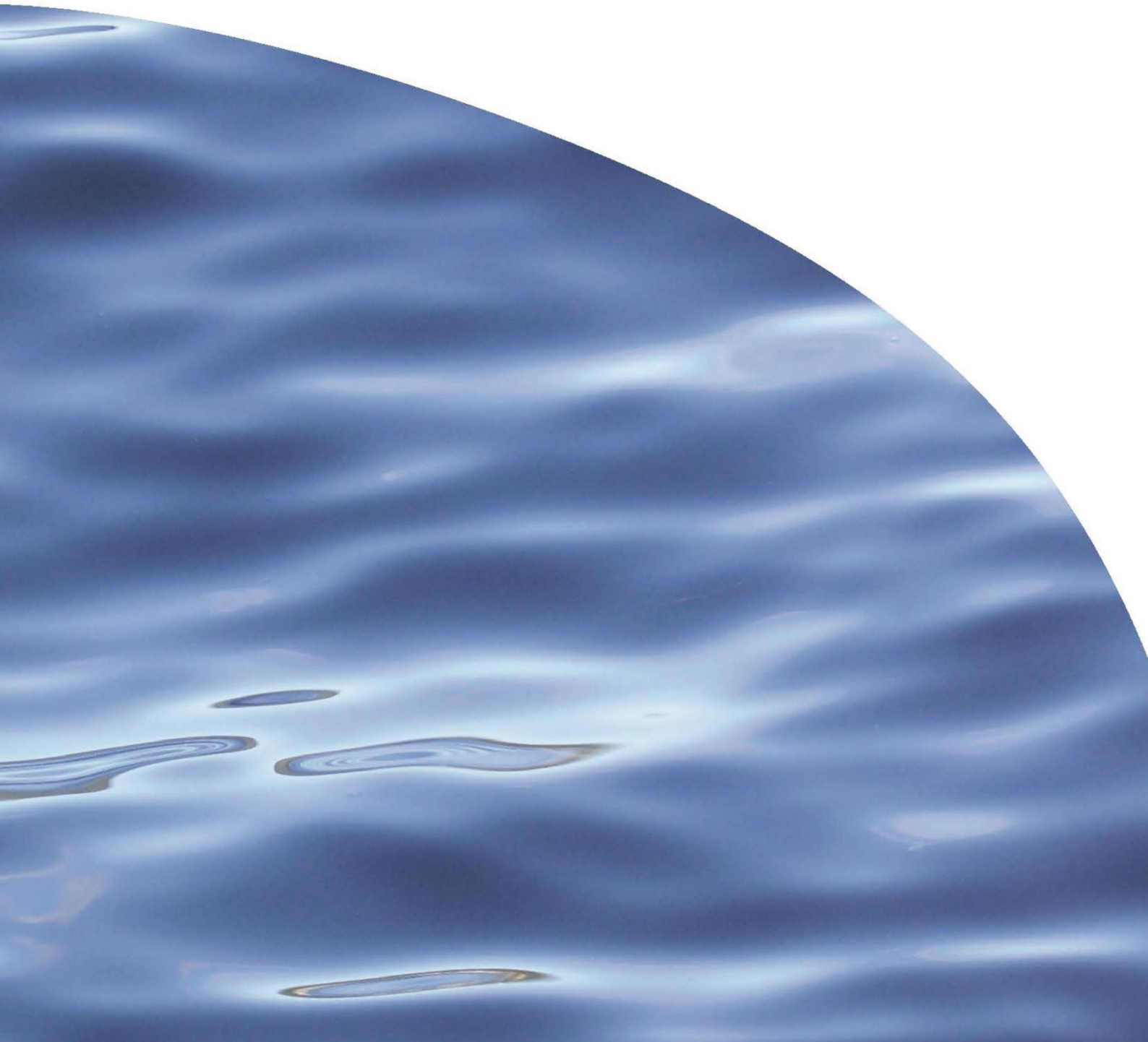
CAWTHRON
The power of science®

REPORT NO. 2945

IMPACT OF THE NELSON (BELL ISLAND) REGIONAL SEWERAGE DISCHARGE ON THE COASTAL ENVIRONMENT: RECEIVING WATER SURVEY - AUGUST 2016



IMPACT OF THE NELSON (BELL ISLAND) REGIONAL SEWERAGE DISCHARGE ON THE COASTAL ENVIRONMENT: RECEIVING WATER SURVEY - AUGUST 2016

DONALD MORRISEY, OLIVIA JOHNSTON, EMMA NEWCOMBE

Prepared for Nelson Regional Sewerage Business Unit

CAWTHRON INSTITUTE
98 Halifax Street East | 7010 | Private Bag 2 | 7042 | Nelson | New Zealand
Ph. +64 3 548 2319 | Fax. + 64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Paul Gillespie

APPROVED FOR RELEASE BY:
Natasha Berkett

ISSUE DATE: 14 October 2016

RECOMMENDED CITATION: Morrisey, D, Johnston O, Newcombe E 2011. Impact of the Nelson (Bell Island) regional sewerage discharge on the coastal environment: receiving water survey - August 2016. Prepared for Nelson Regional Sewerage Business Unit. Cawthron Report No. 2945. 21 p. plus appendices.

EXECUTIVE SUMMARY

Cawthron Institute was commissioned by the Nelson Regional Sewerage Business Unit (NRSBU) to undertake the 2016 monitoring survey of seawater characteristics of Waimea Inlet and inner Tasman Bay sites within the vicinity of the Bell Island regional sewerage outfall. The survey was carried out in accordance to conditions of consent for Coastal Permit RCAC0431 (Annex 3, December 2002). The present report describes the results of this survey and reviews the results of 6-monthly mussel bio-monitoring surveys conducted between 2008 and 2016. The ecological implications of the wastewater discharge are discussed.

Thirteen Waimea Estuary sites and six inner Tasman Bay sites were surveyed on 1 September 2016 following a period of three days with no significant rainfall. Seawater sampling and field analyses of salinity and temperature were carried out in conjunction with the ebb tide wastewater discharge schedule allowing sufficient time for the effluent plume to reach the sample collection sites. Any obvious visual effects (e.g. colouration, surface scum or foam) or unnatural odours were noted. All seawater samples were analysed for concentrations of inorganic nutrients, faecal coliforms, *Escherichia coli* and enterococci. Tasman Bay seawater samples were examined microscopically to assess the composition of the phytoplankton community.

Baskets containing green-lipped mussels (*Perna canaliculus*) were deployed at four estuary and six Tasman Bay sites three days prior to the survey. These were retrieved during the survey and analysed for concentrations of faecal indicator bacteria (FIB).

Conclusions

- Seawater stratification characteristics indicate rapid mixing of the low salinity wastewater discharge with estuarine receiving waters within the ebb tide flow channels.
- Receiving water nutrient concentrations indicate adequate dilution down-current from the Bell Island wastewater outfall to prevent development of eutrophication.
- Ammoniacal-N concentrations at all sites were well below ANZECC (2000) and USEPA (1986) guideline trigger levels, ensuring that potentially toxic conditions were not achieved.
- Phytoplankton characteristics at inner Tasman Bay sites were considered to be normal for the region, reflecting the seasonally productive spring diatom growth period but showing no discharge-related signs of over-enrichment or stimulation of undesirable species.
- Receiving water faecal coliform and enterococci concentrations indicate that the Bell Island outfall discharge was not a significant source of bacterial contamination during the sampling period.

- Concentrations of faecal coliforms and enterococci in mussels, summarised from 16 bio-monitoring surveys (2008-2016), indicate that contributions from the Bell Island discharge were minor in comparison to catchment runoff.

Recommendations

We recommend that the outfall mixing zone survey be repeated in 2021 and interpreted in conjunction with a review of the results of 6-monthly mussel bio-monitoring surveys to be undertaken 2017–2021.

We acknowledge the lack of more general information describing catchment influences on water quality characteristics of Waimea Estuary and inner Tasman Bay waters. Additional investigation of the relationships between multiple (largely diffuse) catchment sources of contaminants and estuary/bay water quality would assist interpretation of the relative significance of point-source discharges, such as the Bell Island wastewater discharge. Although appropriately outside the responsibility of individual consent holders, such an investigation, involving long term monitoring of the water quality of Waimea Inlet/inner Tasman Bay in conjunction with that of freshwater inflows, would facilitate informed management decisions and could be considered an integral component of a regional environmental management plan for Tasman Bay.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

GLOSSARY

Term	Definition
ANZECC	Australia and New Zealand Environment and Conservation Council
APHA	American Public Health Association
Chl-*a*	Chlorophyll-*a*
CTD	Conductivity, Temperature and Depth
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
DRP	Dissolved Reactive Phosphorus
ENT	Enterococci
EPA	Environmental Protection Authority
FC	Faecal Coliform
FIB	Faecal Indicator Bacteria
g/m^3	Grammes per cubic metre (equivalent to mg/L)
GPS	Global Positioning System
km	Kilometre
m	Metre or Metres
mL	Millilitre
MPN	Most Probable Number
N	Nitrogen
NIWA	National Institute of Water and Atmospheric Science
NO_3	Nitrate
NZMG	New Zealand Map Grid (map projection)
NZMOH	New Zealand Ministry of Health
P	Phosphorus
psu	Practical salinity units
TN	Total Nitrogen
TP	Total Phosphorus
UNESCO	United Nations Education, Scientific and Cultural Organisation
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

Cawthron Institute was commissioned by the Nelson Regional Sewerage Business Unit (NRSBU) to assess the receiving water quality of the Nelson (Bell Island) Regional Sewerage Scheme discharge in accordance with conditions of consent for Coastal Permit RCAC0431, as set out in Annex 3 (December 2002).

The receiving water survey, carried out on 1 September 2016, is the subject of this report. The 2016 survey incorporated the earlier modifications made by Gillespie et al. (2011) to the study design used in the 2006 survey (Gillespie et al. 2006). These modifications align the timing and site locations of the 2011 and 2016 surveys with the previously scheduled six-monthly mussel-monitoring programme. This resulted in a total of 19 seawater and 10 mussel monitoring sites sampled during the 2011 and 2016 surveys, rather than the 25 sites indicated in the consent conditions. Shellfish sampling undertaken at estuary sites prior to 2011 was discontinued in 2011 in favour of mussel bio-monitoring to assess shellfish bacteriological quality at selected estuary and inner Tasman Bay sites.

2. METHODS

2.1. Study area

Waimea Inlet (Figure 1) is a shallow, bar-built estuary located within Tasman Bay. The estuary has a tidal compartment of up to ~62 x 10^6 m^3 (Westcott 1981) and a relatively short residence time of about 1.2 tidal periods as a lower limit (Heath 1976). There are two tidal openings to the estuary located at opposite ends of Rabbit Island. The main freshwater tributary, the Waimea River (mean flow ~20/m^3/s^1), separates into a primary and a secondary channel at Rabbit Island to coincide with the two tidal openings. The primary channel, presently taking the majority of the flow, exits the estuary at the eastern (Bell Island) side of the Island.

Background information describing the study area, the Nelson Regional Sewerage Scheme and previous monitoring results was provided by Gillespie et al*.* (2001), Bell et al*.* (1995), Gillespie & Asher (2005) and Gillespie et al*.* (2006). The results of the 2011 survey were presented by Gillespie et al. (2011).

2.2. Sampling locations

Samples were collected from a total of 13 sites in Waimea Inlet, and six sites in southern Tasman Bay (Table 1, Figure 1). GPS (Global Positioning System) coordinates for the sample sites are provided in Appendix 1.

Estuarine sites W2-W12 corresponded to the direction of ebb tide flow from the outfall diffuser through, and beyond, the 500 m 'zone of non-compliance' (or 'mixing zone') suggested by Bell et al*.* (1995). Considering that the effluent is only discharged during the falling tide, and based on the above-referenced dilution modelling, sampling sites targeted areas of least dilution; i.e*.* a 'worst case scenario'. Site W13, in the western entrance to Waimea Inlet, is a reference location. Tasman Bay sites (T1-T6) were included to assess the nutrient and bacteriological quality of inner bay regions outside the estuary.

Note that locations T3, T4, T5 and T6 in the present survey are the same as sites 18, 19, 21 and 22 in the six-monthly mussel-monitoring programme, respectively.

Figure 1. Study area and sample collection sites. Red markers indicate water sampling and mussel deployment sites, yellow markers water sampling only. Station T1B was the substitute water-sampling station for T1.

2.3. Sample collection and field analyses

Sampling of the effluent discharge and receiving waters was done on 1 September 2016 (high tide = 4.0 m at 09:34) during the ebbing tide following a period of five days when no significant rain had fallen[1].

[1] Data from http://www.tasman.govt.nz/environment/water/rainfall/

Table 1. General description of sampling sites and summary of samples (temperature, salinity and chlorophyll-*a*) collected.

Site[a]	Description	Water Samples[b]	Field Analyses[b]	Caged mussels[c]
W1	300 m upstream of the effluent discharge	✓	Temp, Sal, chl-*a*	
W2	Immediately adjacent to the discharge	✓	Temp, Sal, chl-*a*	
W3	Within a 500 m mixing zone down-current from the discharge	✓	Temp, Sal, chl-*a*	
W4		✓	Temp, Sal, chl-*a*	
W5		✓	Temp, Sal, chl-*a*	
W6		✓	Temp, Sal, chl-*a*	
W7		✓	Temp, Sal, chl-*a*	
W8	Outside the 500 m mixing zone but potentially within the effluent receiving water channels	✓	Temp, Sal, chl-*a*	✓
W9		✓	Temp, Sal, chl-*a*	✓
W10		✓	Temp, Sal, chl-*a*	
W11		✓	Temp, Sal, chl-*a*	
W12	Waimea River channel at the NW end of Bests Island.	✓	Temp, Sal, chl-*a*	✓
W13	Main estuary channel off Mapua	✓	Temp, Sal, chl-*a*	✓
T1/T1B	Blind channel	✓(T1B)	Temp, Sal, chl-*a*	✓(T1)
T2	Tahunanui back beach	✓	Temp, Sal, chl-*a*	✓
T3	Approximately 2 and 3 km (respectively) offshore from the eastern estuary outlet	✓	Temp, Sal, chl-*a*	✓
T4		✓	Temp, Sal, chl-*a*	✓
T5	Approximately 2 and 3 km (respectively) offshore from the western estuary outlet at Mapua	✓	Temp, Sal, chl-*a*	✓
T6		✓	Temp, Sal, chl-*a*	✓

a - W = Waimea Inlet; T = Tasman Bay
b - Refer Section 2.3.2.
c - Refer Section 2.3.3.

2.3.1. Effluent

The effluent discharge was sampled from approximately 0.5 m below the surface of the outfall discharge culvert before it enters the discharge pipe (Figure 2). Samples of 500 mL each were collected at half-hourly intervals for the duration of the approximately 3-hour discharge period (between 09:37 and 12:34). The samples were stored on ice and later combined into a single composite sample for analysis, assuming a constant flow rate over the discharge period. The composite was stored at 4°C overnight and analysed on the day after collection.

Figure 2. Discharge sampling location, in front of the grating over the discharge pipe.

2.3.2. Seawater

All seawater samples were collected in 100 mL (bacteriological analysis) or 1000 mL (nutrient analysis) sterile containers, from approximately 0.5 m below the surface. Site W12 was sampled from an aluminium dinghy at 09:00 hours. Estuarine water from sites W1-W11, down current of the effluent diffuser pipe, were collected from the dinghy during the ebb tide after adequate time had been allowed for the effluent to reach those sites. Estuarine site W13, off Mapua, and Tasman Bay sites T1-T6 were sampled from the Cawthron research vessel, *Waihoe*, later in the day (near the time of low tide). Site T1 could not be reached by boat and water samples were collected at site T1B instead (Figure 1). Samples were stored at 4°C overnight and analysed the following day (bacteriology) or 2 d later (nutrients). Profiles of salinity, temperature and concentrations of dissolved oxygen (DO) and chlorophyll-*a* (chl-*a*) were recorded

at all sites where water depth was sufficient, using a Seabird Electronic SBE19 Plus Conductivity Temperature Depth (CTD) profiler.

2.3.3. Shellfish

Green-lipped mussels (*Perna canaliculus*) were purchased from Guytons Seafoods Ltd in the morning of 26 August 2016. The mussels were sub-sampled for determination of pre-deployment bacteriological concentrations and distributed into a series of plastic cages (15 mussels/cage) that were suspended from surface buoys at approximately midwater depths and anchored at sites W8, W9, W12, W13 and T1-T6. Average shell length ranged from 90.0–93.8 mm among sites.

The cages were retrieved on 1 September 2016. Those at sites W13, T1, T2 and T6 could not be found at the time of recovery and were presumed to have been shifted by strong tidal currents or stolen during the deployment period. Cage T1 was sampled on 9 September after being located using the boat's echo-sounder while the marker buoy was submerged by current flow. Samples were put into plastic bags on ice, returned to the laboratory and stored at 4°C overnight. Bacteriological analyses were carried out on the day after collection (the day of collection in the case of T1). There had been no rain for 5 d before the recovery on 1 September and no significant rain (≤ 1 mm/24 h) for 3 d before the recovery of T1 on 9 September[2].

2.4. Laboratory analyses

Analytical methods are listed and referenced in Table 2. Seawater and effluent samples for nutrient analyses were analysed for nitrate-N (NO_3-N), nitrite-N (NO_2-N), ammonia-N (NH_4-N), total N (TN), dissolved reactive phosphorus (DRP) and total phosphorus (TP).

[2] Data from http://www.tasman.govt.nz/environment/water/rainfall/

Table 2. Analytical methods.

Analysis	Method	Reference
Ammoniacal-N	Colorimetric	Solorzano (1969)
Nitrate-N	Colorimetric	APHA 20th edition, Method 4500-NO_3. E
Nitrite-N	Colorimetric	APHA 20th edition, Method 4500-NO_2. I
Dissolved Inorganic N	Addition	
Total N	Photo-oxidation	APHA 20th edition, Method 4500N C
Dissolved Reactive-P	Colorimetric	APHA 20th edition, Method 4500G
Total P	Colorimetric	APHA 20th edition, Method 4500P. A, B-Mod, G
Chlorophyll-*a*	Fluorometric (*in situ*): WET Labs ECO FLNTU	Falmouth Scientific Ltd.
Faecal coliforms (seawater)	Membrane filter.	APHA 20th edition, Method 9222D
Faecal coliforms (shellfish)	Tube dilution	APHA Seawater Shellfish 4th edition
Enterococci (seawater)	Membrane filter.	APHA 20th edition, Method 9230C
Enterococci (shellfish)	Tube dilution	APHA 4th edition. Compendium 2001
Phytoplankton	Utermöhl inv. microscope	UNESCO with modifications

Counts of faecal indicator bacteria (faecal coliforms, *Escherichia coli* (*E. coli*) and enterococci) were carried out using standard membrane filtration procedures. Results were expressed as the most probable number (MPN) per 100 mL.

Shellfish were shucked to provide 125 g of homogenised flesh for microbiological analyses. Results were expressed as the most probable number (MPN) per 100 g wet weight of shellfish flesh.

3. RESULTS AND DISCUSSION

3.1. Seawater stratification characteristics

Temperature and salinity values at estuary sites W1-W12 ranged from 11.6 to 13.3°C and 18.9 to 33.9 psu, respectively (Table 3). Stratification was generally minimal throughout the top 2 m of the water column. Site W12, within the channel of the upper Waimea estuary, had the lowest salinity but was well mixed with tidal waters. The water column at the sites in Tasman Bay was also well mixed, with temperatures from 12.1–12.6°C and salinities from 33.0–34.5 psu (Table 3). Measurements could not be made at sites T1 and T2 due to sea conditions and difficulties of access at low tide.

Table 3. Salinity and temperature readings at Waimea Inlet and Tasman Bay sites (1 September 2016). No data were collected at T1 or T2.

			Salinity (psu)				Temperature (°C)			
Site	**Time (NZST)**	**Depth (m)**	**Surface**	**1 m**	**2 m**	**Bed**	**Surface**	**1 m**	**2 m**	**Bed**
W1	10:28	1	33.0	33.7			12.0	11.9		
W2	10:32	2	32.3	33.5	33.4		12.0	12.0	12.0	
W3	10:36	1	32.3	33.7			12.0	12.0		
W4	10:42	4	33.2	33.4	33.5	33.7	11.9	11.9	11.9	11.9
W5	10:45	3.6	33.4	33.6	33.7	33.8	12.0	12.0	12.0	11.9
W6	10:50	1	33.4	33.7			12.0	12.1		
W7	10:56	5	33.7	33.7	33.8	33.9	12.0	12.0	12.0	12.0
W8	11:51	1	33.7	33.8			12.3	12.3		
W9	11:01	9	33.7	33.8	33.9	33.9	12.0	12.0	12.0	12.0
W10	11:41	<1	33.7				12.1			
W11	11:29	<1	33.2				12.3			
W12	9:44	2	18.9	24.2			11.3	11.6		
W13	15:18	2	28.6	28.7	29.0		13.3	13.3	13.3	
T3	16:28	2.8	33.8			33.9	12.5			12.6
T4	16:15	5.9	33.7			34.3	12.4			12.1
T5	15:42	5.3	33.0			34.3	12.3			12.3
T6	15:59	6.7	33.0			34.5	12.2			12.2

Salinity, temperature and DO concentrations through the water column (at those sites where water depth was sufficient) also show vertical mixing (Appendix 2).

Concentrations of chl-*a* generally increased towards the seabed, probably due to suspension of benthic microalgae by wave and current movement.

3.2. Nutrients

The observed concentrations of nutrients in seawater and effluent samples (Figure 3 and Appendix 3) indicate sufficient dilution of the effluent to prevent development of symptoms of eutrophication.

A comparison of effluent and receiving water concentrations (see Appendix 3) indicates a large reduction of the various nutrient species at estuarine sites W2-W9 (e.g. ranging from 94 to 788-fold for total dissolved inorganic nitrogen or DIN). This suggests an initial dilution greater than the predictions of Bell et al. (1995). The highest concentrations of most nutrients within the ebb flow discharge channel were observed at site W4 approximately 200 m down current from the diffuser, indicating a potential effluent enrichment effect. However nutrient concentrations for adjacent sites along the same channel were not noticeably elevated. Highest NO_3-N concentrations were observed at the low-salinity site (W12) which is strongly influenced by the Waimea River. Ammoniacal-N concentrations were, in all cases, considerably lower than trigger levels proposed by either ANZECC (2000) or USEPA (1986). These triggers were designed to ensure that potentially toxic conditions do not occur. For example, ANZECC (2000) recommend a marine trigger value (based on a pH of 8.0 and protection of 95% of species) of 0.91 g/m^3 whereas the maximum receiving water concentration observed (site W4) was only 0.12 g/m^3. All $N0_2$-N concentrations in estuary receiving waters were below the detection limit of 0.002 g/m^3.

Nutrient concentrations at all Tasman Bay sites were within ranges considered normal for the sampling locations. T1B and T2 were slightly higher than those observed at sites T3-T6, further off shore, and were more in line with those of the estuary sites as might be expected considering their locations. Comparison of results for sites T3 and T4, outside the south-eastern Rabbit Island outlet, with those for sites T5 and T6, outside the north-western Rabbit Island (Mapua) outlet, did not suggest any enrichment of the waters in Tasman Bay (Figure 3).

In general, nutrient concentrations measured in 2016 were similar to those measured in 2011 (Figure 3). However, total nitrogen and total phosphorus concentrations were higher across most sites in 2011. The largest difference between the two surveys was in the concentrations of $N0_2$-N, which were below the level of detection (0.002 g/m^3) at all sites in 2016 but greater than 0.008 g/m^3 at all sites in 2011. This difference is also reflected in the concentrations of $N0_2$-N in the effluent (0.53 g/m^3 in 2011, < 0.002 g/m^3 in 2016). Concentrations of other nutrients in 2016 were similar to, or slightly less than, those in 2011. In the 2011 survey evidence of enrichment was only observed at site W7, c.f. W4 in 2016, perhaps because of a difference between the two surveys in the state of the tide at the time of sampling. As in the 2011 survey, the highest $N0_3$-N concentration amongst all sites was observed at site W12, likely reflecting the influence of the Waimea River.

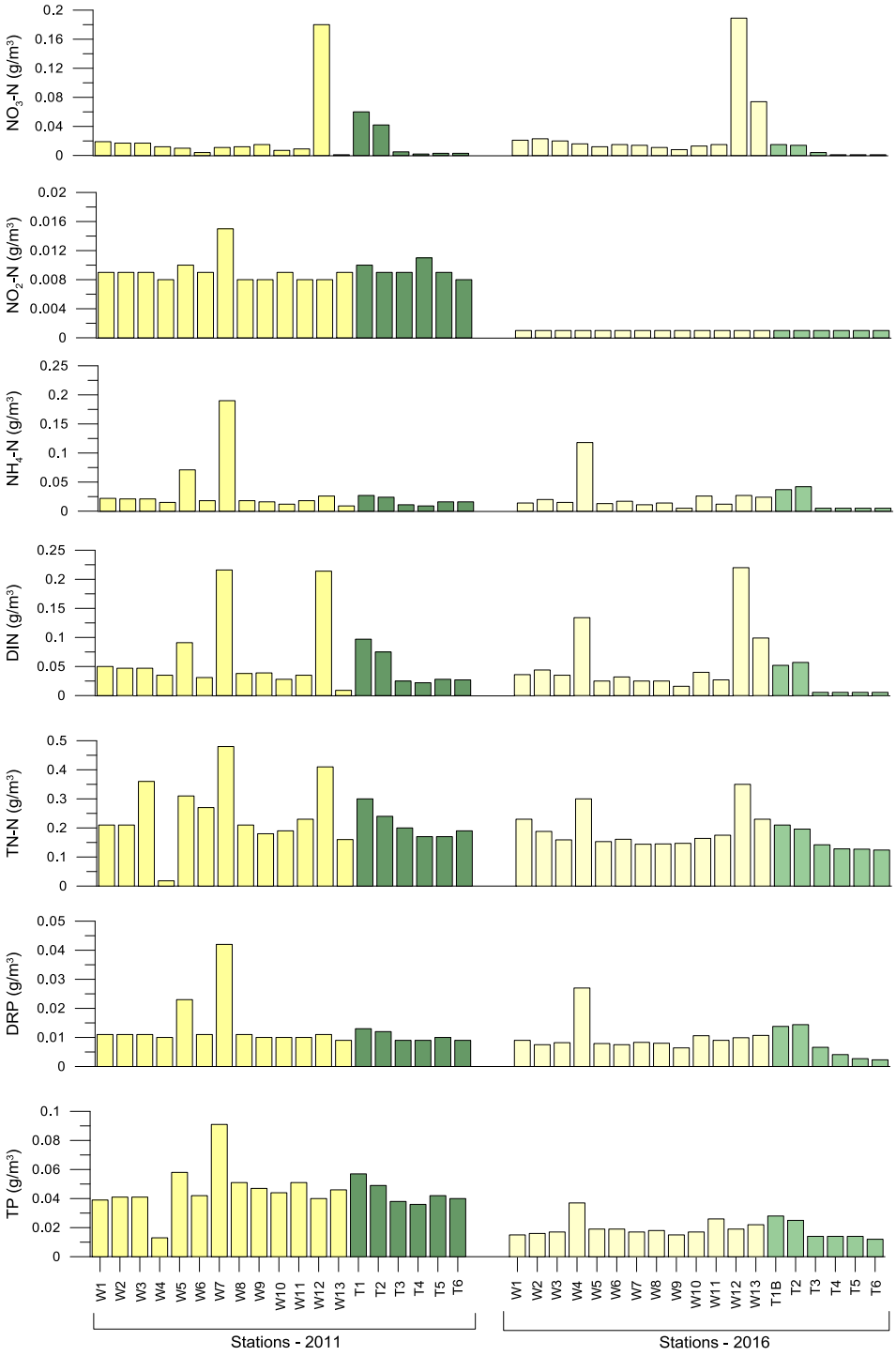


Figure 3. Nutrient concentrations in seawater samples from the Bell Island mixing zone and nearby coastal locations in 2011 and 2016. Values less than the detection limit are shown as half the detection limit.

3.3. Phytoplankton

There were no visual indications (e.g. highly turbid or coloured waters) of unusually high phytoplankton concentrations noted at Tasman Bay sites, T1-T6. However phytoplankton species and abundance reflected the productive spring sampling period with generally high numbers of diatoms; primarily *Chaetoceros* spp. and *Leptocylindrus* spp. (Appendix 4). No major differences were noted between sites T3 and T4 (opposite the outfall discharge channel) and reference sites T5 and T6 (opposite the Mapua channel). Highest cell numbers for the dominant taxa were recorded at the outermost sites, T4 and T6 suggesting offshore controlling factors. For example, *Chaetoceros* spp. and *Leptocylindrus* spp. counts were 582,000 and 108,000 cells/L respectively, indicating high spring productivity that was also evident in near-bottom chl-*a* concentrations of 4-5 mg/m^3 (Appendix 2).

Four potentially toxigenic algal taxa were recorded: *Pseudo-nitzschia* spp. (present at all sites); *Chrysochromulina* spp (present at sites T2, T4 and T6), *Heterosigma akashiwo* (T3) and *Dictyocha* spp. (T6). *Phaeocystis* spp., observed in low numbers at site T6 only, is better described as potentially noxious, as opposed to ichthyotoxic, as described in Appendix 4. Concentrations of *Pseudo-nitzschia* spp. exceeded the trigger value that may potentially cause toxic events (100,000 cells/L) at site T5 (114,000 cells/L). Although species within these genera can be toxic to fish or shellfish when present in high concentrations, the risks represented by the observed concentrations are considered to be low or moderate (e.g. in the case of *Pseudo-nitzschia* spp. at T5 and T6). Given that concentrations of potentially toxigenic or noxious taxa were highest at sites T5 and T6, furthest from the eastern arm of the Waimea Inlet, there is no indication that the phytoplankton community is influenced by the WWTP discharge.

In summary, the results to date do not show a linkage between potentially toxic or noxious algal taxa and the discharge from the WWTP.

As noted in the 2011 report (Gillespie et al. 2011), these results are not unexpected since the generation time for coastal phytoplankton is normally in the range of a few days rather than hours (Weiler & Chisholm 1976) and the rate of dilution down-current from the diffuser would be expected to preclude any measurable effluent-related bloom formation within the near-field mixing zone. This is because nutrients were seen to be diluted to near-ambient levels before the microalgae could respond by reproducing.

3.4. Bacterial water quality

Concentrations of faecal indicator bacteria (FIB) were, in general, very low at all sites and often below the limits of detection (Figure 4, Appendix 3). This was not surprising

considering the low FIB concentrations observed in a composite sample of the effluent discharged during the survey (13 MPN/100 mL, 5 MPN/100 mL and < 10 MPN/100 mL for faecal coliforms, *E. coli* and enterococci, respectively: Appendix 3). The highest receiving-water concentration of faecal coliforms (and of *E. coli*) was 13/100 mL at site W12, within the Waimea River channel. All other values were either at or below the detection limit of 2/100 mL. Concentrations of enterococci were at or below the detection limit of 10/100 mL at all sites except site T1 (124/100 mL). These results indicate that the Bell Island discharge was not a significant source of receiving water FIB during the sampling period. Concentrations of FIB at sites in Waimea Inlet and Tasman Bay recorded in 2016 were similar to those in 2011.

Concentrations of FIB were generally below standards for bathing water quality. ANZECC (2000) Section 5.2.3.1 'Microbiological characteristics for primary contact' states that:

> The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed:
>
> - 150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL);
> - 35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL).

The only exception is the count of 124 enterococci/100 mL at site T1B. Nelson City Council's contact recreation standards for FIB vary according to geographical location (NMRP 2012). The limit for the main beach at Tahunanui is 104 enterococci/100 mL whereas that for the Tahunanui back beach and Monaco is 275/100 mL. The concentration recorded at T1B, west of the back beach, complies with the latter standard. Council standards for shellfish gathering state that not more than 10% of water samples collected over a shellfish-gathering season should exceed a faecal coliform concentration of 43 MPN/100 mL. All of the samples collected during the present survey complied with this standard.

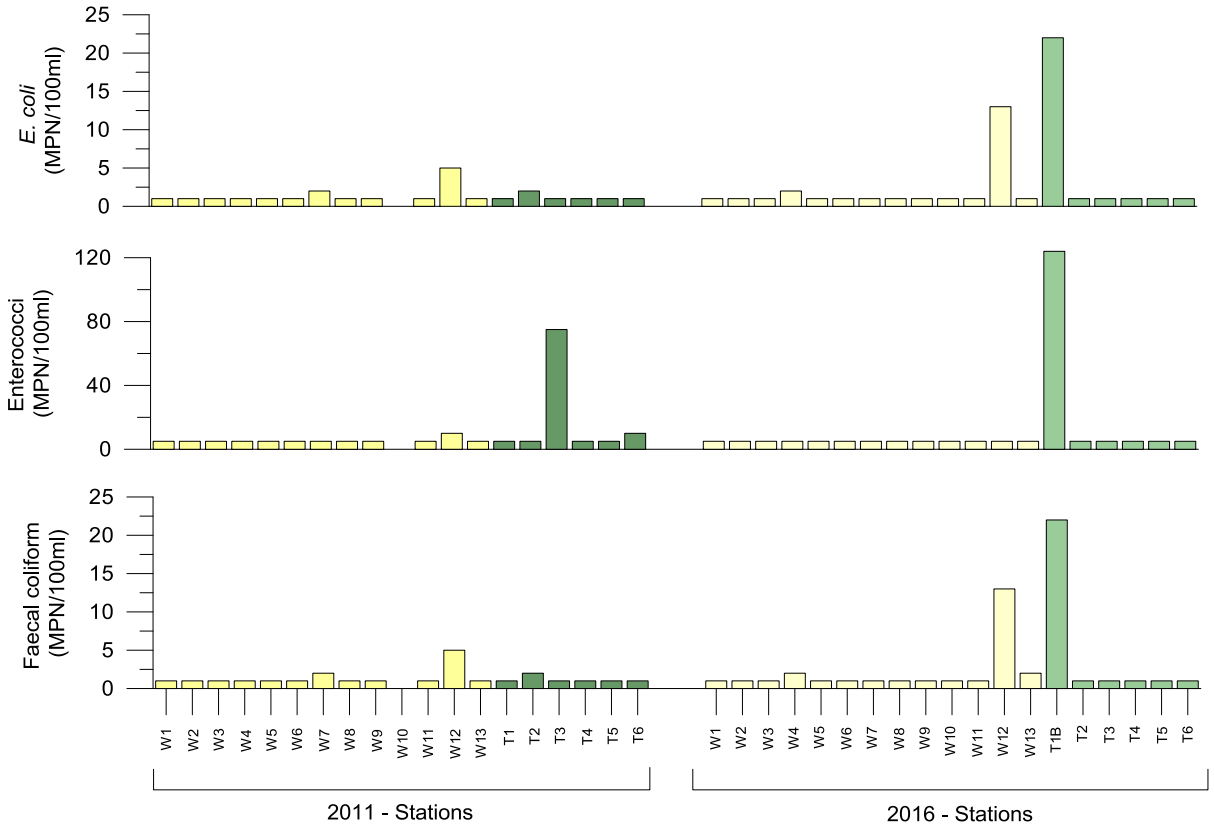


Figure 4. Concentrations of faecal indicator bacteria in seawater samples from the Bell Island mixing zone and nearby coastal locations in 2011 and 2016. Where values were less than the analytical detection limits (10 MPN/100 mL for enterococci, 2 MPN/100 mL for faecal coliforms and *E. coli*), the values were graphed as half the detection limit.

Comparison of concentrations of FIB at sites T3–T6 in Tasman Bay from 2008–2016 does not suggest any conspicuous trend or pattern over time (Figure 5). All samples collected comply with the Nelson City Council's contact-recreation standard (104 enterococci/100 mL) and all but one with the shellfish-gathering standard (43 faecal coliforms/100 mL).

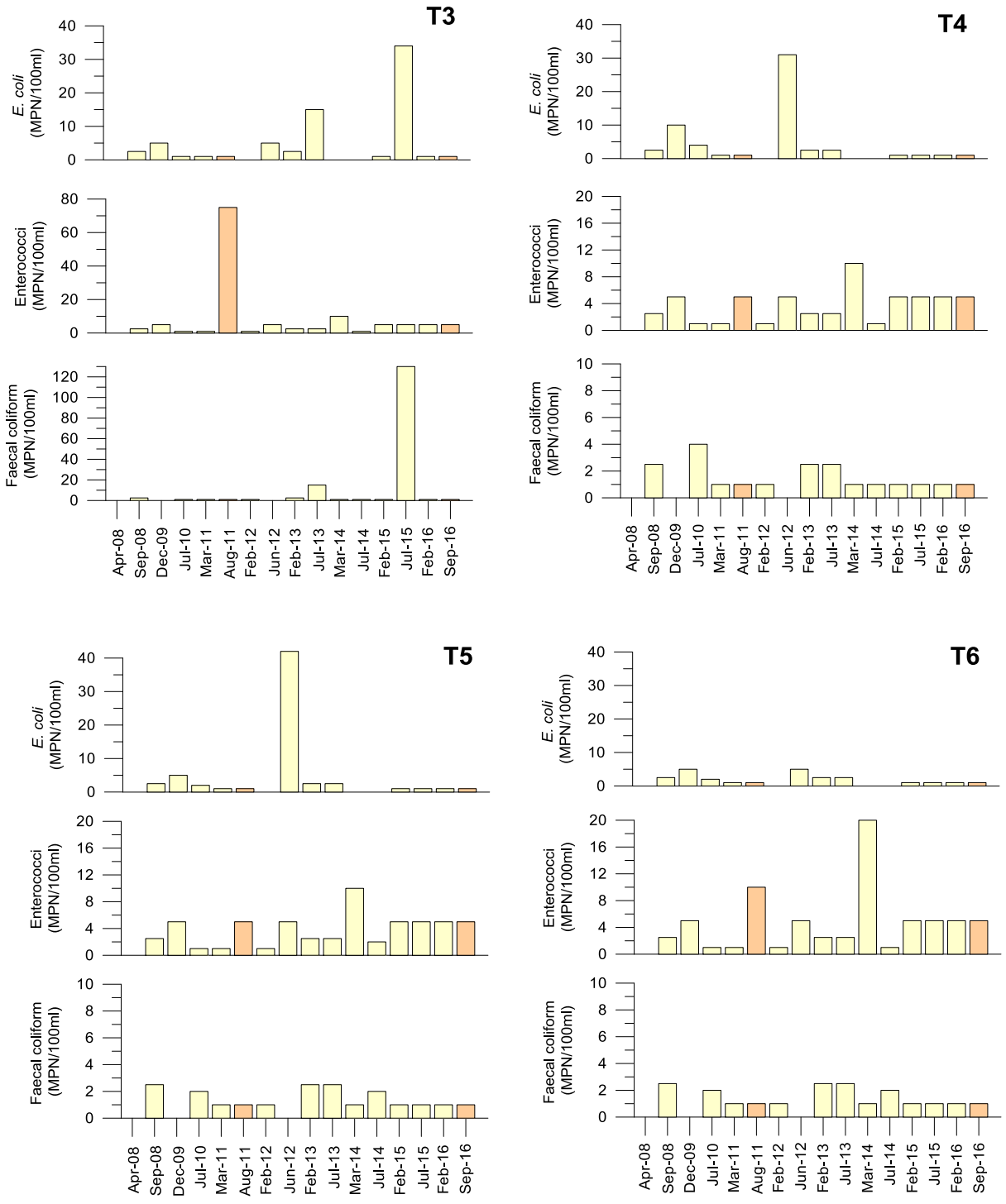


Figure 5. Concentrations of faecal indicator bacteria in seawater samples from the Tasman Bay sampling sites from 2008–2016. Orange coloured bars indicate five-yearly mixing-zone surveys, yellow bars six-monthly monitoring. Note different y-axis scales for T3.

3.5. Mussel bio-monitoring

3.5.1. August 2016 survey

Consistent with low seawater FIB concentrations, the concentrations of faecal coliforms in mussel flesh at all sites (Figure 6, Appendix 5) were below the recommended upper limit for the harvesting of shellfish for human consumption (230 MPN/100 g: NZMOH 1995). An enterococcal concentration of 790 MPN/100 g was recorded at site T3 (offshore from the eastern arm of the Waimea Inlet: Figure 1) suggesting an unidentified source of contamination outside the influence of the outfall discharge. Bacterial concentrations were generally slightly higher for mussels deployed in the estuary than for those deployed at inner Tasman Bay sites, and were similar to those recorded in 2011. Concentrations were considerably lower than previously reported for wild shellfish collected from estuarine locations (Gillespie et al. 2006). This suggests that, although bacterial contamination of the deployed mussels was minor over the present survey period, there may at times be a cumulative effect from multiple catchment sources over the longer term (as evidenced by the concentrations in the wild shellfish).

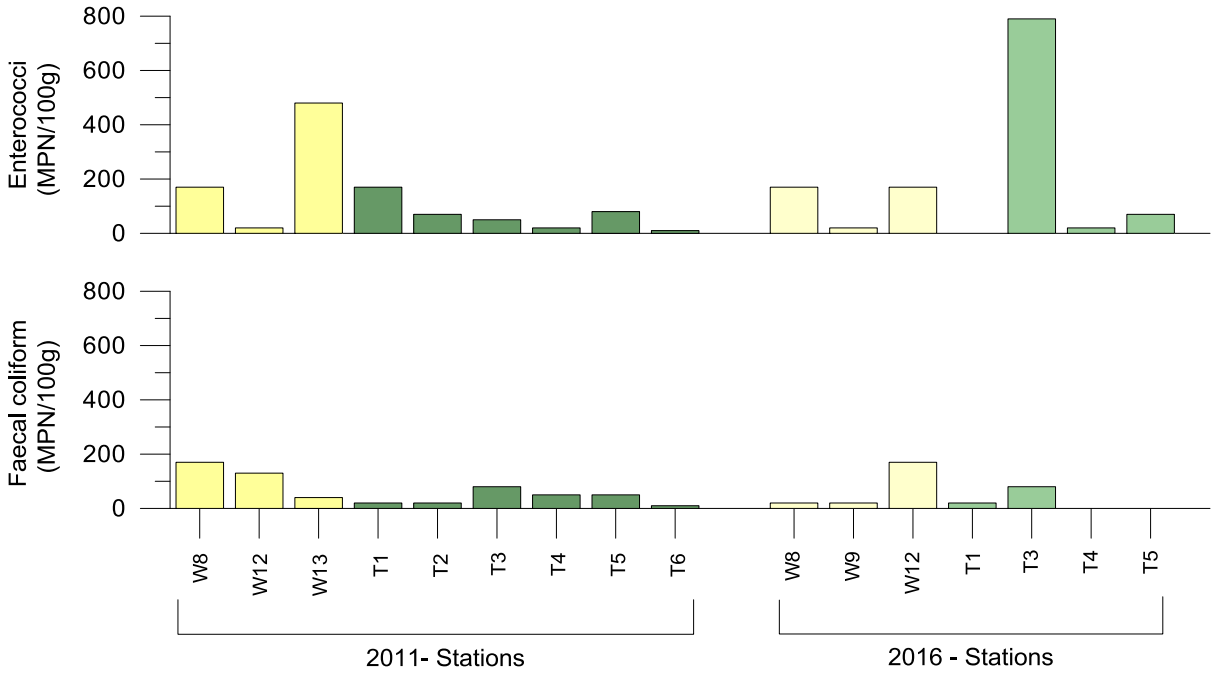


Figure 6. Concentrations of faecal indicator bacteria in caged mussels from the Bell Island mixing zone and nearby Tasman Bay locations (1 September 2016). Samples were not recovered from site W9 in 2011 and sites W13, T2 and T6 in 2016. Where values were less than the analytical detection limit (20 MPN/100 mL), the values were graphed as half the detection limit.

3.5.2. Review of mussel monitoring surveys, April 2008–present

The effect of the outfall discharge on bacteriological water quality was further evaluated through review of previous mussel bio-monitoring results from April 2008 (Figure 7). Although FIB concentrations of inner Tasman Bay seawater samples and deployed mussels varied considerably amongst sites and surveys, no obvious spatial or temporal trends were noted that might indicate a significant contribution from the outfall discharge. For example, FIB concentrations in mussels (and seawater: Figure 5) were often higher at sites T5 and T6 in the vicinity of the Mapua outlet channel than at sites T3 and T4, closer to the Bell Island outlet channel. For each of the four sites there was at least one occasion between 2008 and 2016 when mussels accumulated faecal coliforms to concentrations exceeding the NZMOH (1995) guidelines for human consumption. However, there was no correspondence in the timing of these events among site (or for incidences of high concentrations of enterococci).

These results indicate that the bacterial component of water quality of inner Tasman Bay can be affected to a greater degree by catchment runoff than by FIB contributions from the Bell Island wastewater discharge. Monitoring by Tasman District Council of bacteriological water quality in streams draining to the eastern part of Waimea Inlet indicate that concentrations of *E. coli* are often high (James & McCallum 2015). The median concentration in Reservoir Creek during the period 2005–2009 was 75/100 mL, but deteriorated to 200/100 mL during 2010–2014. Sources in the catchment of this stream include livestock, which had access to the waterway, and ducks. The median concentration of *E. coli* in Borck Creek was 1050/100 mL in 2012 and the 95th percentile during 2010–2014 was > 1000/100 mL. Neimann Creek (median concentration 673/100 mL over eight samples) and Pearl Creek (> 1000/100 mL over 30% of samples) also contributed large loads of FIB to Waimea Inlet.

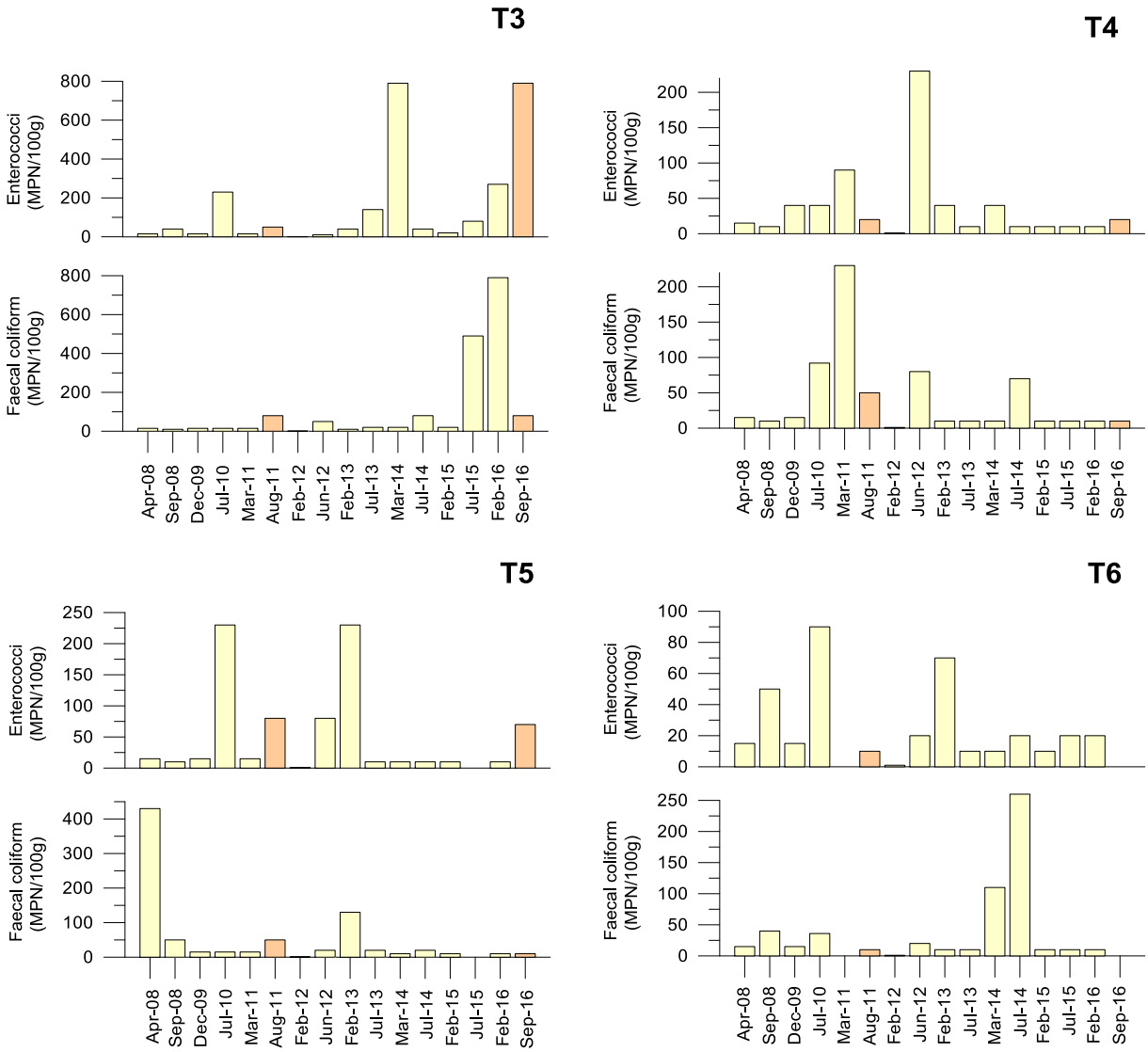


Figure 7. Concentrations of faecal indicator bacteria in caged mussels from the Tasman Bay sampling sites from 2008–2016. Orange coloured bars indicate five-yearly mixing-zone surveys, yellow bars six-monthly monitoring. Note different y-axis scales for different sites.

4. CONCLUSIONS

- Seawater stratification characteristics indicate rapid mixing of the low salinity wastewater discharge with estuarine receiving waters within the ebb tide flow channels.
- Receiving water nutrient concentrations indicate adequate dilution down-current from the Bell Island wastewater outfall to prevent development of eutrophication.
- Ammoniacal-N concentrations at all sites were well below ANZECC (2000) and USEPA (1986) guideline trigger levels, ensuring that potentially toxic conditions were not achieved.
- Phytoplankton characteristics at inner Tasman Bay sites were considered to be normal for the region, reflecting the seasonally productive spring diatom growth period but showing no discharge-related signs of over-enrichment or stimulation of undesirable species.
- Receiving water faecal coliform and enterococci concentrations indicate that the Bell Island outfall discharge was not a significant source of bacterial contamination during the sampling period.
- Concentrations of faecal coliforms and enterococci in mussels, summarised from 16 bio-monitoring surveys (2008-2016), indicate that contributions from the Bell Island discharge were minor in comparison to catchment runoff.

5. RECOMMENDATIONS

We recommend that the outfall mixing zone survey, as described here, be repeated in 2021 and interpreted in conjunction with a review of the results of 6-monthly mussel bio-monitoring surveys to be undertaken 2017–2021.

As noted in the previous report (Gillespie et al. 2011), we acknowledge the lack of more general information describing catchment influences on water quality characteristics of Waimea Estuary and inner Tasman Bay waters. Additional investigation of the relationships between multiple (largely diffuse) catchment sources of contaminants and estuary/bay water quality would assist interpretation of the relative significance of point-source discharges, such as the Bell Island wastewater discharge. Although appropriately outside the responsibility of individual consent holders, such an investigation, involving long term monitoring of the water quality of Waimea Inlet/inner Tasman Bay in conjunction with that of freshwater inflows, would facilitate informed management decisions and could be considered an integral component of a regional environmental management plan for Tasman Bay.

6. ACKNOWLEDGMENTS

Thanks to Paul Meredith, Marc Jary, Jamie Downs and Bruce Lines for help with field work.

7. REFERENCES

American Public Health Association (APHA) 1992. Compendium of methods for the microbiological examination of foods, APHA 4th edition.

American Public Health Association (APHA) 1998. Standard methods for examination of water and wastewater. APHA 20th edition.

Australian and New Zealand Environment and Conservation Council (ANZECC) 2000. Australian and New Zealand guidelines for fresh and marine water quality. Volume 1. The guidelines. A3, 89-94.

Bell RG, Williams BL, Gibbs MM 1995. Bells Island outfall mixing zone study. NIWA Report No. BCH011/1 for Nelson Regional Sewerage Authority. 24 p.

Gillespie PA, Asher RA 2001. Impact of the Nelson (Bell Island) regional sewerage discharge on Waimea Inlet: April 2001 receiving water survey. Cawthron Report No. 695. Prepared for Nelson Regional Sewerage Business Unit. 13 p.

Gillespie PA, Asher RA 2005. Impact of the Nelson (Bell Island) regional sewerage discharge on coastal water quality: April 2005 receiving water survey. Report for the Nelson Regional Sewerage Business Unit. Cawthron Report No 1039. 14 p plus appendices.

Gillespie PA, Asher RA, Doyle M 2001. Impact of the Nelson (Bell Island) regional sewerage discharge on Waimea Inlet Part II: Nutrient enrichment potential of receiving waters. Cawthron Report No. 680. Prepared for Nelson Regional Sewerage Business Unit and Tasman District Council. 30 p.

Gillespie PA, Asher RA, Forrest R, Johnston O 2011. Impact of the Nelson (Bell Island) regional sewerage discharge on the coastal environment: Receiving water survey – August 2011. Cawthron Report No. 2046. Prepared for Nelson Regional Sewerage Business Unit. 17 p plus appendices.

Gillespie PA, Clark K, Asher RA 2006. Impact of the Nelson (Bell Island) regional sewerage discharge on coastal water quality: May 2006 receiving water survey. Cawthron Report No.1198 Prepared for the Nelson Regional Sewerage Business Unit.23 p.

Heath RA 1976. Broad classification of New Zealand inlets with emphasis on residence times. New Zealand Journal of Marine and Freshwater Research 10: 469-483.

James T, McCallum J 2015. State of the environment report: river water quality in Tasman District 2015. Prepared for Tasman District Council. 349 p. plus appendices.

New Zealand Ministry of Health (NZMOH) 1995. Microbiological reference criteria for food. Version 2.0. 28 p.

Nelson Regional Management Plan (NMRP 2012). http://nelson.govt.nz/environment/nelson-resource-management-plan/nelson-resource-management-plan-2/view-the-nrmp/download-the-nrmp-2/ accessed September 2016.

Solorzano L 1969. Determination of ammonia in natural waters by the phenol hypochlorite method. Limnology and Oceanography 14: 799-801.

United Nations Education, Scientific and Cultural Organization 1978. Monographs on oceanographic methodology. Phytoplankton Manual. Paris, France.

United Nations Education, Scientific and Cultural Organization 2010. Karlson B, Cusack C, Bresnan E (editors). Microscopic and molecular methods for quantitative phytoplankton analysis. IOC Manuals and Guides, No. 55. Paris, France.

United States Environmental Protection Agency (USEPA) 1986. Quality criteria for water. Office of Water Regulations and Standards. EPA 140/5-86-001. Washington DC.

Weiler CS, Chisholm SW 1976. Phased cell division in natural populations of marine dinoflagellates from shipboard cultures. Journal of Experimental Marine Biology and Ecology 25: 239-247.

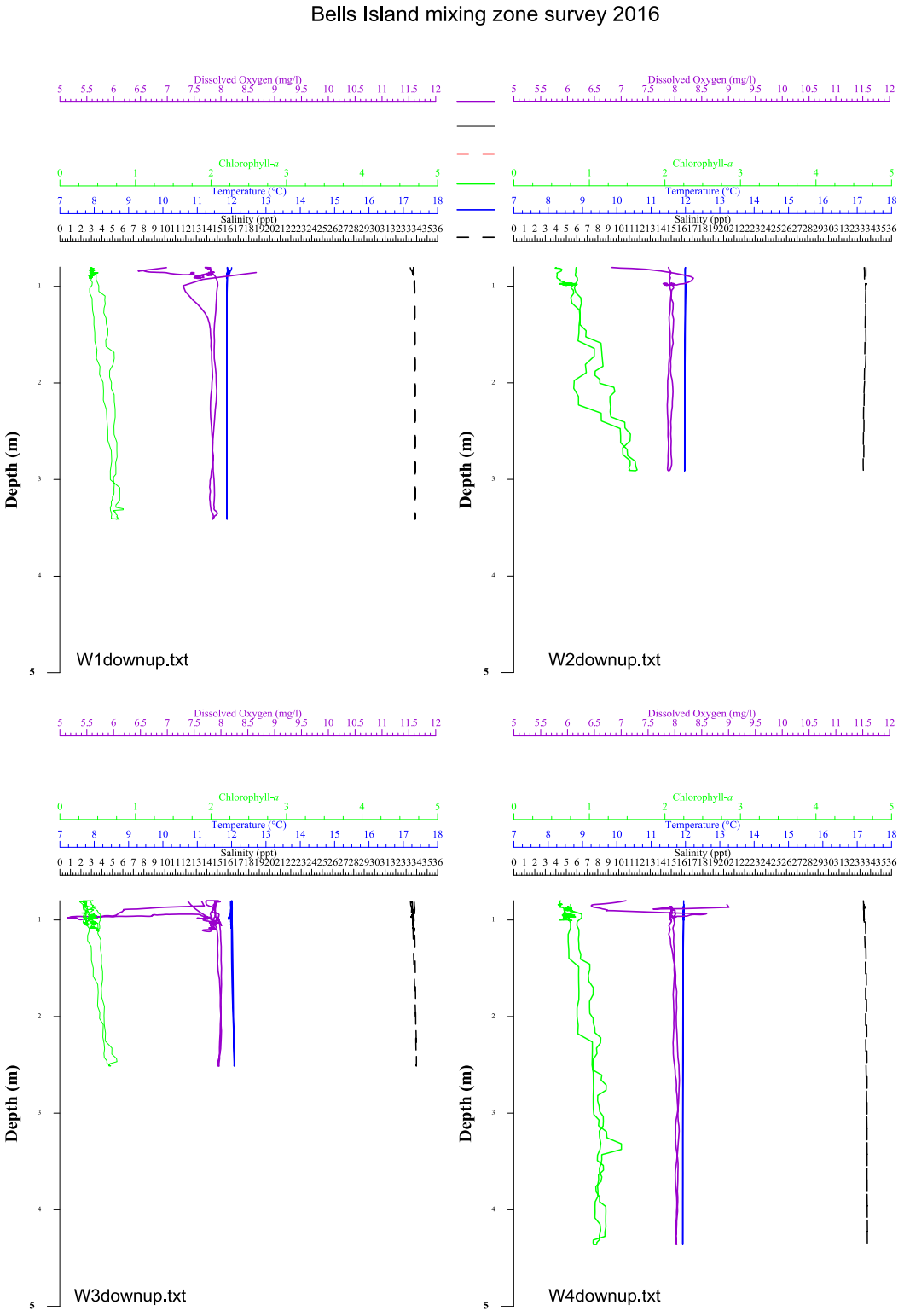
Westcott KG 1981. Aspects of circulation in the Waimea Inlet: dye tracer studies. In: Proceedings of the River and Estuary Mixing Workshop. Hamilton. 17-18 November. 132-146.

8. APPENDICES

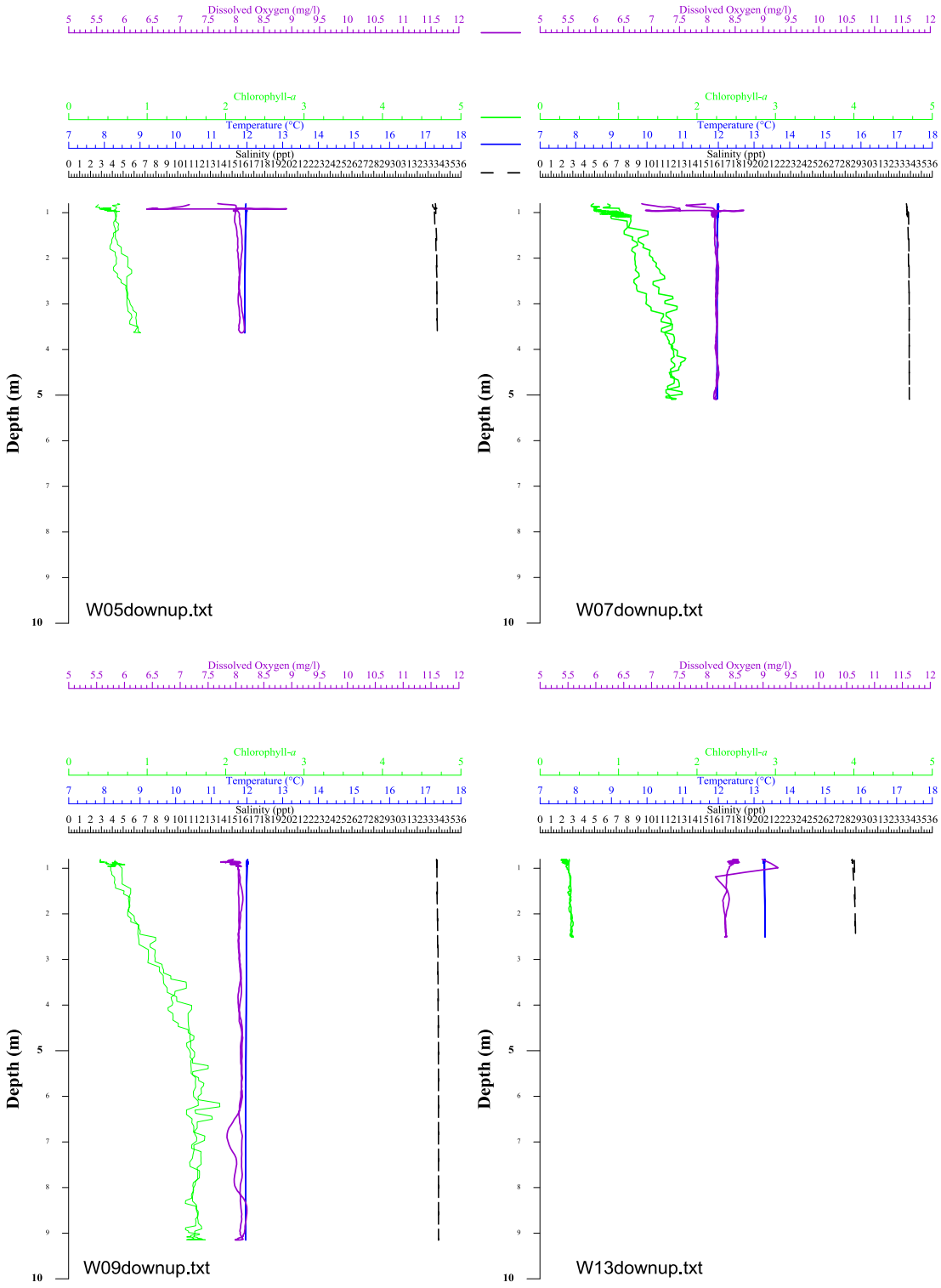
Appendix 1. GPS coordinates of sampling site locations (1 September 2016).

Site	Latitude	Longitude
W1	S41°17.99423'	E173°10.952'
W2	S41°17.90116'	E173°11.04417'
W3	S41°17.80164'	E173°11.11267'
W4	S41°17.87606	E173°11.19956'
W5	S41°17.87587'	E173°11.32135'
W6	S41°17.71719'	E173°11.21846'
W7	S41°17.85148'	E173°11.69883'
W8	S41°17.571'	E173°11.675'
W9	S41°17.830'	E173°12.060'
W10	S41°17.38812'	E173°11.9045'
W11	S41°17.77642'	E173°12.61775'
W12	S41°17.05673'	E173°08.23409'
W13	S41°15.15675'	E173°06.47267'
T1	S41°17.232'	E173°13.412'
T1B	S41° 16.491'	E173° 13.813'
T2	S41°16.651'	E°173°14.092'
T3	S41°16.03262'	E173°12.78341'
T4	S41°15.48149'	E173°12.806'
T5	S41°14.19712'	E173°07.65641'
T6	S41°13.77191'	E173°08.14584'

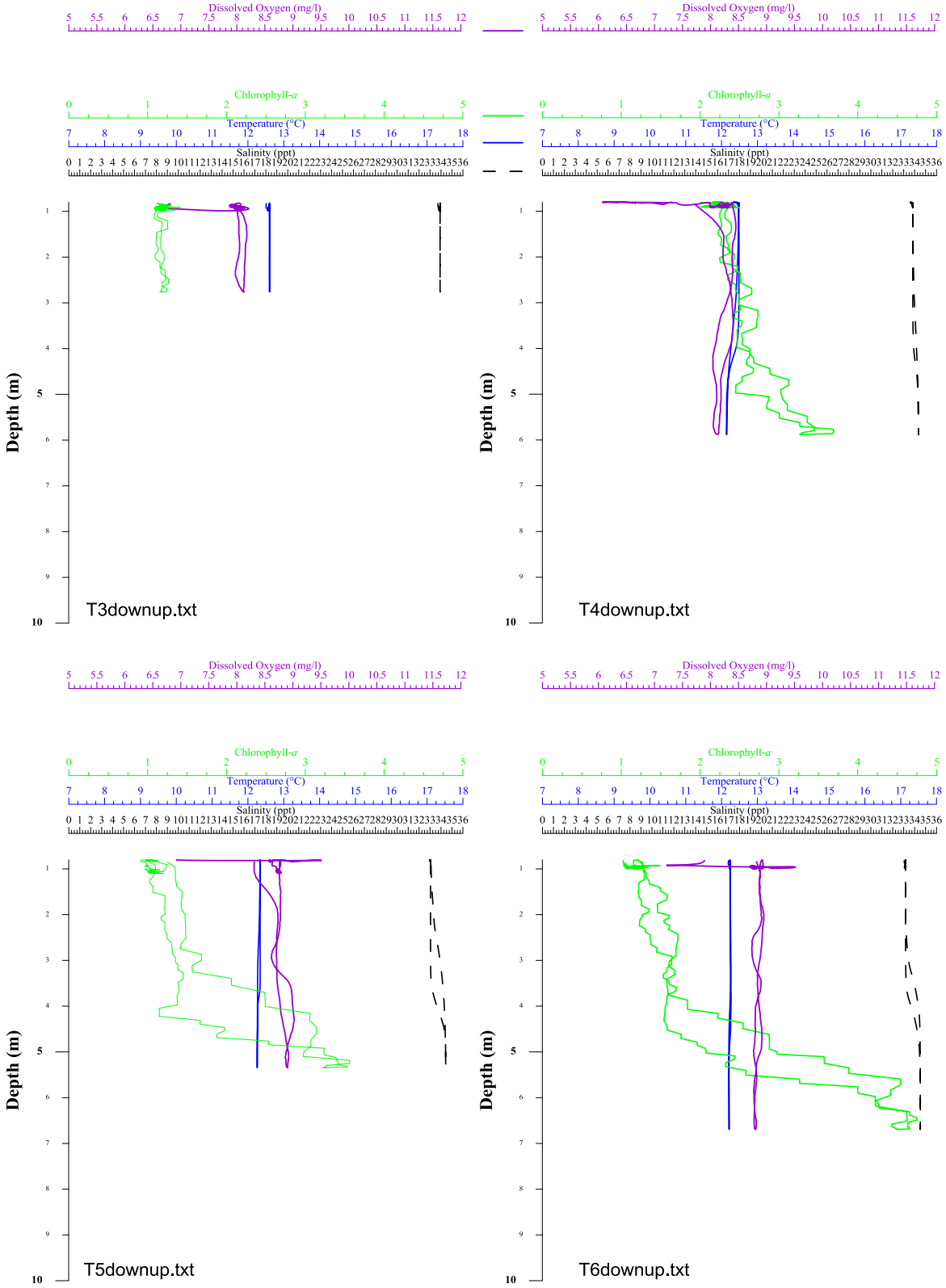
Appendix 2. Water-column profiles of dissolved oxygen (purple), chlorophyll-*a* (mg/m^3) (green), temperature (blue) and salinity (black) from CTD casts at sites in Waimea Inlet (W1–W13 and Tasman Bay (T3–T6). See Figure 1 for the location of sites. Water depths at sites W6, W8, W10, W11 and W12 were too shallow to obtain casts. No casts were made at sites T1 or T2.



Bells Island mixing zone survey 2016



Bells Island mixing zone survey 2016



Appendix 3. Nutrient (g/m^3) and faecal indicator bacterial concentrations (MPN/100 mL) in seawater and effluent samples (1 September 2016). FC = faecal coliforms, EC = *E. coli*, ENT = enterococci. Concentrations in the effluent sample for 2011 are also shown for comparison (NR = not recorded).

Site	NO_2-N	NO_3-N	NH_4-N	DIN	TN-N	DRP	TP	FC	EC	ENT
W1	<0.002	0.021	0.014	0.036	0.23	0.0090	0.015	<2	<2	<10
W2	<0.002	0.023	0.020	0.044	0.188	0.0075	0.016	<2	<2	<10
W3	<0.002	0.020	0.015	0.035	0.159	0.0082	0.017	<2	<2	<10
W4	<0.002	0.016	0.118	0.134	0.300	0.0270	0.037	2	2	<10
W5	<0.002	0.012	0.013	0.025	0.153	0.0079	0.019	<2	<2	<10
W6	<0.002	0.015	0.017	0.032	0.161	0.0075	0.019	<2	<2	<10
W7	<0.002	0.014	0.011	0.025	0.144	0.0083	0.017	<2	<2	<10
W8	<0.002	0.011	0.014	0.025	0.145	0.0080	0.018	<2	<2	<10
W9	<0.002	0.008	<0.010	0.016	0.147	0.0064	0.015	<2	<2	<10
W10	<0.002	0.013	0.026	0.040	0.164	0.0106	0.017	<2	<2	<10
W11	<0.002	0.015	0.012	0.027	0.175	0.0090	0.026	<2	<2	<10
W12	<0.002	0.189	0.027	0.220	0.350	0.0099	0.019	13	13	<10
W13	<0.002	0.074	0.024	0.099	0.230	0.0107	0.022	2	<2	<10
T1B	<0.002	0.015	0.037	0.052	0.210	0.0138	0.028	22	22	124
T2	<0.002	0.014	0.042	0.057	0.196	0.0144	0.025	<2	<2	<10
T3	<0.002	0.004	<0.010	<0.011	0.142	0.0066	0.014	<2	<2	<10
T4	<0.002	<0.002	<0.010	<0.011	0.128	0.0041	0.014	<2	<2	<10
T5	<0.002	<0.002	<0.010	<0.011	0.127	0.0027	0.014	<2	<2	<10
T6	<0.002	<0.002	<0.010	<0.011	0.124	0.0023	0.012	<2	<2	<10
Effluent 2016	<0.10	<0.10	12.5	12.6	17.2	2.3	2.8	13	5	<10
Effluent 2011	0.53	0.13	11.0	11.7	20.0	3.1	4.2	790	NR	20

Appendix 4. Phytoplankton species abundance in water samples from inner Tasman Bay sites T1-T6 (1 September 2016).

CAWTHRON INSTITUTE

Cawthron Analytical Services:
Ensuring Integrity Through Analytical Excellence.

Certificate of Analysis: Final

Cawthron Contract Number: 10210

Project Number: T76545

Cawthron Institute
Private Bag 2
NELSON

Customer Order No: BST 16332
Email Recipients: Don Morrisey

Sample Details

Laboratory ID: T76545-1 **Sample Type:** Grab
Description: Sea water Tasman bay
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T1

Date Sampled: 01/09/2016
Date Received: 02/09/2016 09:00

Species	Description	Count (cells/L)	Trigger (cells/L)	Risk	Action
Biomass : Low					
Pseudo-nitzschia spp.	**Toxic in Shellfish**	**28000**	100000	Low	
Rhizosolenia spp.	Potential Problem Species	6000			
Bacillaria spp.	Other Dominant Species	800			
Cerataulina spp.	Other Dominant Species	600			
Ceratium spp.	Other Dominant Species	200			
Chaetoceros spp.	Other Dominant Species	34000			
Ciliate (unidentified)	Other Dominant Species	1000			
Cochlodinium spp.	Other Dominant Species	200			
Ditylum brightwelli	Other Dominant Species	1000			
Entomoneis spp.	Other Dominant Species	600			
Guinardia spp.	Other Dominant Species	2800			
Gymnodinium spp.	Other Dominant Species	400			
Gyrodinium spp.	Other Dominant Species	400			
Katodinium spp.	Other Dominant Species	200			
Lauderia spp.	Other Dominant Species	200			
Leptocylindrus spp.	Other Dominant Species	35000			
Navicula spp.	Other Dominant Species	200			
Nitzschia spp.	Other Dominant Species	1400			
Paralia spp.	Other Dominant Species	2400			
Peridinium spp.	Other Dominant Species	800			
Pleurosigma spp.	Other Dominant Species	200			
Scrippsiella spp.	Other Dominant Species	200			
Skeletonema spp.	Other Dominant Species	5200			
Small Flagellates	Other Dominant Species	800			
Thalassiosira spp.	Other Dominant Species	200			

ilac-MRA IANZ ACCREDITED LABORATORY

Unless otherwise specified, all tests reported herein have been performed in accordance with the laboratory's scope of registration.

Report Number: 633853
Project Number: T76545
V18.23
SL:P

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Sample Details

Laboratory ID: T76545-1 **Sample Type:** Grab
Description: Sea water Tasman bay
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T1

Date Sampled: 01/09/2016
Date Received: 02/09/2016 09:00

Mesodinium rubrum	**Non-toxic bloom forming spp.**	**600**	Low

Method: In-house, based on UNESCO 1978 and IOC Manual and Guides 55 2010

Sample Details

Laboratory ID: T76545-2 **Sample Type:** Grab
Description: Sea water Tasman bay
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T2

Date Sampled: 01/09/2016
Date Received: 02/09/2016 09:00

Species	Description	Count (cells/L)	Trigger (cells/L)	Risk	Action
Biomass : Low					
Pseudo-nitzschia spp.	**Toxic in Shellfish**	**13000**	100000	Low	
Chrysochromulina spp.	**Ichthyotoxic Species**	**200**		Low	
Rhizosolenia spp.	Potential Problem Species	600			
Bacteriastrum spp.	Other Dominant Species	2200			
Chaetoceros spp.	Other Dominant Species	12000			
Ciliate (unidentified)	Other Dominant Species	600			
Cochlodinium spp.	Other Dominant Species	200			
Diploneis spp.	Other Dominant Species	200			
Diplopsalis spp.	Other Dominant Species	200			
Ditylum brightwelli	Other Dominant Species	400			
Euglenoid spp.	Other Dominant Species	200			
Guinardia spp.	Other Dominant Species	2400			
Gymnodinium spp.	Other Dominant Species	2200			
Hemiaulus spp.	Other Dominant Species	400			
Heterocapsa spp.	Other Dominant Species	200			
Leptocylindrus spp.	Other Dominant Species	13000			
Licmophora spp.	Other Dominant Species	200			
Navicula spp.	Other Dominant Species	1200			
Nitzschia spp.	Other Dominant Species	200			
Odontella spp.	Other Dominant Species	200			
Paralia spp.	Other Dominant Species	6200			
Peridinium spp.	Other Dominant Species	200			
Scrippsiella spp.	Other Dominant Species	400			
Skeletonema spp.	Other Dominant Species	2800			
Small Flagellates	Other Dominant Species	200			
Thalassionema spp.	Other Dominant Species	400			
Thalassiosira spp.	Other Dominant Species	600			
Mesodinium rubrum	**Non-toxic bloom forming spp.**	**800**		Low	

Method: In-house, based on UNESCO 1978 and IOC Manual and Guides 55 2010

Report Number: 633853
Project Number: T76545
V18.23
SL:P

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Sample Details

Laboratory ID: T76545-3 **Sample Type:** Grab **Date Sampled:** 01/09/2016
Description: Sea water Tasman bay **Date Received:** 02/09/2016 09:00
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T3

Species	Description	Count (cells/L)	Trigger (cells/L)	Risk	Action
Biomass : Low					
Pseudo-nitzschia spp.	**Toxic in Shellfish**	**48000**	100000	Low	
Heterosigma akashiwo	**Ichthyotoxic Species**	**400**		Low	
Rhizosolenia spp.	Potential Problem Species	4200			
Asterionellopsis spp.	Other Dominant Species	5400			
Bacteriastrum spp.	Other Dominant Species	800			
Cerataulina spp.	Other Dominant Species	1400			
Chaetoceros spp.	Other Dominant Species	63000			
Ciliate (unidentified)	Other Dominant Species	1600			
Dinobryon spp.	Other Dominant Species	39000			
Ditylum brightwelli	Other Dominant Species	600			
Euglenoid spp.	Other Dominant Species	400			
Guinardia spp.	Other Dominant Species	34000			
Gymnodinium spp.	Other Dominant Species	400			
Hemiaulus spp.	Other Dominant Species	200			
Heterocapsa spp.	Other Dominant Species	200			
Lauderia spp.	Other Dominant Species	400			
Leptocylindrus spp.	Other Dominant Species	48000			
Nitzschia spp.	Other Dominant Species	1200			
Oxytoxum spp.	Other Dominant Species	400			
Protoperidinium spp.	Other dominant species	200			
Scrippsiella spp.	Other Dominant Species	1600			
Skeletonema spp.	Other Dominant Species	19000			
Small Flagellates	Other Dominant Species	800			
Thalassiosira spp.	Other Dominant Species	800			
Mesodinium rubrum	**Non-toxic bloom forming spp.**	**1200**		Low	

Method: In-house, based on UNESCO 1978 and IOC Manual and Guides 55 2010

Report Number: 633853
Project Number: T76545
V18.23
SL:P

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Sample Details

Laboratory ID: T76545-4 **Sample Type:** Grab
Description: Sea water Tasman bay
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T4

Date Sampled: 01/09/2016
Date Received: 02/09/2016 09:00

Species	Description	Count (cells/L)	Trigger (cells/L)	Risk	Action
Biomass : Low					
Pseudo-nitzschia spp.	**Toxic in Shellfish**	**36000**	100000	Low	
Chrysochromulina spp.	**Ichthyotoxic Species**	**200**		Low	
Rhizosolenia spp.	Potential Problem Species	1400			
Chaetoceros spp.	Other Dominant Species	280000			
Ciliate (unidentified)	Other Dominant Species	2400			
Cryptomonads	Other Dominant Species	1200			
Dinobryon spp.	Other Dominant Species	8600			
Ditylum spp.	Other Dominant Species	1400			
Eucampia spp.	Other Dominant Species	400			
Guinardia spp.	Other Dominant Species	50000			
Gyrodinium spp.	Other Dominant Species	1200			
Hemiaulus spp.	Other Dominant Species	2400			
Heterocapsa spp.	Other Dominant Species	1000			
Katodinium spp.	Other Dominant Species	200			
Leptocylindrus spp.	Other Dominant Species	400			
Nitzschia spp.	Other Dominant Species	200			
Peridinium spp.	Other Dominant Species	400			
Protoperidinium spp.	Other dominant species	200			
Scrippsiella spp.	Other Dominant Species	200			
Skeletonema spp.	Other Dominant Species	56000			
Small Flagellates	Other Dominant Species	1200			
Thalassionema spp.	Other Dominant Species	3200			
Thalassiosira spp.	Other Dominant Species	36000			

Method: In-house, based on UNESCO 1978 and IOC Manual and Guides 55 2010

Report Number: 633853
Project Number: T76545
V18.23
SL:P

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Sample Details

Laboratory ID: T76545-5 **Sample Type:** Grab
Description: Sea water Tasman bay
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T5

Date Sampled: 01/09/2016
Date Received: 02/09/2016 09:00

Species	Description	Count (cells/L)	Trigger (cells/L)	Risk	Action
Biomass : Low					
TRIGGER BREACHES					
Pseudo-nitzschia spp.	**Toxic in Shellfish**	**114000**	100000	Moderate	DNA probe or Flesh test
OTHER RESULTS					
Rhizosolenia spp.	Potential Problem Species	600			
Asterionellopsis spp.	Other Dominant Species	3000			
Cerataulina spp.	Other Dominant Species	1200			
Ceratium spp.	Other Dominant Species	200			
Chaetoceros spp.	Other Dominant Species	97000			
Ciliate (unidentified)	Other Dominant Species	1400			
Dinobryon spp.	Other Dominant Species	6800			
Diplopsalis spp.	Other Dominant Species	400			
Ditylum brightwelli	Other Dominant Species	600			
Eucampia spp.	Other Dominant Species	800			
Guinardia spp.	Other Dominant Species	28000			
Gymnodinium spp.	Other Dominant Species	3600			
Gyrodinium spp.	Other Dominant Species	1800			
Hemiaulus spp.	Other Dominant Species	3400			
Heterocapsa spp.	Other Dominant Species	3000			
Katodinium spp.	Other Dominant Species	2000			
Leptocylindrus spp.	Other Dominant Species	74000			
Oxytoxum spp.	Other Dominant Species	200			
Paralia spp.	Other Dominant Species	2600			
Peridinium spp.	Other Dominant Species	1200			
Polykrikos schwartzii	Other Dominant Species	600			
Prorocentrum spp.	Other Dominant Species	200			
Protoperidinium spp.	Other dominant species	800			
Scrippsiella spp.	Other Dominant Species	2400			
Small Flagellates	Other Dominant Species	1000			
Thalassionema spp.	Other Dominant Species	8600			
Thalassiosira spp.	Other Dominant Species	2200			
Mesodinium rubrum	**Non-toxic bloom forming spp.**	**800**		Low	

Method: In-house, based on UNESCO 1978 and IOC Manual and Guides 55 2010

Report Number: 633853
Project Number: T76545
V18.23
SL:P

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Sample Details

Laboratory ID: T76545-6 **Sample Type:** Grab
Description: Sea water Tasman bay
Site Description PU01 - Phyto Site Unspecified
Sample Comment: T6

Date Sampled: 01/09/2016
Date Received: 02/09/2016 09:00

Species	Description	Count (cells/L)	Trigger (cells/L)	Risk	Action
Biomass : Low					
Pseudo-nitzschia spp.	**Toxic in Shellfish**	**81000**	100000	Moderate	
Chrysochromulina spp.	**Ichthyotoxic Species**	**400**		Low	
Dictyocha spp.	**Ichthyotoxic Species**	**200**		Low	
Phaeocystis spp.	**Ichthyotoxic Species**	**2400**		Moderate	
Rhizosolenia spp.	Potential Problem Species	1600			
Bacteriastrum spp.	Other Dominant Species	800			
Cerataulina spp.	Other Dominant Species	600			
Chaetoceros spp.	Other Dominant Species	582000			
Ciliate (unidentified)	Other Dominant Species	6000			
Coscinodiscus spp.	Other Dominant Species	400			
Cryptomonads	Other Dominant Species	800			
Dinobryon spp.	Other Dominant Species	75000			
Diplopsalis spp.	Other Dominant Species	200			
Ditylum spp.	Other Dominant Species	1200			
Eucampia spp.	Other Dominant Species	1000			
Euglenoid spp.	Other Dominant Species	600			
Guinardia spp.	Other Dominant Species	61000			
Gymnodinium spp.	Other Dominant Species	1800			
Gyrodinium spp.	Other Dominant Species	1200			
Hemiaulus spp.	Other Dominant Species	2400			
Heterocapsa spp.	Other Dominant Species	1000			
Leptocylindrus spp.	Other Dominant Species	108000			
Navicula spp.	Other Dominant Species	200			
Peridinium spp.	Other Dominant Species	1400			
Polykrikos schwartzii	Other Dominant Species	600			
Prorocentrum spp.	Other Dominant Species	200			
Protoperidinium spp.	Other dominant species	600			
Scrippsiella spp.	Other Dominant Species	1000			
Skeletonema spp.	Other Dominant Species	35000			
Small Flagellates	Other Dominant Species	1400			
Thalassionema spp.	Other Dominant Species	4000			
Thalassiosira spp.	Other Dominant Species	1000			
Mesodinium rubrum	**Non-toxic bloom forming spp.**	**400**		Low	

Method: In-house, based on UNESCO 1978 and IOC Manual and Guides 55 2010

Results apply to samples as received

Our routine detection limits for chemical testing relate to samples with a clean matrix.
Reported detection limits may be higher for individual samples if there is insufficient sample or the matrix is complex.

< means less than, > means greater than

Date Generated: 6/9/16

Report Number: 633853
Project Number: T76545
V18.23
SL:P

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Authorised by: Catherine Elise Moisan

Position: Section Head, Natural Toxins Laboratory

Signature:

Unless otherwise specified, all tests reported herein have been performed in accordance with the laboratory's scope of registration.

T (+64) 03 548 2839 | F (+64) 03 546 9464 | 98 Halifax Street East, Nelson 7010. Private Bag 2, Nelson 7042. New Zealand | www.cawthron.org.nz

Appendix 5. Concentrations of faecal indicator bacteria in caged mussels from the vicinity of the Bell Island outfall mixing zone and nearby coastal locations (September 2016).

Site	**Enterococci (MPN/100 g)**	***E. coli* (MPN/100 g)**	**Faecal coliforms (MPN/100 g)**
Pre-deployment	20	<20	<20
W8	170	20	20
W9	20	< 20	20
W12	170	170	170
W13	Lost	Lost	Lost
T1	20	< 20	< 20
T2	Lost	Lost	Lost
T3	790	80	80
T4	20	< 20	< 20
T5	70	< 20	< 20
T6	Lost	Lost	Lost