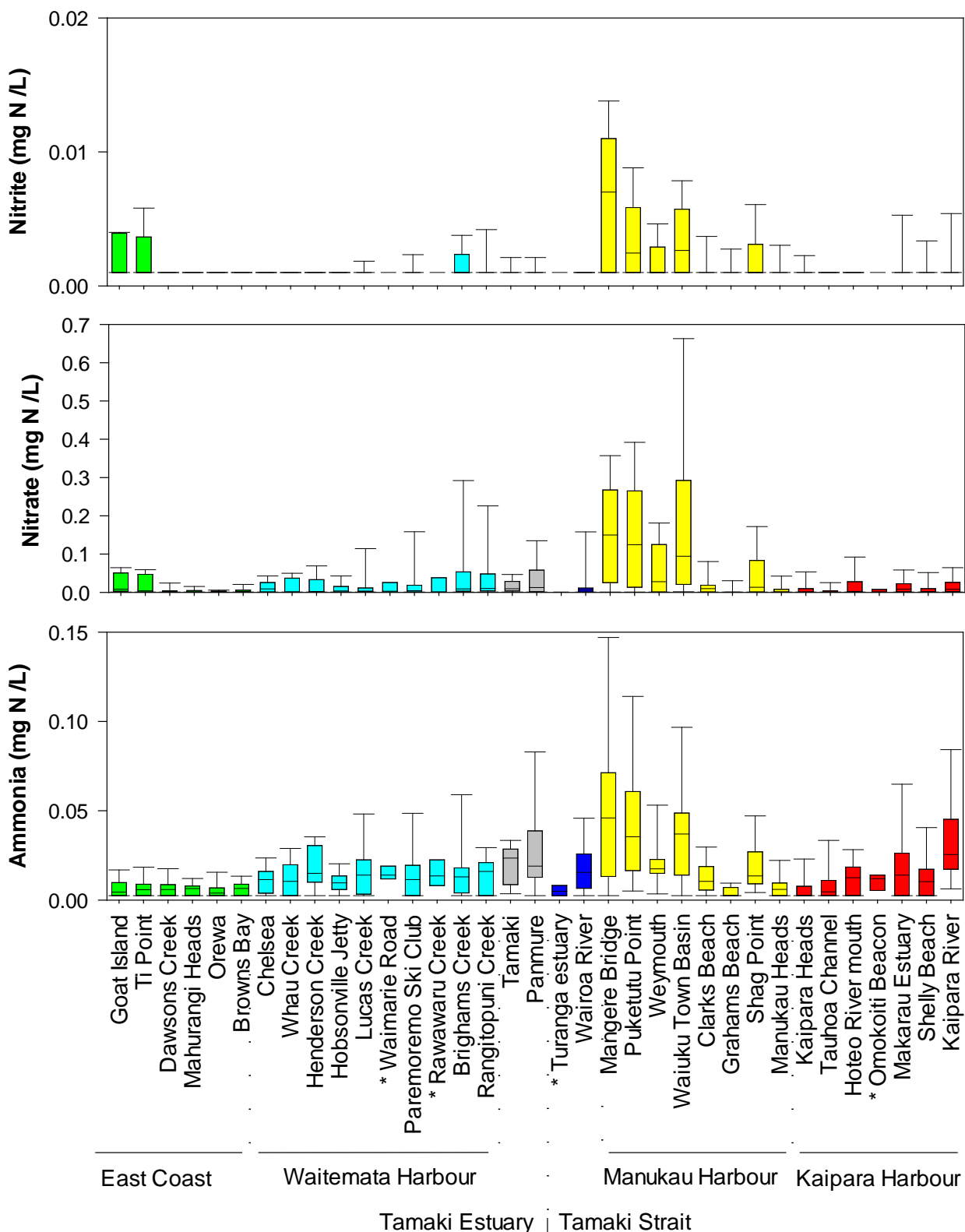


Figure 4-3 Spatial patterns in nitrite, nitrate and ammonia. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2015 to December 2015. Percentile values calculated using the standard method in SigmaPlot (v12). * = sites with only 6 months of data.

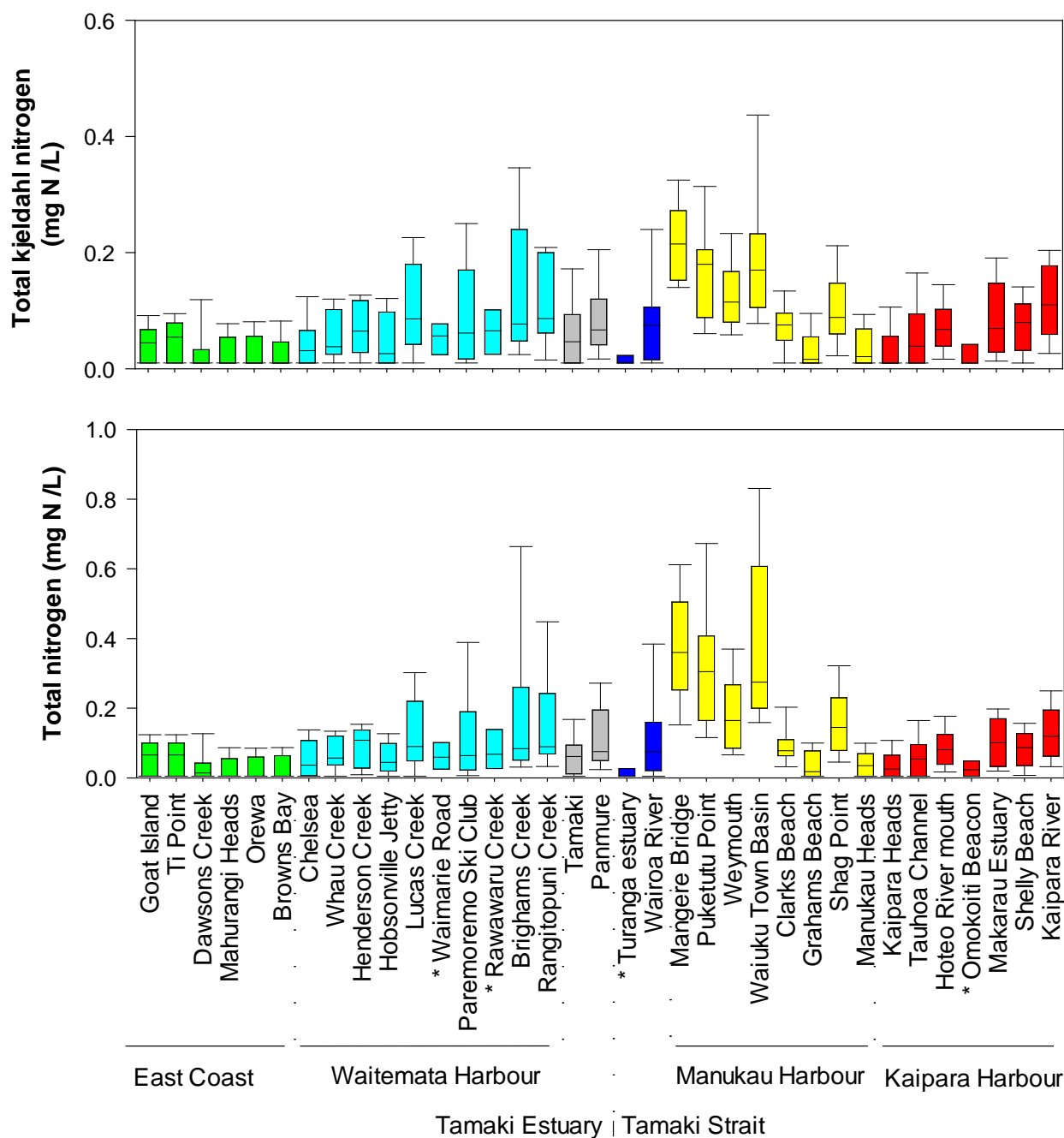


Figure 4-4 Spatial patterns in total kjeldahl nitrogen and total nitrogen. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2015 to December 2015. Percentile values calculated using the standard method in SigmaPlot (v12). * = sites with only 6 months of data.

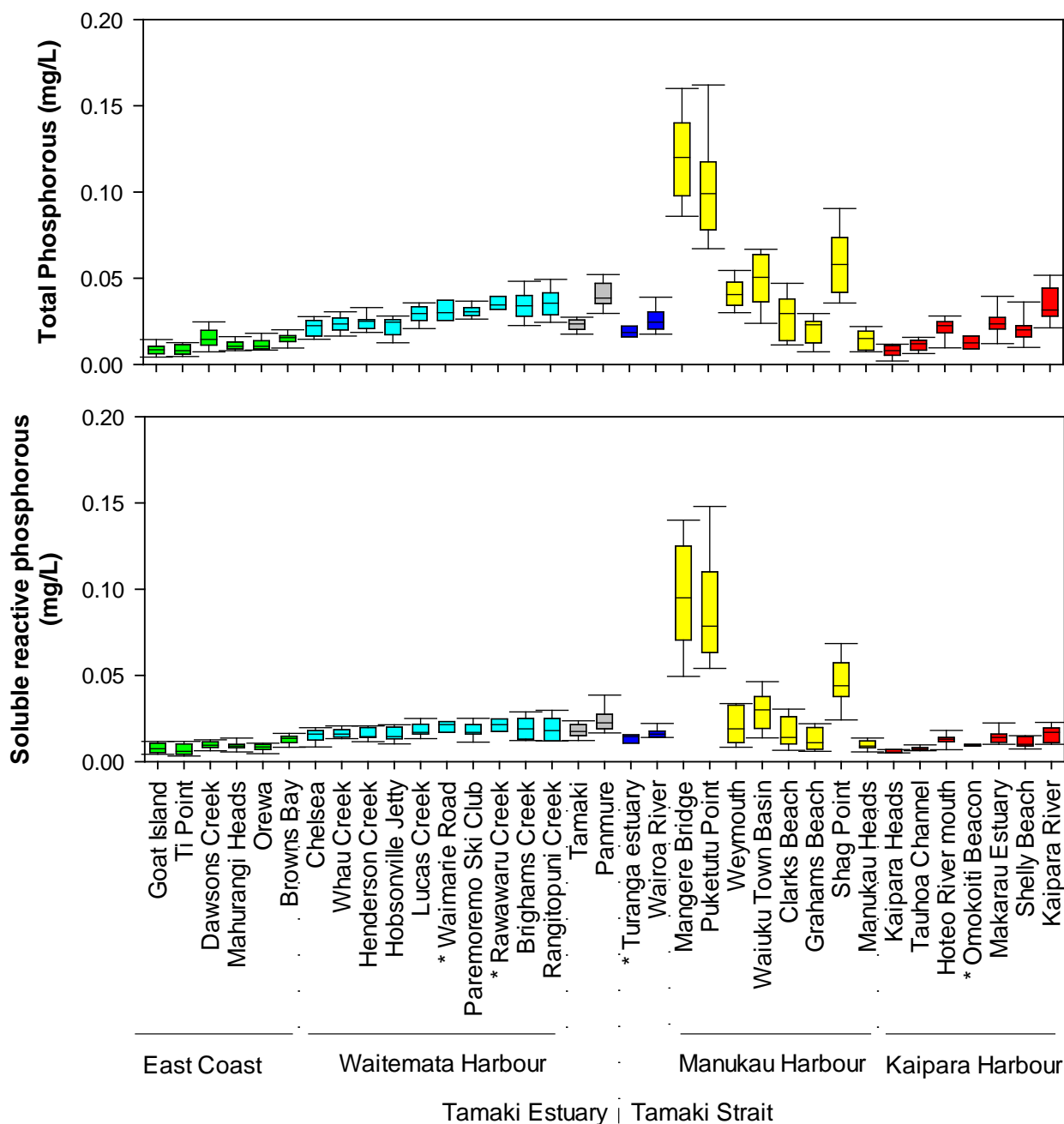


Figure 4-5 Spatial patterns in total phosphorous and soluble reactive phosphorous. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2015 to December 2015. Percentile values calculated using the standard method in SigmaPlot (v12). * = sites with only 6 months of data.

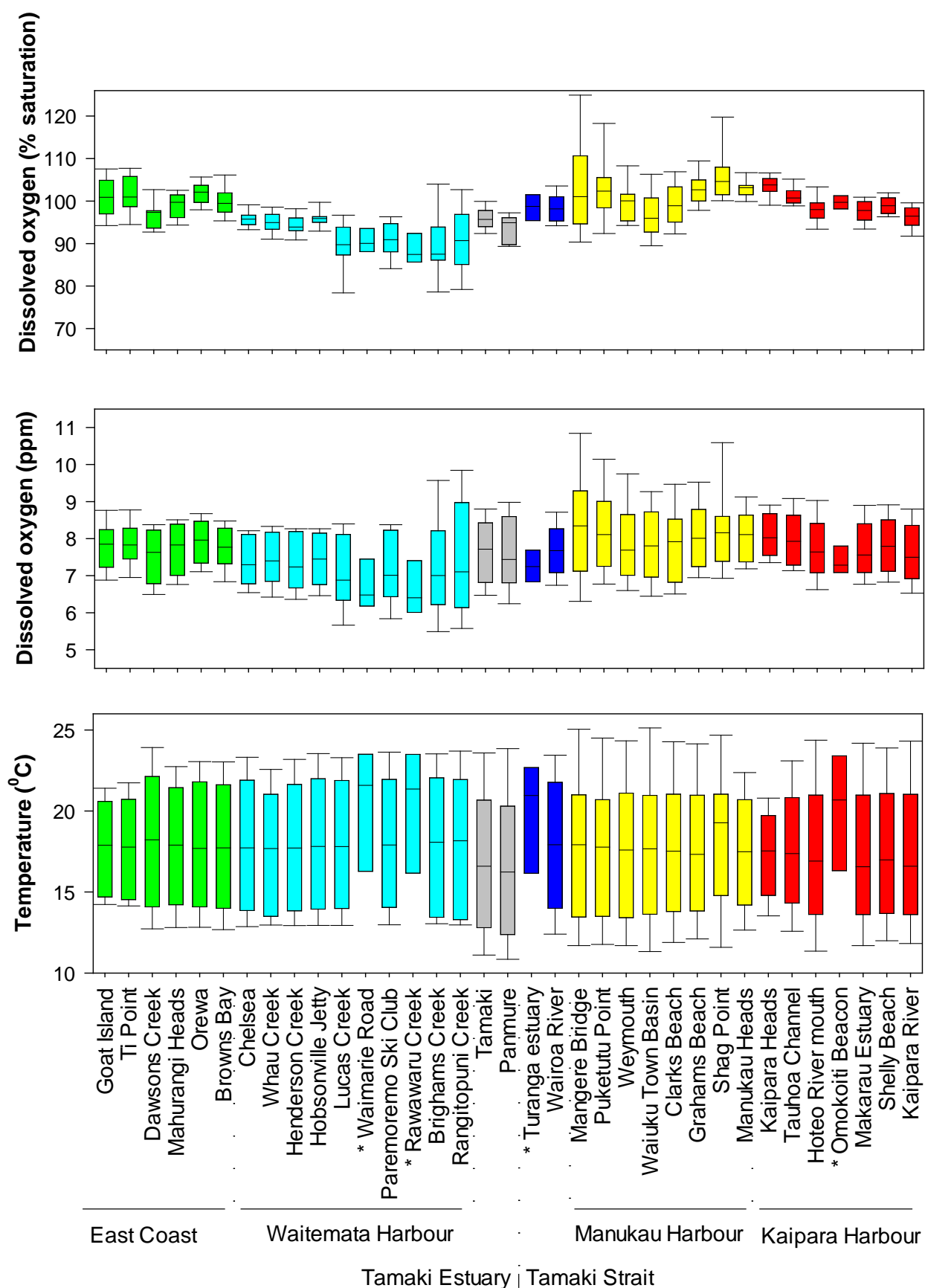


Figure 4-6 Spatial patterns in two indices of dissolved oxygen (ppm and % saturation) and sea surface temperature. Boxes represent the median, 25th and 75th percentiles while whiskers are 5th and 95th percentiles for data collected from January 2015 to December 2015. Percentile values calculated using the standard method in SigmaPlot (v12). * = sites with only 6 months of data.

4.2 Marine Water Quality Index

Using the methodology described in Appendix A 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). Before an index can be calculated, appropriate objectives need to be defined. Variables from reference sites are used to summarize water quality from Auckland's harbours to create objectives to be tested against. Prior to 2015, only east coast sites have been included as reference sites due to the lack of enough data from west coast harbours. However two sites, Kaipara Heads and Manukau Harbour Mouth have now reached five years of data and have been included with the reference sites to calculate objectives. Five years of data collection at these two sites show they have some of the 'best' water quality observed in each of the two harbours. These two sites join others from both the east coast (Ti Point and Goat Island) and Waitemata Harbour (Chelsea and Hobsonville Jetty). It should be noted here, that the inclusion of the two west coast sites has slightly lowered the objective values, due to lower water quality results.

A three year rolling average was used to calculate the final 2015 WQI score, incorporating the WQIs from the previous two years (i.e. 2013 and 2014). This averaging eliminates any major inter annual variations due to environmental changes (e.g. heavy rain fall and storms) or human impacts such as development. The decision to present a three year averaged WQI aligns with the State of Auckland marine report cards water quality indicator and allows for greater consistency in the communication of water quality data and the relative changes in the environment.

2015 results showed that seven sites (Browns Bay, Goat Island, Hobsonville, Mahurangi Heads, Omokoiti Beacon Orewa and Ti Point) all shared the top spot in 2015, with the highest possible WQI of 100 (Table 4-2). Mangere Bridge had the worst water quality in 2015, unchanged from 2014 (Walker and Vaughan, 2015).

Twelve sites changed water quality class from their 2014 classification (Walker and Vaughan, 2015). Seven sites had an increase in water quality of one class and Grahams Beach increased by two classes from Fair to excellent (one as a result of an increase in environmental water quality and the other due to the inclusion of new reference sites). Five sites decreased in water quality (Kaipara Heads, Turanga and Manukau Heads – excellent to good, and Lucas creek and Paremoremo Ski Club fair to poor).

When considering the results over the past three years, two sites have maintained excellent water quality (Orewa and Mahurangi Heads), one site has maintained good water quality (Dawsons Creek), no sites have stayed as fair water quality and nine sites have remained as poor water quality (Rangitopuni Creek, Weymouth, Brighams Creek, Kaipara River, Panmure, Waiuku Town Basin, Puketutu Point, Shag Point and Mangere Bridge).

For the 2015 calendar year, the proportion of poor and excellent sites are similar (31% and 29% respectively, Table 4-1) while the proportion of good and fair sites are both 20%.

Table 4-1 Percentage of sites per water quality class. Note there are 35 sites in 2011, 2014 and 2015 and 36 sites in 2012 and 2013. The 2015 proportions are based on the 'new' water quality index.

Water Quality Class	2013	2014	2015
Excellent	9%	20%	29%
Good	20%	26%	20%
Fair	29%	23%	20%
Poor	43%	31%	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 Appendix A. * = sites with only 6 months' data in 2015.

Site	2013 class	2014 class	2015 class	2015 WQI
Browns Bay	Good	Excellent	Excellent	100.0
Goat Island	Good	Good	Excellent	100.0
Hobsonville Jetty	Fair	Good	Excellent	100.0
Mahurangi Heads	Excellent	Excellent	Excellent	100.0
Omokoiti Beacon*	Fair	Good	Excellent	100.0
Orewa	Excellent	Excellent	Excellent	100.0
Ti Point	Good	Excellent	Excellent	100.0
Chelsea	Excellent	Good	Excellent	92.8
Grahams Beach	Fair	Fair	Excellent	92.5
Tamaki	Good	Good	Excellent	91.9
Kaipara Heads	Fair	Excellent	Good	85.5
Whau Creek	Fair	Good	Good	85.5
Tauhoa Channel	Fair	Good	Good	85.4
Turanga*	Good	Excellent	Good	85.3
Dawsons Creek	Good	Good	Good	78.3
Manukau Heads	Fair	Excellent	Good	78.2
Henderson Creek	Fair	Good	Good	77.9
Waimarie*	Poor	Fair	Fair	69.9
Shelly Beach	Good	Fair	Fair	63.6
Hoteo River mouth	Fair	Fair	Fair	63.5
Clarks Beach	Poor	Fair	Fair	63.2
Wairoa River Mouth	Fair	Fair	Fair	62.9
Makarau Estuary	Poor	Poor	Fair	62.6
Rawawaru Creek*	Poor	Poor	Fair	61.9
Kaipara River	Poor	Poor	Poor	57.5
Lucas Creek	Poor	Fair	Poor	55.6
Paremoremo Ski Club	Poor	Fair	Poor	55.3
Brighams Creek	Poor	Poor	Poor	53.8
Shag Point	Poor	Poor	Poor	53.2
Weymouth	Poor	Poor	Poor	50.6
Panmure	Poor	Poor	Poor	46.9

Site	2013 class	2014 class	2015 class	2015 WQI
Rangitopuni Creek	Poor	Poor	Poor	46.2
Waiuku Town Basin	Poor	Poor	Poor	42.5
Puketutu Point	Poor	Poor	Poor	33.1
Mangere Bridge	Poor	Poor	Poor	29.0

4.3 Comparison of WQI before and after the addition of new reference sites

To determine how much change the inclusion of the two new reference sites, Kaipara Heads and Manukau Harbour Mouth, has had to WQI classes for sites a comparison of the calculation with and without the new sites was carried out. The addition of the west coast sites caused the objective values to slightly lower, and as a result there was a decrease in the number of poor sites and an increase in the number of excellent sites.

By altering the objectives 71% of sites had the same result as they would have done prior to the addition of new reference sites, and nine sites (26%) were different by one water quality class and one (Henderson Creek) by two water quality classes (Table 4-3).

Overall there is some change in the results from the addition of west coast reference sites that are not due to environmental change between the years. However, by including sites from both coasts presents a reference set that is more representative of Auckland, and will allow results to be more reflective of the types and quality of the marine water throughout the region.

Table 4-3 Comparison of water quality results with and without west coast reference sites included in objectives. Comparisons were undertaken for 2015 analysis only.

Site	Old WQI	New WQI	Change in grade
Browns Bay	Excellent	Excellent	No
Goat Island	Excellent	Excellent	No
Hobsonville	Excellent	Excellent	No
Mahurangi Heads	Excellent	Excellent	No
Omokoiti Beacon	Excellent	Excellent	No
Orewa	Excellent	Excellent	No
Ti Point	Excellent	Excellent	No
Chelsea	Good	Excellent	Up 1
Grahams Beach	Good	Excellent	Up 1
Tamaki	Good	Excellent	Up 1
Kaipara Heads	Good	Good	No
Whau Creek	Good	Good	No
Tauhoa Channel	Good	Good	No
Turanga	Good	Good	No
Dawsons Creek	Good	Good	No
Manukau Heads	Fair	Good	Up 1
Henderson Creek	Poor	Good	Up 2
Waimarie	Fair	Fair	No
Shelly Beach	Poor	Fair	Up 1
Hoteo	Fair	Fair	No
Clarks Beach	Poor	Fair	Up 1
Wairoa River	Poor	Fair	Up 1
Makarau Estuary	Poor	Fair	Up 1
Rawawaru Creek	Poor	Fair	Up 1
Kaipara River	Poor	Poor	No
Lucas Creek	Poor	Poor	No
Paremoremo Ski Club	Poor	Poor	No
Brighams Creek	Poor	Poor	No
Shag Point	Poor	Poor	No
Weymouth	Poor	Poor	No
Panmure	Poor	Poor	No
Rangitopuni Creek	Poor	Poor	No
Waiuku	Poor	Poor	No
Puketutu Point	Poor	Poor	No
Mangere Bridge	Poor	Poor	No

4.3.1 Effect on the water quality indicator within the State of the Environment marine report cards

To assess the effect of the change in the calculation of the WQI for the publication of the 2016 marine report cards a slightly more complex assessment was called for. The marine report cards had an added level of complexity which required a comparison between the 2014 and 2016 report cards alongside the assessment of the effect of the WQI calculation change (as described in this present report). This multi-level comparison was required to determine whether observed changes in water quality grades (at individual sites and at the harbour/area level) were attributable to real changes in water quality or a change in the calculation of the water quality index. These comparisons were undertaken by calculating the water quality grades for each site and harbour/area from data included in the 2016 marine report card using the old WQI calculations and the new WQI calculations (similar to that described in this present report). The next step was to repeat this same process using the water quality data reported in the 2014 marine report cards and to compare the relative changes in water quality grades. This allowed an assessment of the changes identified between 2014 and 2016 to be made, and give indication whether these changes were attributed to either a change in the calculation of the water grades or real changes in the water column.

In a comparison of data used to calculate the WQI for the 2014 and the 2016 marine report cards, 15 sites (43%) improved in their WQI, one site decreased and the remaining 19 sites (54%) did not change (Table 4-3). Of the 15 sites that improved, 5 sites improved due a change in the calculation methodology and 10 sites improved due to real improvements (Table 4-4). The remaining 19 sites showed no change. Only one site displayed a reduction in WQI and this was identified as a real environmental change.

Although 19 sites did not experience a change in WQI, the majority of these sites exhibited an increase in the scores that underpin the WQI. This does not have an immediate impact on the WQI, but it does have a flow on effect for the calculation of the overall water quality indicator for the State of Auckland marine report cards. Where multiple sites are used to calculate an overall grade for a report card location and the individual site scores have all increased (but did not translate into a change in grade) then there is the potential for the overall grade to increase without site level changes to grades.

Table 4-4 Comparison of the new calculation of the water quality index applied to the 2014 and 2016 marine report cards data to assess the effect (or change) in the resultant water quality grade. The “change” column indicates if a change in the grade occurred (up, down, same) and “due to” represents whether the change was attributable to either the new calculation (Calc) or a real change (Real) in the environment. n/a = no change in grade.

Sites	2014 Grade	2016 Grade	Change	Due to
Browns Bay	Good	Excellent	Up1	Real
Chelsea	Good	Excellent	Up1	Calc
Goat Island	Good	Excellent	Up1	Real
Mahurangi Heads	Excellent	Excellent	Same	n/a
Orewa	Excellent	Excellent	Same	n/a
Ti Point	Good	Excellent	Up1	Real
Clarks Beach	Fair	Fair	Same	n/a
Henderson Creek	Fair	Fair	Same	n/a
Hoteo River mouth	Poor	Fair	Up1	Real
Shelly Beach	Fair	Fair	Same	n/a
Waimarie Road	Poor	Fair	Up1	Real
Wairoa River Mouth	Poor	Fair	Up1	Calc
Dawsons Creek	Good	Good	Same	n/a
Grahams Beach	Fair	Good	Up1	Calc
Hobsonville Jetty	Fair	Good	Up1	Real
Kaipara Heads	Fair	Good	Up1	Real
Manukau Hbr @ Mouth	Fair	Good	Up 1	Calc
Omokoiti Beacon	Fair	Good	Up1	Real
Tamaki	Fair	Good	Up1	Calc
Tauhoa Channel	Fair	Good	Up 1	Real
Turanga Est Mouth	Good	Good	Same	n/a
Whau Creek	Fair	Good	Up1	Real
Brighams Creek	Poor	Poor	Same	n/a
Kaipara River	Poor	Poor	Same	n/a
Lucas Creek	Poor	Poor	Same	n/a
Makarau Estuary	Poor	Poor	Same	n/a
Mangere Bridge	Poor	Poor	Same	n/a
Panmure	Poor	Poor	Same	n/a
Paremoremo Ski Club	Fair	Poor	Down1	Real
Puketutu Point	Poor	Poor	Same	n/a
Rangitopuni Creek	Poor	Poor	Same	n/a
Rawawaru Creek	Poor	Poor	Same	n/a
Shag Point	Poor	Poor	Same	n/a
Waiuku Town Basin	Poor	Poor	Same	n/a
Weymouth	Poor	Poor	Same	n/a

4.4 Data tables

Table 4-5 Electrical conductivity ($\text{mS}\cdot\text{cm}^{-1}$) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	48.19	54.80	53.99	53.25	0.55
Ti Point		12	47.94	54.87	54.06	53.27	0.61
Dawsons Creek		12	42.24	55.21	52.22	51.12	1.10
Mahurangi Heads		12	45.19	55.04	53.44	52.59	0.80
Orewa		12	38.19	55.30	54.01	52.32	1.36
Browns Bay		12	44.68	55.51	53.76	52.72	0.86
Chelsea		12	50.77	54.13	52.38	52.36	0.32
Whau Creek		12	44.04	54.60	50.94	50.55	1.01
Henderson Creek		12	44.18	54.73	51.22	50.53	1.02
Hobsonville Jetty		12	46.26	54.73	51.95	51.31	0.82
Lucas Creek		12	33.80	54.67	49.39	47.67	1.70
Waimarie Road*		6	42.37	54.95	52.72	51.29	1.86
Paremoremo Ski Club		12	28.15	54.87	49.79	47.56	2.14
Rawawaru Creek*		6	34.14	54.83	51.58	49.27	3.10
Brighams Creek		12	19.22	54.80	47.80	44.31	3.05
Rangitopuni Creek		12	12.56	54.74	46.43	41.54	3.79
Tamaki		12	47.72	53.45	52.38	51.37	0.58
Panmure		12	41.09	52.58	48.80	47.90	1.05
Turanga Est Mouth*		6	52.08	55.18	54.79	54.28	0.49
Wairoa River Mouth		12	39.88	53.89	51.26	50.06	1.29
Mangere Bridge		12	41.43	54.33	47.75	48.28	1.24
Puketutu Point		12	39.88	53.94	49.25	49.17	1.20
Weymouth		12	42.26	54.42	48.25	48.84	1.23
Waiuku Town Basin		12	35.46	52.44	42.85	44.90	1.82
Clarks Beach		12	37.30	54.49	50.10	49.60	1.51
Grahams Beach		12	36.06	54.47	51.15	50.72	1.47
Shag Point		11	34.96	54.40	49.99	49.75	1.69
Manukau Hbr @ Mouth		12	38.00	54.52	51.58	50.97	1.31
Kaipara Heads		12	42.86	55.13	53.12	52.19	0.91
Tauhoa Channel		12	33.77	54.27	50.28	49.22	1.60
Hoteo River mouth		12	42.65	54.72	48.17	48.75	1.18
Omokoiti Beacon*		6	50.49	54.20	52.95	52.57	0.63
Makarau Estuary		12	44.80	53.38	48.29	48.88	0.98
Shelly Beach		12	34.00	53.55	49.57	48.62	1.54
Kaipara River		12	44.31	52.82	48.80	48.80	0.88

Table 4-6 Salinity (ppt) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	31.84	36.36	35.68	35.22	0.37
Ti Point		12	31.66	36.41	35.77	35.24	0.41
Dawsons Creek		12	27.84	36.65	34.31	33.68	0.76
Mahurangi Heads		12	29.84	36.53	35.22	34.74	0.55
Orewa		12	25.21	36.73	35.71	34.59	0.91
Browns Bay		12	29.49	36.89	35.55	34.84	0.58
Chelsea		12	33.28	35.85	34.56	34.51	0.25
Whau Creek		12	28.41	36.21	33.44	33.20	0.74
Henderson Creek		12	28.52	36.29	33.65	33.18	0.75
Hobsonville Jetty		12	30.02	36.29	34.19	33.77	0.60
Lucas Creek		12	21.23	36.25	32.30	31.12	1.22
Waimarie Road*		6	27.24	36.45	34.80	33.75	1.36
Paremoremo Ski Club		12	17.38	36.39	32.68	31.06	1.53
Rawawaru Creek*		6	21.47	36.37	33.96	32.31	2.23
Brighams Creek		12	11.46	36.35	31.25	28.79	2.14
Rangitopuni Creek		12	7.24	36.30	30.30	26.90	2.62
Tamaki		12	30.94	35.31	34.55	33.76	0.45
Panmure		12	26.28	34.65	31.92	31.23	0.77
Turanga Est Mouth*		6	34.26	36.63	36.34	35.95	0.37
Wairoa River Mouth		12	25.47	35.67	33.60	32.90	0.91
Mangere Bridge		12	27.14	35.96	31.17	31.57	0.88
Puketutu Point		12	26.18	35.68	32.15	32.24	0.84
Weymouth		12	27.72	36.04	31.54	31.99	0.88
Waiuku Town Basin		12	22.30	34.56	27.58	29.19	1.29
Clarks Beach		12	24.51	36.09	32.77	32.61	1.03
Grahams Beach		12	23.71	36.10	33.55	33.40	0.99
Shag Point		11	22.98	36.01	32.67	32.71	1.15
Manukau Hbr @ Mouth		12	25.03	36.15	33.85	33.59	0.88
Kaipara Heads		12	28.26	36.60	35.11	34.46	0.62
Tauhoa Channel		12	22.19	35.95	32.93	32.32	1.08
Hoteo River mouth		12	27.33	36.30	31.42	31.89	0.86
Omokoiti Beacon*		6	33.09	35.90	34.97	34.68	0.47
Makarau Estuary		12	28.88	35.30	31.45	31.98	0.71
Shelly Beach		12	22.32	35.42	32.46	31.87	1.04
Kaipara River		12	28.54	34.88	31.87	31.91	0.65

Table 4-7 pH (pH units) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	7.88	8.16	8.06	8.04	0.03
Ti Point		12	7.94	8.20	8.09	8.08	0.02
Dawsons Creek		12	7.81	8.12	8.01	8.00	0.03
Mahurangi Heads		12	7.94	8.20	8.06	8.07	0.02
Orewa		12	7.95	8.23	8.09	8.09	0.02
Browns Bay		12	7.95	8.25	8.08	8.08	0.03
Chelsea		12	7.83	8.12	7.99	7.99	0.03
Whau Creek		12	7.82	8.08	7.98	7.97	0.02
Henderson Creek		12	7.81	8.08	7.98	7.97	0.03
Hobsonville Jetty		12	7.84	8.10	8.02	8.00	0.03
Lucas Creek		12	7.63	8.06	7.90	7.87	0.04
Waimarie Road*		6	7.69	8.08	7.85	7.85	0.05
Paremoremo Ski Club		12	7.66	8.06	7.88	7.88	0.04
Rawawaru Creek*		6	7.62	8.02	7.77	7.78	0.06
Brighams Creek		12	7.56	8.11	7.82	7.80	0.05
Rangitopuni Creek		12	7.56	8.04	7.80	7.79	0.05
Tamaki		12	7.74	8.04	7.94	7.93	0.03
Panmure		12	7.78	8.10	7.96	7.93	0.03
Turanga Est Mouth*		6	7.95	8.17	8.01	8.03	0.03
Wairoa River Mouth		12	7.96	8.16	8.11	8.08	0.02
Mangere Bridge		12	7.82	8.42	8.01	8.05	0.06
Puketutu Point		12	7.93	8.41	8.09	8.10	0.04
Weymouth		12	7.91	8.25	8.05	8.07	0.04
Waiuku Town Basin		12	7.70	8.22	7.91	7.95	0.05
Clarks Beach		12	7.83	8.23	8.04	8.06	0.04
Grahams Beach		12	7.92	8.26	8.12	8.12	0.03
Shag Point		12	7.93	8.34	8.12	8.12	0.04
Manukau Hbr @ Mouth		12	7.91	8.23	8.11	8.11	0.03
Kaipara Heads		12	7.92	8.18	8.10	8.08	0.02
Tauhoa Channel		12	7.95	8.14	8.09	8.07	0.02
Hoteo River mouth		12	7.88	8.15	8.05	8.02	0.02
Omokoiti Beacon*		6	7.92	8.13	7.97	7.99	0.03
Makarau Estuary		12	7.82	8.09	8.00	7.98	0.03
Shelly Beach		12	7.84	8.10	8.04	7.99	0.03
Kaipara River		12	7.64	8.00	7.87	7.86	0.03

Table 4-8 Turbidity (NTU) for data collected from January 2015 to December 2015.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	0.20	0.95	0.38	0.44	0.07
Ti Point	12	0.25	0.80	0.38	0.45	0.05
Dawsons Creek	12	2.70	8.70	4.60	4.88	0.49
Mahurangi Heads	12	0.90	2.30	1.80	1.69	0.13
Orewa	12	0.25	1.40	0.88	0.77	0.10
Browns Bay	12	0.25	2.20	0.75	0.97	0.19
Chelsea	12	1.90	5.60	3.45	3.33	0.31
Whau Creek	12	2.00	6.50	3.85	3.97	0.42
Henderson Creek	12	2.60	8.90	3.90	4.83	0.66
Hobsonville Jetty	12	2.00	6.40	4.20	4.07	0.41
Lucas Creek	12	2.60	12.00	5.00	6.09	0.89
Waimarie Road*	6	2.00	6.30	4.25	4.27	0.63
Paremoremo Ski Club	12	2.50	20.00	6.40	7.43	1.39
Rawawaru Creek*	6	3.10	8.60	5.40	5.80	0.91
Brighams Creek	12	3.70	17.00	7.25	8.18	1.29
Rangitopuni Creek	12	3.60	55.00	6.60	11.62	4.25
Tamaki	12	1.10	3.10	2.20	2.16	0.16
Panmure	12	1.70	25.00	6.95	8.85	1.80
Turanga Est Mouth*	6	1.60	14.00	2.35	4.17	1.98
Wairoa River Mouth	12	1.90	29.00	3.85	7.74	2.64
Mangere Bridge	12	3.60	22.00	8.55	10.35	1.90
Puketutu Point	12	1.80	15.00	3.85	6.05	1.34
Weymouth	12	5.10	18.00	10.40	10.22	1.30
Waiuku Town Basin	12	4.30	19.00	8.55	9.41	1.12
Clarks Beach	12	3.00	7.50	5.60	5.36	0.43
Grahams Beach	12	1.30	6.20	2.75	2.98	0.38
Shag Point	12	1.40	16.00	3.20	5.18	1.39
Manukau Hbr @ Mouth	12	0.70	5.90	1.85	2.32	0.49
Kaipara Heads	12	0.55	2.90	1.25	1.47	0.23
Tauhoa Channel	12	0.80	5.40	1.45	1.95	0.39
Hoteo River mouth	12	1.10	11.00	4.60	4.73	0.82
Omokoiti Beacon*	6	1.40	4.70	2.80	2.88	0.48
Makarau Estuary	12	1.70	14.00	4.75	6.40	1.22
Shelly Beach	12	1.80	14.00	2.75	4.34	1.08
Kaipara River	12	4.20	28.00	9.85	11.38	1.90

Table 4-9 Suspended sediment (mg/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.60	13.00	3.00	3.59	0.90
Ti Point		12	0.80	18.00	2.50	3.78	1.33
Dawsons Creek		12	8.00	26.00	10.00	12.03	1.45
Mahurangi Heads		12	4.00	16.00	7.00	6.94	0.91
Orewa		12	1.30	7.60	3.90	4.28	0.53
Browns Bay		12	3.20	12.00	4.70	5.63	0.72
Chelsea		12	4.80	20.00	10.00	10.93	1.21
Whau Creek		12	5.20	16.00	11.50	11.08	1.02
Henderson Creek		12	4.80	24.00	12.00	12.58	1.45
Hobsonville Jetty		12	7.00	19.00	12.50	12.92	1.17
Lucas Creek		12	6.00	25.00	15.00	15.25	1.37
Waimarie Road*		6	9.80	15.00	13.00	12.63	0.69
Paremoremo Ski Club		12	7.60	39.00	14.50	16.63	2.36
Rawawaru Creek*		6	12.00	16.00	14.50	14.17	0.75
Brighams Creek		12	7.40	22.00	17.00	16.22	1.30
Rangitopuni Creek		12	7.60	74.00	15.00	20.18	5.21
Tamaki		12	3.80	12.00	5.80	6.67	0.70
Panmure		12	9.40	53.00	14.50	19.98	3.59
Turanga Est Mouth*		6	6.20	33.00	7.90	13.23	4.35
Wairoa River Mouth		12	6.80	54.00	12.50	17.97	4.13
Mangere Bridge		12	9.00	65.00	29.50	33.17	4.80
Puketutu Point		12	8.80	43.00	14.00	18.53	3.34
Weymouth		12	14.00	50.00	32.50	31.58	2.76
Waiuku Town Basin		12	11.00	45.00	21.00	22.17	2.47
Clarks Beach		12	11.00	28.00	20.00	19.00	1.73
Grahams Beach		12	6.30	24.00	11.00	12.57	1.62
Shag Point		12	6.20	50.00	12.50	16.57	3.95
Manukau Hbr @ Mouth		12	2.20	25.00	8.10	10.15	2.02
Kaipara Heads		12	2.00	14.00	6.70	6.83	1.19
Tauhoa Channel		12	2.80	12.00	7.40	7.45	0.90
Hoteo River mouth		12	5.20	29.00	14.00	15.88	2.29
Omokoiti Beacon*		6	5.80	14.00	9.90	10.00	1.16
Makarau Estuary		12	9.30	36.00	15.50	18.03	2.39
Shelly Beach		12	7.60	44.00	13.00	14.98	2.83
Kaipara River		12	15.00	56.00	26.50	28.58	3.23

Table 4-10 Chlorophyll a (mg/L) for data collected from January 2015 to December 2015.

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	0.003	0.001	0.001	0.000
Dawsons Creek		12	0.001	0.008	0.002	0.003	0.001
Mahurangi Heads		12	0.000	0.002	0.002	0.002	0.000
Orewa		12	0.000	0.002	0.001	0.001	0.000
Browns Bay		12	0.000	0.004	0.001	0.002	0.000
Chelsea		12	0.000	0.002	0.002	0.002	0.000
Whau Creek		12	0.001	0.003	0.002	0.002	0.000
Henderson Creek		12	0.001	0.005	0.002	0.002	0.000
Hobsonville Jetty		12	0.001	0.003	0.002	0.002	0.000
Lucas Creek		12	0.001	0.008	0.003	0.004	0.001
Waimarie Road*		6	0.002	0.004	0.002	0.003	0.000
Paremoremo Ski Club		12	0.001	0.016	0.004	0.004	0.001
Rawawaru Creek*		6	0.002	0.007	0.003	0.004	0.001
Brighams Creek		11	0.001	0.009	0.005	0.005	0.001
Rangitopuni Creek		11	0.001	0.029	0.004	0.008	0.003
Tamaki		12	0.000	0.003	0.002	0.002	0.000
Panmure		12	0.001	0.007	0.003	0.003	0.001
Turanga Est Mouth*		6	0.001	0.004	0.002	0.002	0.000
Wairoa River Mouth		12	0.001	0.005	0.002	0.002	0.000
Mangere Bridge		12	0.002	0.031	0.010	0.012	0.003
Puketutu Point		12	0.001	0.029	0.005	0.009	0.002
Weymouth		12	0.002	0.015	0.006	0.008	0.001
Waiuku Town Basin		12	0.002	0.013	0.005	0.007	0.001
Clarks Beach		12	0.002	0.010	0.004	0.005	0.001
Grahams Beach		12	0.000	0.010	0.003	0.004	0.001
Shag Point		12	0.001	0.019	0.003	0.006	0.002
Manukau Hbr @ Mouth		12	0.001	0.006	0.002	0.003	0.000
Kaipara Heads		12	0.000	0.006	0.002	0.002	0.000
Tauhoa Channel		12	0.001	0.005	0.003	0.003	0.000
Hoteo River mouth		12	0.003	0.007	0.003	0.004	0.000
Omokoiti Beacon*		6	0.002	0.004	0.003	0.003	0.000
Makarau Estuary		12	0.002	0.010	0.004	0.005	0.001
Shelly Beach		12	0.003	0.006	0.003	0.004	0.000
Kaipara River		12	0.003	0.009	0.007	0.006	0.001

Table 4-11 Nitrite (mg N/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.001	0.004	0.001	0.002	0.000
Ti Point		12	0.001	0.006	0.001	0.002	0.001
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	0.001	0.001	0.001	
Whau Creek		12	0.001	0.001	0.001	0.001	
Henderson Creek		12	0.001	0.001	0.001	0.001	
Hobsonville Jetty		12	0.001	0.001	0.001	0.001	
Lucas Creek		12	0.001	0.002	0.001	0.001	0.000
Waimarie Road*		6	0.001	0.001	0.001	0.001	
Paremoremo Ski Club		12	0.001	0.003	0.001	0.001	0.000
Rawawaru Creek*		6	0.001	0.001	0.001	0.001	
Brighams Creek		12	0.001	0.004	0.001	0.002	0.000
Rangitopuni Creek		11	0.001	0.004	0.001	0.002	0.000
Tamaki		12	0.001	0.003	0.001	0.001	0.000
Panmure		12	0.001	0.003	0.001	0.001	0.000
Turanga Est Mouth*		6	0.001	0.001	0.001	0.001	
Wairoa River Mouth		12	0.001	0.001	0.001	0.001	
Mangere Bridge		12	0.001	0.015	0.007	0.007	0.001
Puketutu Point		12	0.001	0.009	0.002	0.004	0.001
Weymouth		12	0.001	0.005	0.001	0.002	0.000
Waiuku Town Basin		12	0.001	0.009	0.003	0.003	0.001
Clarks Beach		12	0.001	0.004	0.001	0.001	0.000
Grahams Beach		12	0.001	0.004	0.001	0.001	0.000
Shag Point		12	0.001	0.007	0.001	0.002	0.001
Manukau Hbr @ Mouth		12	0.001	0.004	0.001	0.001	0.000
Kaipara Heads		12	0.001	0.003	0.001	0.001	0.000
Tauhoa Channel		12	0.001	0.001	0.001	0.001	
Hoteo River mouth		12	0.001	0.001	0.001	0.001	
Omokoiti Beacon*		6	0.001	0.001	0.001	0.001	
Makarau Estuary		12	0.001	0.006	0.001	0.002	0.000
Shelly Beach		12	0.001	0.004	0.001	0.001	0.000
Kaipara River		12	0.001	0.006	0.001	0.002	0.000

Table 4-12 Nitrate (mg N/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.001	0.065	0.008	0.025	0.008
Ti Point		12	0.001	0.060	0.004	0.020	0.007
Dawsons Creek		12	0.001	0.029	0.002	0.005	0.002
Mahurangi Heads		12	0.001	0.019	0.001	0.004	0.002
Orewa		12	0.001	0.006	0.001	0.002	0.001
Browns Bay		12	0.001	0.026	0.003	0.005	0.002
Chelsea		12	0.001	0.043	0.009	0.014	0.005
Whau Creek		12	0.001	0.050	0.001	0.015	0.006
Henderson Creek		12	0.001	0.076	0.002	0.017	0.007
Hobsonville Jetty		12	0.001	0.045	0.004	0.011	0.004
Lucas Creek		12	0.001	0.130	0.004	0.021	0.012
Waimarie Road*		6	0.001	0.088	0.003	0.017	0.014
Paremoremo Ski Club		12	0.001	0.190	0.004	0.028	0.016
Rawawaru Creek*		6	0.001	0.140	0.001	0.025	0.023
Brighams Creek		12	0.001	0.340	0.009	0.054	0.030
Rangitopuni Creek		11	0.001	0.260	0.010	0.045	0.023
Tamaki		12	0.001	0.052	0.009	0.016	0.005
Panmure		12	0.001	0.160	0.013	0.032	0.014
Turanga Est Mouth*		6	0.001	0.001	0.001	0.001	
Wairoa River Mouth		12	0.001	0.170	0.006	0.029	0.017
Mangere Bridge		12	0.001	0.360	0.150	0.155	0.038
Puketutu Point		12	0.001	0.440	0.125	0.148	0.040
Weymouth		12	0.001	0.190	0.028	0.063	0.020
Waiuku Town Basin		12	0.001	0.720	0.095	0.185	0.067
Clarks Beach		12	0.001	0.089	0.010	0.019	0.008
Grahams Beach		12	0.001	0.043	0.001	0.005	0.004
Shag Point		12	0.001	0.190	0.013	0.047	0.018
Manukau Hbr @ Mouth		12	0.001	0.056	0.001	0.008	0.005
Kaipara Heads		12	0.001	0.070	0.001	0.010	0.006
Tauhoa Channel		12	0.001	0.032	0.001	0.005	0.003
Hoteo River mouth		12	0.001	0.110	0.002	0.018	0.010
Omokoiti Beacon*		6	0.001	0.028	0.001	0.006	0.005
Makarau Estuary		12	0.001	0.065	0.008	0.016	0.006
Shelly Beach		12	0.001	0.064	0.002	0.010	0.005
Kaipara River		12	0.001	0.071	0.008	0.017	0.006

Table 4-13 Ammonia (mg N/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.003	0.019	0.004	0.007	0.002
Ti Point		12	0.003	0.022	0.006	0.007	0.002
Dawsons Creek		12	0.003	0.021	0.006	0.007	0.002
Mahurangi Heads		12	0.003	0.013	0.006	0.006	0.001
Orewa		12	0.003	0.019	0.004	0.005	0.001
Browns Bay		12	0.003	0.015	0.007	0.006	0.001
Chelsea		12	0.003	0.026	0.012	0.011	0.002
Whau Creek		12	0.003	0.031	0.011	0.012	0.003
Henderson Creek		12	0.003	0.036	0.015	0.019	0.004
Hobsonville Jetty		12	0.003	0.023	0.010	0.010	0.002
Lucas Creek		12	0.003	0.053	0.014	0.017	0.004
Waimarie Road*		6	0.009	0.025	0.014	0.015	0.002
Paremoremo Ski Club		12	0.003	0.057	0.012	0.015	0.004
Rawawaru Creek*		6	0.003	0.042	0.014	0.016	0.005
Brighams Creek		12	0.003	0.059	0.013	0.019	0.006
Rangitopuni Creek		11	0.003	0.031	0.016	0.014	0.003
Tamaki		12	0.003	0.034	0.024	0.020	0.003
Panmure		12	0.003	0.100	0.019	0.027	0.008
Turanga Est Mouth*		6	0.003	0.009	0.005	0.005	0.001
Wairoa River Mouth		12	0.003	0.047	0.016	0.018	0.004
Mangere Bridge		12	0.003	0.150	0.046	0.054	0.014
Puketutu Point		12	0.003	0.120	0.036	0.045	0.010
Weymouth		12	0.003	0.063	0.018	0.021	0.004
Waiuku Town Basin		12	0.003	0.097	0.037	0.039	0.009
Clarks Beach		12	0.003	0.033	0.011	0.013	0.003
Grahams Beach		12	0.003	0.010	0.003	0.004	0.001
Shag Point		12	0.003	0.051	0.014	0.019	0.004
Manukau Hbr @ Mouth		12	0.003	0.027	0.006	0.007	0.002
Kaipara Heads		12	0.003	0.029	0.003	0.006	0.002
Tauhoa Channel		12	0.003	0.034	0.005	0.010	0.003
Hoteo River mouth		12	0.003	0.030	0.013	0.012	0.003
Omokoiti Beacon*		6	0.003	0.017	0.012	0.010	0.002
Makarau Estuary		12	0.003	0.073	0.014	0.020	0.006
Shelly Beach		12	0.003	0.043	0.010	0.013	0.004
Kaipara River		12	0.003	0.095	0.026	0.033	0.007

Table 4-14 Total kjedahl nitrogen (mg N/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.010	0.100	0.045	0.041	0.009
Ti Point		12	0.010	0.095	0.055	0.047	0.010
Dawsons Creek		12	0.010	0.130	0.010	0.031	0.011
Mahurangi Heads		12	0.010	0.081	0.010	0.026	0.008
Orewa		12	0.010	0.083	0.010	0.027	0.008
Browns Bay		12	0.010	0.084	0.010	0.026	0.008
Chelsea		12	0.010	0.130	0.031	0.044	0.012
Whau Creek		12	0.010	0.120	0.038	0.055	0.012
Henderson Creek		12	0.010	0.130	0.065	0.069	0.013
Hobsonville Jetty		12	0.010	0.130	0.026	0.048	0.013
Lucas Creek		11	0.010	0.230	0.086	0.102	0.023
Waimarie Road*		6	0.010	0.120	0.057	0.056	0.015
Paremoremo Ski Club		12	0.010	0.280	0.062	0.091	0.025
Rawawaru Creek*		6	0.010	0.190	0.066	0.072	0.026
Brighams Creek		11	0.020	0.370	0.077	0.137	0.034
Rangitopuni Creek		10	0.010	0.210	0.087	0.110	0.022
Tamaki		12	0.010	0.190	0.047	0.060	0.016
Panmure		12	0.010	0.220	0.067	0.085	0.018
Turanga Est Mouth*		6	0.010	0.062	0.010	0.019	0.009
Wairoa River Mouth		12	0.010	0.270	0.075	0.084	0.022
Mangere Bridge		12	0.140	0.340	0.215	0.215	0.019
Puketutu Point		12	0.053	0.320	0.180	0.169	0.024
Weymouth		12	0.057	0.260	0.115	0.128	0.016
Waiuku Town Basin		12	0.072	0.500	0.170	0.192	0.033
Clarks Beach		12	0.010	0.140	0.076	0.072	0.011
Grahams Beach		12	0.010	0.100	0.017	0.035	0.009
Shag Point		12	0.020	0.230	0.089	0.105	0.018
Manukau Hbr @ Mouth		12	0.010	0.095	0.021	0.038	0.010
Kaipara Heads		12	0.010	0.120	0.010	0.034	0.010
Tauhoa Channel		12	0.010	0.180	0.039	0.058	0.016
Hoteo River mouth		12	0.010	0.160	0.068	0.071	0.012
Omokoiti Beacon*		6	0.010	0.075	0.010	0.024	0.011
Makarau Estuary		12	0.010	0.200	0.070	0.087	0.019
Shelly Beach		12	0.010	0.150	0.080	0.070	0.013
Kaipara River		12	0.025	0.210	0.110	0.112	0.018

Table 4-15 Total nitrogen (by calculation, mg N/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.005	0.130	0.066	0.056	0.014
Ti Point		12	0.005	0.130	0.066	0.057	0.014
Dawsons Creek		12	0.005	0.130	0.014	0.034	0.013
Mahurangi Heads		12	0.005	0.089	0.005	0.024	0.010
Orewa		12	0.005	0.089	0.005	0.025	0.010
Browns Bay		12	0.005	0.088	0.005	0.026	0.010
Chelsea		12	0.005	0.150	0.037	0.054	0.015
Whau Creek		12	0.005	0.140	0.057	0.069	0.014
Henderson Creek		12	0.005	0.160	0.108	0.086	0.016
Hobsonville Jetty		12	0.005	0.130	0.045	0.057	0.013
Lucas Creek		11	0.005	0.320	0.090	0.124	0.030
Waimarie Road*		6	0.005	0.210	0.060	0.072	0.029
Paremoremo Ski Club		12	0.005	0.470	0.064	0.119	0.038
Rawawaru Creek*		6	0.017	0.340	0.068	0.099	0.049
Brighams Creek		11	0.028	0.720	0.084	0.191	0.065
Rangitopuni Creek		10	0.029	0.470	0.090	0.149	0.043
Tamaki		12	0.005	0.180	0.062	0.065	0.016
Panmure		12	0.020	0.290	0.076	0.118	0.025
Turanga Est Mouth*		6	0.005	0.062	0.005	0.016	0.009
Wairoa River Mouth		12	0.005	0.450	0.075	0.111	0.037
Mangere Bridge		12	0.140	0.630	0.360	0.375	0.044
Puketutu Point		12	0.110	0.760	0.305	0.318	0.052
Weymouth		12	0.063	0.370	0.165	0.191	0.031
Waiuku Town Basin		12	0.150	0.870	0.275	0.380	0.070
Clarks Beach		12	0.025	0.230	0.078	0.092	0.015
Grahams Beach		12	0.005	0.100	0.018	0.037	0.011
Shag Point		12	0.033	0.340	0.145	0.163	0.027
Manukau Hbr @ Mouth		12	0.005	0.100	0.036	0.042	0.011
Kaipara Heads		12	0.005	0.120	0.026	0.038	0.011
Tauhoa Channel		12	0.005	0.180	0.055	0.059	0.017
Hoteo River mouth		12	0.011	0.180	0.081	0.089	0.015
Omokoiti Beacon*		6	0.005	0.075	0.024	0.029	0.011
Makarau Estuary		12	0.015	0.210	0.101	0.103	0.020
Shelly Beach		12	0.005	0.160	0.087	0.081	0.015
Kaipara River		12	0.025	0.250	0.120	0.130	0.022

Table 4-16 Total phosphorus (mg/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.004	0.015	0.009	0.009	0.001
Ti Point		12	0.004	0.013	0.008	0.008	0.001
Dawsons Creek		12	0.007	0.025	0.015	0.016	0.002
Mahurangi Heads		12	0.008	0.017	0.011	0.011	0.001
Orewa		12	0.008	0.019	0.011	0.012	0.001
Browns Bay		12	0.008	0.021	0.016	0.015	0.001
Chelsea		12	0.014	0.028	0.023	0.021	0.001
Whau Creek		12	0.015	0.032	0.024	0.024	0.001
Henderson Creek		12	0.018	0.036	0.025	0.025	0.001
Hobsonville Jetty		12	0.012	0.029	0.025	0.022	0.002
Lucas Creek		12	0.019	0.036	0.030	0.029	0.001
Waimarie Road*		6	0.024	0.044	0.030	0.032	0.003
Paremoremo Ski Club		12	0.026	0.037	0.031	0.031	0.001
Rawawaru Creek*		6	0.029	0.041	0.035	0.035	0.002
Brighams Creek		11	0.022	0.049	0.034	0.035	0.002
Rangitopuni Creek		10	0.024	0.050	0.036	0.036	0.003
Tamaki		12	0.017	0.028	0.024	0.023	0.001
Panmure		12	0.029	0.053	0.039	0.040	0.002
Turanga Est Mouth*		6	0.013	0.023	0.019	0.019	0.002
Wairoa River Mouth		12	0.017	0.042	0.025	0.026	0.002
Mangere Bridge		12	0.082	0.160	0.120	0.121	0.007
Puketutu Point		12	0.065	0.180	0.099	0.101	0.009
Weymouth		12	0.030	0.056	0.041	0.042	0.002
Waiuku Town Basin		12	0.022	0.068	0.051	0.049	0.005
Clarks Beach		12	0.011	0.047	0.030	0.028	0.004
Grahams Beach		12	0.007	0.031	0.023	0.020	0.002
Shag Point		12	0.035	0.091	0.058	0.060	0.005
Manukau Hbr @ Mouth		12	0.007	0.022	0.015	0.014	0.002
Kaipara Heads		12	0.002	0.012	0.008	0.008	0.001
Tauhoa Channel		12	0.006	0.016	0.012	0.011	0.001
Hoteo River mouth		12	0.006	0.029	0.023	0.021	0.002
Omokoiti Beacon*		6	0.009	0.021	0.013	0.013	0.002
Makarau Estuary		12	0.010	0.044	0.024	0.024	0.002
Shelly Beach		12	0.009	0.041	0.020	0.020	0.002
Kaipara River		12	0.020	0.052	0.032	0.035	0.003

Table 4-17 Soluble reactive phosphorus (mg/L) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	0.004	0.012	0.008	0.008	0.001
Ti Point		12	0.003	0.012	0.006	0.007	0.001
Dawsons Creek		12	0.006	0.013	0.010	0.010	0.001
Mahurangi Heads		12	0.005	0.014	0.009	0.009	0.001
Orewa		12	0.004	0.011	0.009	0.008	0.001
Browns Bay		12	0.008	0.017	0.014	0.013	0.001
Chelsea		12	0.007	0.020	0.016	0.015	0.001
Whau Creek		12	0.013	0.021	0.016	0.016	0.001
Henderson Creek		12	0.011	0.021	0.015	0.016	0.001
Hobsonville Jetty		12	0.010	0.022	0.015	0.016	0.001
Lucas Creek		12	0.013	0.025	0.017	0.018	0.001
Waimarie Road*		6	0.017	0.024	0.022	0.021	0.001
Paremoremo Ski Club		12	0.011	0.026	0.017	0.018	0.001
Rawawaru Creek*		6	0.016	0.027	0.022	0.021	0.002
Brighams Creek		11	0.012	0.029	0.019	0.020	0.002
Rangitopuni Creek		11	0.012	0.030	0.018	0.019	0.002
Tamaki		12	0.011	0.024	0.018	0.018	0.001
Panmure		12	0.016	0.041	0.023	0.024	0.002
Turanga Est Mouth*		6	0.010	0.017	0.015	0.014	0.001
Wairoa River Mouth		12	0.014	0.023	0.016	0.017	0.001
Mangere Bridge		12	0.044	0.140	0.095	0.095	0.009
Puketutu Point		12	0.052	0.160	0.079	0.089	0.009
Weymouth		12	0.008	0.034	0.019	0.022	0.003
Waiuku Town Basin		12	0.012	0.047	0.030	0.029	0.003
Clarks Beach		12	0.006	0.031	0.014	0.017	0.003
Grahams Beach		12	0.006	0.022	0.011	0.013	0.002
Shag Point		12	0.020	0.070	0.044	0.046	0.004
Manukau Hbr @ Mouth		12	0.005	0.014	0.009	0.010	0.001
Kaipara Heads		12	0.005	0.007	0.006	0.006	0.000
Tauhoa Channel		12	0.006	0.010	0.008	0.008	0.000
Hoteo River mouth		12	0.006	0.019	0.013	0.013	0.001
Omokoiti Beacon*		6	0.009	0.010	0.010	0.010	0.000
Makarau Estuary		12	0.010	0.023	0.014	0.015	0.001
Shelly Beach		12	0.007	0.015	0.010	0.011	0.001
Kaipara River		12	0.010	0.023	0.017	0.016	0.001

Table 4-18 Dissolved oxygen (% saturation) for data collected from January 2015 to December 2015.

Site	Count	Min	Max	Median	Mean	Standard error
Goat Island	12	93.40	107.80	100.90	101.02	1.29
Ti Point	12	94.00	108.10	100.95	101.78	1.29
Dawsons Creek	12	92.70	104.00	97.35	96.65	0.93
Mahurangi Heads	12	93.80	102.80	99.70	98.95	0.83
Orewa	12	97.40	106.00	102.10	102.02	0.72
Browns Bay	12	94.90	107.20	99.45	99.83	0.97
Chelsea	12	93.20	99.80	95.75	95.73	0.53
Whau Creek	12	90.20	99.00	94.95	95.01	0.69
Henderson Creek	12	90.00	98.50	93.90	94.37	0.66
Hobsonville Jetty	12	92.40	100.40	95.90	95.96	0.56
Lucas Creek	12	75.70	96.80	89.75	89.74	1.66
Waimarie Road*	6	86.00	97.00	90.05	90.72	1.53
Paremoremo Ski Club	12	82.60	96.50	90.90	90.95	1.19
Rawawaru Creek*	6	81.00	98.40	87.45	88.65	2.32
Brighams Creek	12	76.80	106.70	87.50	89.58	2.19
Rangitopuni Creek	12	77.30	103.70	90.70	90.98	2.26
Tamaki	12	92.30	100.80	95.70	95.87	0.71
Panmure	12	89.20	97.60	94.90	93.32	0.94
Turanga Est Mouth*	6	91.80	102.70	98.75	98.28	1.59
Wairoa River Mouth	12	94.20	104.20	98.15	98.06	0.94
Mangere Bridge	12	89.30	125.10	101.05	103.92	3.39
Puketutu Point	12	90.90	118.70	102.35	103.55	2.31
Weymouth	12	94.20	110.20	100.05	99.63	1.31
Waiuku Town Basin	12	88.50	108.50	95.95	96.77	1.58
Clarks Beach	12	91.50	108.10	98.90	99.11	1.37
Grahams Beach	12	97.80	111.20	102.65	102.69	1.07
Shag Point	11	100.00	122.30	104.60	105.72	1.92
Manukau Hbr @ Mouth	12	99.30	107.70	103.15	102.98	0.59
Kaipara Heads	12	98.00	107.00	103.80	103.54	0.68
Tauhoa Channel	12	98.70	105.20	100.75	101.28	0.61
Hoteo River mouth	12	93.00	104.60	98.00	97.98	0.87
Omokoiti Beacon*	6	98.00	102.70	99.70	99.85	0.71
Makarau Estuary	12	92.60	101.10	97.80	97.62	0.73
Shelly Beach	12	96.20	102.00	98.90	98.98	0.60
Kaipara River	12	91.50	99.90	96.45	96.24	0.76

Table 4-19 Dissolved oxygen (ppm) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	6.78	8.87	7.85	7.82	0.18
Ti Point		12	6.84	8.86	7.83	7.87	0.17
Dawsons Creek		12	6.39	8.39	7.63	7.51	0.20
Mahurangi Heads		12	6.76	8.53	7.83	7.70	0.19
Orewa		12	7.09	8.68	7.96	7.91	0.17
Browns Bay		12	6.77	8.48	7.77	7.73	0.16
Chelsea		12	6.46	8.24	7.30	7.43	0.19
Whau Creek		12	6.35	8.34	7.40	7.46	0.20
Henderson Creek		12	6.26	8.28	7.24	7.39	0.21
Hobsonville Jetty		12	6.36	8.30	7.45	7.46	0.20
Lucas Creek		12	5.42	8.51	6.88	7.10	0.28
Waimarie Road*		6	5.94	8.40	6.48	6.78	0.36
Paremoremo Ski Club		12	5.71	8.40	7.01	7.19	0.27
Rawawaru Creek*		6	5.61	8.87	6.41	6.73	0.46
Brighams Creek		12	5.34	9.93	7.01	7.22	0.38
Rangitopuni Creek		12	5.37	10.00	7.11	7.45	0.44
Tamaki		12	6.42	8.88	7.72	7.65	0.24
Panmure		12	6.15	9.10	7.44	7.61	0.28
Turanga Est Mouth*		6	6.66	8.05	7.25	7.28	0.20
Wairoa River Mouth		12	6.67	8.80	7.68	7.67	0.19
Mangere Bridge		12	6.11	11.41	8.35	8.25	0.42
Puketutu Point		12	6.61	10.58	8.11	8.20	0.32
Weymouth		12	6.51	10.02	7.69	7.91	0.30
Waiuku Town Basin		12	6.40	9.37	7.81	7.80	0.28
Clarks Beach		12	6.47	9.66	7.92	7.83	0.29
Grahams Beach		12	6.90	9.77	8.01	8.06	0.25
Shag Point		11	6.88	10.96	8.16	8.26	0.34
Manukau Hbr @ Mouth		12	7.18	9.30	8.11	8.09	0.20
Kaipara Heads		12	7.29	8.98	8.03	8.11	0.16
Tauhoa Channel		12	7.12	9.19	7.93	7.99	0.20
Hoteo River mouth		12	6.51	9.19	7.64	7.78	0.23
Omokoiti Beacon*		6	6.95	8.38	7.29	7.44	0.21
Makarau Estuary		12	6.68	8.97	7.56	7.76	0.22
Shelly Beach		12	6.74	9.00	7.80	7.84	0.21
Kaipara River		12	6.40	8.90	7.50	7.65	0.23

Table 4-20 Summary table of temperature (°C) for data collected from January 2015 to December 2015.

Site		Count	Min	Max	Median	Mean	Standard error
Goat Island		12	14.15	21.50	17.89	17.70	0.82
Ti Point		12	14.06	21.84	17.77	17.69	0.86
Dawsons Creek		12	12.69	24.07	18.22	18.15	1.23
Mahurangi Heads		12	12.74	22.96	17.90	17.68	1.06
Orewa		12	12.64	23.27	17.69	17.90	1.09
Browns Bay		12	12.47	23.15	17.72	17.82	1.11
Chelsea		12	12.76	23.67	17.72	17.88	1.14
Whau Creek		12	12.91	22.58	17.69	17.71	1.11
Henderson Creek		12	12.91	23.39	17.71	17.93	1.15
Hobsonville Jetty		12	12.91	23.78	17.81	18.05	1.17
Lucas Creek		12	12.89	23.49	17.81	18.11	1.16
Waimarie Road*		6	14.26	23.71	21.58	20.25	1.56
Paremoremo Ski Club		12	12.95	23.68	17.90	18.25	1.18
Rawawaru Creek*		6	14.07	23.63	21.36	20.12	1.57
Brighams Creek		12	13.04	23.54	18.07	18.17	1.20
Rangitopuni Creek		12	12.93	23.73	18.17	18.17	1.22
Tamaki		12	10.75	24.29	16.60	16.81	1.25
Panmure		12	10.54	24.74	16.24	16.57	1.31
Turanga Est Mouth*		6	14.01	23.57	20.96	19.79	1.48
Wairoa River Mouth		12	12.33	23.52	17.92	18.08	1.20
Mangere Bridge		12	11.34	25.46	17.92	17.91	1.35
Puketutu Point		12	11.42	24.85	17.77	17.67	1.29
Weymouth		12	11.43	24.67	17.59	17.71	1.29
Waiuku Town Basin		12	10.78	25.65	17.67	17.77	1.36
Clarks Beach		12	11.62	24.51	17.52	17.78	1.26
Grahams Beach		12	11.90	24.41	17.33	17.75	1.23
Shag Point		11	11.41	24.84	19.28	18.27	1.35
Manukau Hbr @ Mouth		12	12.41	22.48	17.49	17.53	1.03
Kaipara Heads		12	13.04	20.80	17.53	17.31	0.78
Tauhoa Channel		12	12.37	23.25	17.37	17.75	1.09
Hoteo River mouth		12	10.85	24.82	16.91	17.58	1.29
Omokoiti Beacon*		6	14.04	23.45	20.68	19.89	1.51
Makarau Estuary		12	11.41	24.52	16.56	17.51	1.26
Shelly Beach		12	11.75	24.10	16.98	17.71	1.23
Kaipara River		12	11.55	24.67	16.59	17.55	1.28

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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 2015 sampling season, special thanks to Peter Williams and Kristi Holland for organising the sampling and we acknowledge the efforts from other members of the Environmental Monitoring, Research and Evaluation teams within RIMU who helped with the sampling.

Laboratory analyses were carried out by Watercare Laboratory Services Ltd.

Appendix A Physical-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	EXO Sonde (Xylem Analytics)	Field
Dissolved oxygen saturation	% sat	0.01	EXO Sonde (Xylem Analytics)	Field
Temperature	°C	0.01	EXO Sonde (Xylem Analytics)	Field
Conductivity	(mS cm)	0.01	EXO Sonde (Xylem Analytics)	Field
Salinity	ppt	0.2	EXO Sonde (Xylem Analytics)	Field
pH	pH units	0.1	EXO Sonde (Xylem Analytics)	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)	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 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, Manukau Heads, Kaipara Heads, Chelsea and Hobsonville jetty) over the five years preceding this report (2010 to 2014). 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.

Parameter	Objective (acceptable if)
Dissolved oxygen (% saturation)	greater than 91%
pH	Between 7.6 and 8.3
Turbidity	Less than 7.8 NTU
Ammoniacal nitrogen	Less than 0.024 mg N l ⁻¹
Total suspended sediment	Less than 20 mg l ⁻¹
Total phosphorus	Less than 0.040 mg P l ⁻¹
Nitrate + nitrite nitrogen	Less than 0.042 mg N l ⁻¹

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