Mahurangi Estuary Ecological Monitoring Programme:

Report on data collected from July 1994 to January 2018

K R Carter and S F Hailes

August 2020 Technical Report 2020/012

Research and Evaluation Unit RIMU

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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Technical Report 2020/012
ISSN 2230-4525 (Print)
ISSN 2230-4533 (Online)

ISBN 978-1-99-002252-4 (Print)
ISBN 978-1-99-002253-1 (PDF)

This report has been peer reviewed by the Peer Review Panel.
Review completed on 25 August 2020 Reviewed by two reviewers
Approved for Auckland Council publication by: Name: Eva McLaren Position: Manager, Research and Evaluation Unit (RIMU) Name: Megan Carbines Position: Manager, Air, Land and Biodiversity (RIMU)
Date: 25 August 2020

Recommended citation

Carter, K R and S F Hailes (2020). Mahurangi Estuary ecological monitoring programme: report on data collected from July 1994 to January 2018. Prepared by the National Institute of Water and Atmospheric Research, NIWA for Auckland Council. Auckland Council technical report, TR2020/012

Executive summary

In July 1994, a long-term ecological monitoring programme of the intertidal and subtidal benthic communities in Mahurangi Estuary commenced. The monitoring forms part of our long-term State of the Environment monitoring under Section 35 of the Resource Management Act and is designed to track the long-term health of soft sediment ecology in the harbour. This report details the results from the intertidal sampling in Mahurangi Estuary conducted between July 1994 and January 2018.

Monitoring focuses on animals living in mud and sand flats (benthic communities), as these animals form an important link between sediment and water column processes. They are important prey items for birds and fish, are sensitive to anthropogenic activities, and are relatively stationary and are therefore representative of local conditions. For these reasons, they are also widely used internationally for monitoring the health of ecosystems.

Five sites, Hamilton Landing, Jamieson Bay, Mid Harbour, Cowan's Bay and Te Kapa Inlet have been sampled quarterly since July 1994. In 2005, in response to implementation of catchment management plans in the estuary, monitoring commenced at a sixth intertidal site in Dyers Creek. In 2011, after a review of the monitoring programme, sampling of the most temporally consistent intertidal site Cowans Bay was paused and reinstated in July 2016 for a period of two years consistent with the nested monitoring approach used in Manukau and Waitematā Harbours.

This report provides an update on the ecological health of the Mahurangi Harbour by addressing three key questions.

1. Have there been any new changes in the environmental characteristics of each site?

   There have been minimal recent changes in the characteristics of the six monitored intertidal sites. Site Dyers Creek is displaying a decreasing trend in sand and an increase in the mud content. Hamilton Landing is the only site showing a significant trend in chlorophyll *a* content, with an increase observed over the monitored period. The sediments in the Hamilton Landing and Te Kapa Inlet sites are showing a small but significant decrease in percent organic content.

2. Are there any changes of concern in the monitored benthic communities?

   The combined health scores indicate little change in health at the sites over the monitored period. Cowans Bay has showed some improvement from poor to good health, but is generally variable over time. The Dyers Creek and Mid Harbour sites continue to be in moderate health, and the Hamilton Landing site has remained in the poor health category. The site at Jamieson Bay has shown no change in health score when compared with initial sampling (good health). The site at Te Kapa Inlet is the only site demonstrating a degradation in overall health with a shift from good in the first two years of sampling to generally moderate health thereafter.

   The sites with the greatest changes indicating declining health are Jamieson Bay and Dyers Creek. Dyers Creek is the only site where an increase in mud content has been observed; there are changes in abundance of eight species that would be expected to reflect terrigenous (land derived) sediment impacts and declines in health index scores. The site at Jamieson Bay shows similar trends in health scores and changes in abundance of 10 species that would be expected to reflect terrigenous sediment impacts.

The sites at Mid Harbour and Te Kapa Inlet show some trends that warrant further investigation. At Mid Harbour, there are changes in abundance of nine species that would be expected to reflect terrigenous sediment impacts and an a declining health index. At Te Kapa Inlet, there are also changes in abundance of nine species that would be expected to reflect terrigenous sediment impacts, but no trends over time in health scores.

3. Do observed changes reflect an estuary-wide change?

There have been consistent trends in the abundance of some monitored taxa across sites. Increasing trends in the abundance of five mud-tolerant monitored taxa are occurring at multiple sites. There have also been consistent decreasing trends in abundances of two mud-intolerant species *Macomona* (wedge shellfish) and *Linucula* (nut shellfish) at all sites except Cowans Bay.

With three more years of data, monitoring continues to show increased abundances of mud tolerant species across all sites, and a general decrease in mud sensitive species.

This monitoring programme has continued to provide useful information on cycles and trends in monitored taxa populations and sediment characteristics.

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1.0 Background

In July 1994 a long-term ecological monitoring programme of the intertidal and subtidal benthic communities in Mahurangi Estuary commenced. The monitoring programme was designed to, i) provide information on the ecology of the benthic communities, ii) assess the overall condition of Mahurangi Estuary in terms of the benthic communities and iii) to provide a basis on which to document any ecological changes that may occur as a result of catchment and estuary development. This monitoring forms part of our long-term State of the Environment monitoring under Section 35 of the Resource Management Act. Monitoring in the first six years detected estuary-wide changes in the abundance of some macrofaunal taxa and the horse mussel *Atrina zelandica*, and increases in the proportion of fine sand present in the sediments (Cummings et al. 2001, 2003).

The monitoring focuses on animals living in mud and sand flats (benthic communities), as these animals form an important link between sediment and water column processes. These macrofauna are important prey items for birds and fish, are sensitive to anthropogenic activities, and are relatively stationary and are therefore representative of local conditions. For these reasons, they are also widely used internationally for monitoring impacts on, and health of, ecosystems. For cost effectiveness, the intertidal monitoring is based on 19 taxa selected to provide a range of responses to different anthropogenic impacts and environmental conditions (See Cummings et al. 1994, for further information). These taxa are used to investigate the present status of the benthic communities using trend and community analyses. Further, there is also an assessment of health using Auckland Council indices related to functional traits (TBI), storm-water contaminants (BHMmetals), sediment mud concentrations (BHMmud) and a Combined Health Index. These indices require all taxa present at a site (not just those selected for monitoring) to be identified in October of each year.

Initially, there were five intertidal sites monitored quarterly, and three subtidal sites monitored six monthly. In 2001, a review of the monitoring programme noted that the ability to detect changes over time for the subtidal sites was lower than that of the intertidal sites, due to the six monthly versus quarterly sampling (Cummings et al. 2001). The number of subtidal sites was then reduced to two and quarterly sampling commenced in October 2001. In 2005, in response to management plans in the estuary, monitoring at a new intertidal site in Dyers Creek commenced. In 2011 following the recommendations of Halliday & Cummings (2011), monitoring at the most temporally consistent intertidal site, Cowans Bay, was suspended and both subtidal sites were dropped. In July 2016, sampling at Cowans Bay was reinstated as part of the nested sampling regime (two years of sampling, followed by a five year sampling break). Sampling at the subtidal sites remains on hold (as recommended by Cummings et al. 2016).

This report presents the results of data collected quarterly (July 1994 to January 2018) from six intertidal sites (Figure 1). The report addresses the following questions, based on trend and community analysis of the monitored species, and on the four community health indices:

1. Have there been any changes in the environmental characteristics of each monitored site?
2. Are there any changes of concern in the monitored benthic communities?
3. Do observed changes reflect an estuary-wide change?
4. Has the reinstated sampling at Cowans Bay revealed any changes of concern that suggests it needs to be monitored more regularly?

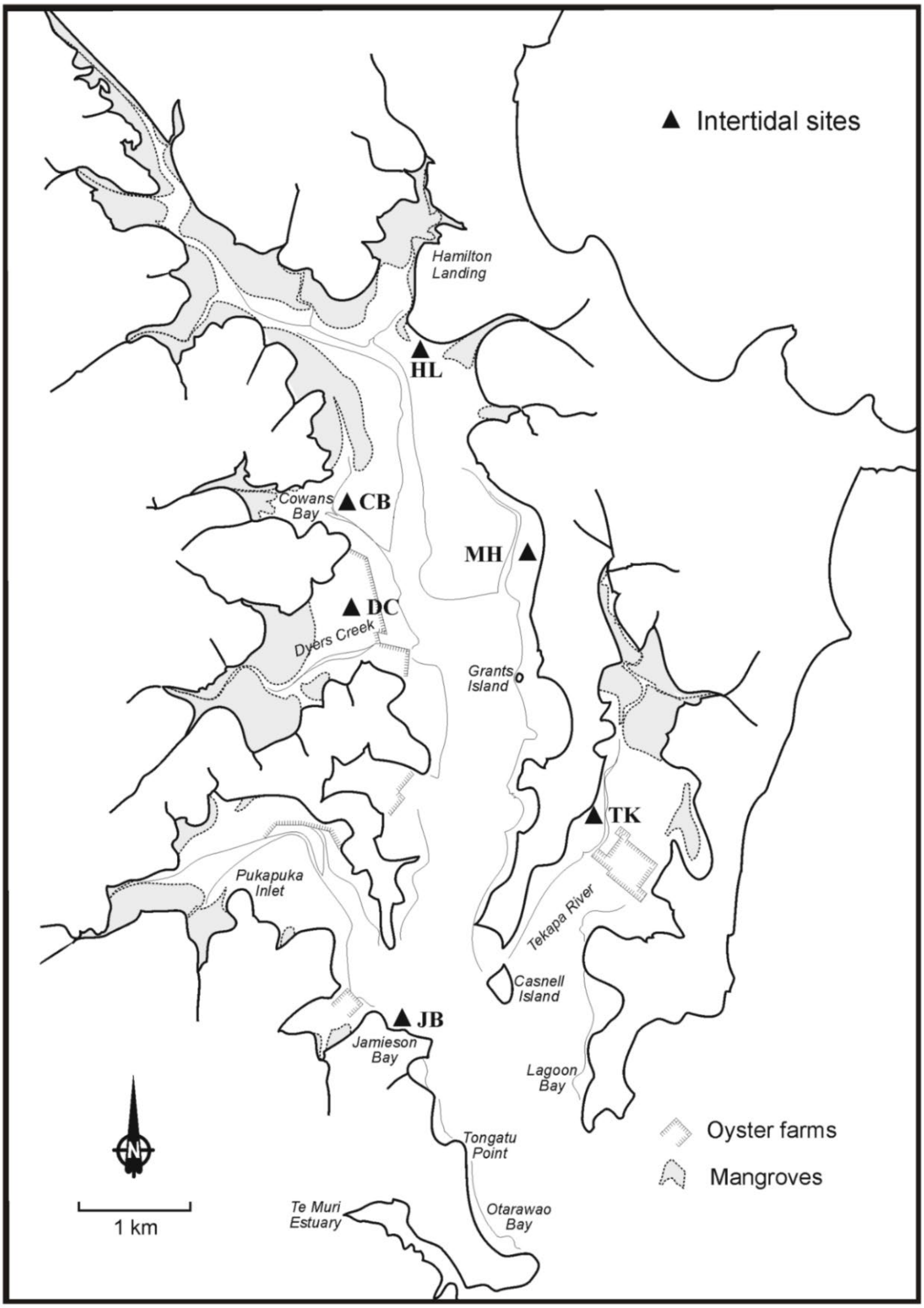

Figure 1 Map of Mahurangi Estuary showing the locations of intertidal monitoring sites Cowans Bay (CB), Dyers Creek (DC), Hamilton Landing (HL), Jamieson Bay (JB), Mid Harbour (MH) and Te Kapa Inlet (TK).

2.0 Methods

In July 1994, five intertidal sites were established to be sampled quarterly in locations predetermined from an initial survey of the estuary conducted in April 1993 (Cummings et al. 1994 – Figure 1). Four of the five sites cover areas of 9000m^2 and are situated at around mid-tide level. The fifth intertidal site (Jamieson Bay) is constrained by the size of the bay and occupies a slightly smaller area (7200m^2). The Jamieson Bay site also covers a greater tidal range than the other intertidal sites due to the steep gradient of the beach. In October 2005, an additional permanent intertidal site was established at Dyers Creek (9000m^2). The site was chosen and established by Auckland Regional Council, ARC (now Auckland Council), near a site initially surveyed by NIWA in 1993 (Cummings et al. 1994).

Sampling of the Cowans Bay site was suspended in April 2011 following recommendations made by Halliday and Cummings (2011). This site had shown a high level of stability in the sediment composition and benthic ecology and was therefore placed onto a rotational schedule for monitoring. Sampling was reinstated at Cowans Bay in July 2016 for a two year period, in line with the previous recommendations from Cummings et al. (2016).

Sites are marked using wooden stakes and can be located using GPS coordinates (Table 1).

Table 1 Dimensions and GPS coordinates for the Mahurangi Estuary monitoring sites. GPS coordinates mark the 0, 0m point of each monitored area.

Site	Dimensions (m)		GPS coordinates (NZTM)	
	X	Y	North	East
Cowans Bay (CB)	100	90	5964766	1753459
Dyers Creek (DC)	100	90	5963749	1753106
Hamilton Landing (HL)	180	50	5966477	1753798
Jamieson Bay (JB)	120	60	5959771	1753677
Mid Harbour (MH)	180	50	5964505	1754969
Te Kapa Inlet (TK)	100	90	5961577	1755357

Methods and techniques used for sampling and sample processing are consistent with those of sentinel locations established in Manukau Harbour (Greenfield et al. 2016, Hewitt 2006). The methods used are briefly described below.

2.1 Macrofauna

On each sampling occasion, 12 sediment cores (13cm diameter, 15cm deep) are collected from each site. To provide an adequate spread of cores over the site, each site is ‘divided’ into 12 equal sections and one core is taken from a random location within each section (Appendix A). To reduce the influence of previous sampling activity and spatial autocorrelation, samples are not placed within a 5m radius of each other or of any samples collected in the previous 12 months. Core samples are sieved through a 500µm mesh and the residues stained with rose bengal and preserved in 70% isopropyl alcohol. Samples are then sorted and stored in 50% isopropyl alcohol. The 19 selected species (see Table 2) are identified, counted and stored in 50% isopropyl alcohol. Other macrofauna are not discarded; rather they are preserved in 50% IPA in sealed specimen jars to be processed if other funding becomes available. All taxa collected during the October sampling each year are identified and enumerated.

Table 2 The 19 taxa routinely monitored in Mahurangi Estuary. Sediment preferences derived from Gibbs & Hewitt (2004) and from Norkko et al. (2001). Optimum range = the percent mud where taxa exhibit their highest abundances. Distribution range = total range of mud concentrations over which taxa occur. SS = strong preference for sand, S = prefers sand, I = prefers some mud but not in high percentages, M = mud preference, MM = strong mud preference. - denotes no information is available.

Taxonomic name	Common name/ description	Optimum range (%)	Distribution range (%)	Sediment preference
Aonides trifida	worm	0-5	0-5	SS
Aricidea sp.	worm	35-40	0-70	I
Arthritica bifurca	small shellfish	20-60	0-75	I
Austrovenus stutchburyi	cockle	5-10	0-60	S
Cossura consimilis	worm	20-25	5-65	I
Hemiplax hirtipes	stalk-eyed mud crab	45-50	0-65	I
Heteromastus filiformis	worm	0-15	0-95	I
Linucula hartvigiana	nut shell	0-5	0-60	S
Macomona liliana	wedge shell	0-5	0-40	S
Nemertea	ribbon worm	55-60	0-95	I
Notoacmea scapha	limpet	0-5	0-10	SS
Oligochaetes	worm	95-100	0-100	MM
Owenia petersenae	tube dwelling worm	-	-	S
Paracalliope novizealandiae	sand hopper	35-40	0-50	S
Perinereis vallata	worm	30-55	0-80	I
Polydorids	tube dwelling worm	10-35	0-50	I
Prionospio aucklandica	worm	20-70	0-95	I
Scoloplos cylindrifer	worm	0-5	0-60	S
Torridoharpinia hurleyi	sand hopper	-	-	S

2.2 Bivalve size-class analysis range

After identification, individual *Austrovenus stutchburyi* and *Macomona liliana* are measured and the results summarised into size classes <5 mm, 5-10 mm, 10-20mm and >20mm (longest shell length). These are consistent with the bivalve size classes used across all other Auckland Council monitoring programmes.

2.3 Sediment characteristics

During sampling at each site, attention is paid to the appearance of the site and the surrounding area. In particular, surficial mud layer depth and surface features such as burrows, shells, tube worms, gastropods, birds, macro algae and marine flora are noted and quantified.

Sediment samples are collected for analysis of particle size, organic content and chlorophyll *a* concentration. At six random locations within the site, two small sediment cores (2cm deep, 2cm diameter) are collected; one to determine particle size and organic content and the other for chlorophyll *a* analysis. Cores from the six locations are pooled and kept frozen in the dark prior to being analysed as described below. At Te Kapa Inlet there are two discrete areas (TKmud and TKsand) which are sampled separately for sediment characteristics.

<u>Particle size:</u> The samples are homogenised and a subsample of approximately 5g of sediment taken, which is then digested in ~ 9% hydrogen peroxide until frothing ceases. The sample is then wet sieved through 2000μm, 500μm, 250μm and 63μm mesh sieves. Pipette analysis is used to separate the <63μm fraction into >3.9μm and ≤3.9μm. All fractions are then dried at 60ºC until a constant weight is achieved (fractions are weighed at ~ 40hr and then again at 48hr). The results of the analysis are presented as percentage weight of gravel/shell hash (>2000μm), coarse sand (500-2000μm), medium sand (250-500μm), fine sand (62.5-250μm), silt (3.9-62.5μm) and clay (≤3.9μm). Sand content is calculated as the sum of coarse, medium and fine sand, while mud content is calculated as the sum of the silt and clay content.

<u>Organic content:</u> Approximately 5g of sediment is placed in a dry, pre-weighed tray. The sample is then dried at 60°C until a constant weight is achieved (the sample is weighed after ~ 40hr and then again after 48hr). The sample is then ashed for 5.5hrs at 400°C (Mook and Hoskin 1982) and reweighed to calculate percent weight lost on ignition.

<u>Chlorophyll *a*:</u> Within one month of sampling, the full sample is freeze dried, weighed, then homogenised and a subsample (~0.5g) taken for analysis. Chlorophyll *a* is extracted by boiling the sediment in 90% ethanol, and the extract processed using a spectrophotometer. An acidification step is used to separate degradation products from chlorophyll *a* (Sartory 1982).

2.4 Statistical analyses

The analysis of monitoring programmes is strongly dependent on the length of time the data has been collected. Initially, little can be done other than to graphically determine cyclic patterns. As the time series extends past five years, the data may be statistically analysed for trends (long-term increases or decreases). However, a trend detected over a time period of less than 10 years may in reality be part of a long-term cyclic pattern. As the time series lengthens, statistical analyses become more likely to detect very small, possibly unimportant, changes due to increasing degrees of freedom, and it becomes essential to determine that the changes are not part of multi-year cycles and to estimate the magnitude of change relative to natural variability. To investigate ecologically important long-term trends and cycles in environmental characteristics and species abundance data at all six monitored sites, a number of different analyses were conducted (described below). For macrofauna, all analyses were performed on the sum of the 12 cores collected at a site on each sampling occasion.

2.4.1 Trend analysis

Trend analyses were conducted to test the significance of any trends suggested (from 2.4.2 above) in the abundance of the monitored taxa, bivalve size classes or measured environmental variables. Autocorrelation in each time series was investigated using Durban-Watson statistics. Gradual changes were investigated by ordinary least squares regression on raw or log transformed data, unless autocorrelation was present. Where autocorrelation was indicated, increasing or decreasing trends were investigated by adjusting parameters and significance levels. Residuals of statistically significant trends were examined for indications of multi-year cycles where these indicated significant bias, and/or the trend was considered to be a multi-year cycle rather than a trend. For the intermittently monitored site Cowans Bay, the time series was assessed relative to previous variation and to the time series at the permanently monitored sites. Step trends were determined based on the significance of Yule-Walker parameter estimates following the Autoreg procedure (SAS 9.4) on time series data points grouped before and after a suspected change (if autocorrelation was present, degrees of freedom were adjusted).

2.4.2 Macrofaunal community analysis

Analyses were conducted to identify the dominant monitored taxa at each site, and to evaluate the stability of the composition of the monitored taxa community over time. The three most abundant (top ranked) monitored taxa found at each site were identified, and this information was summarised in rank abundance tables. Multivariate ordinations of the monitored taxa communities at each site in October of each year were constructed using Non-metric Multidimensional Scaling (MDS) of Bray Curtis similarities (PRIMER; Clarke and Gorley, 2006). Average similarity across the monitored period was also calculated for each site using the monitored taxa (SIMPER in PRIMER; Clarke and Gorley, 2006).

2.5 State of the Environment Indicators

2.5.1 Traits Based Index (TBI)

Organisms can be categorised according to characteristics (traits) that are likely to reflect ecosystem function (i.e., their feeding mode, degree of mobility, position in the sediment column, body size, body shape, capacity to create tubes/pits/mounds). During 2010 and 2011, an index based on these biological traits was created (van Houte-Howes and Lohrer 2010) and improved (Lohrer and Rodil 2011). This Traits Based Index (TBI) is based on seven broad trait categories (living position, sediment topography feature created, direction of sediment particle movement, degree of mobility, feeding behaviour, body size, body shape and body hardness). Specifically, the richness of taxa exhibiting seven particular traits is used to create the index: living in the top 2cm of sediment, having an erect structure or tube, moving sediment around within the top 2cm, being sedentary or only moving within a fixed tube, being a suspension feeder, being of medium size, or being worm shaped. An adjustment is available that allows the metric to be applied to a wider range of sites and those sampled with differing numbers of replicates (Lohrer and Rodil 2011).The index score ranges from 0-1, with TBI scores <0.3 indicating low levels of functional redundancy and highly degraded sites(Table 3). Scores >0.4 indicate high levels of functional redundancy, which is indicative of healthy areas (high functional redundancy tends to increase inherent resistance and resilience in the face of environmental changes(Hewitt et al. 2012)).

Table 3 Conversion of Traits Based Index (TBI) scores into health groups (1 is most healthy). These groups are then converted (along with CAPmetals and CAPmud scores) into values of similar scale (0 to 1) that run in the same direction (higher values indicating more degraded conditions), to facilitate their combination into overall health scores.

Group	TBI	
	Cut off	Value
1	>0.4	0.33
2	0.3-0.4	0.67
3	<0.3	1.00

2.5.2 Benthic Health Models

The original benthic health model (**BHMmetals**) was developed by Auckland Regional Council, Marti Anderson (then Auckland University) and Simon Thrush and Judi Hewitt (NIWA), to determine the health of macrofaunal communities relative to storm-water contaminants. The model is based on a multivariate analysis of the variation in macrofaunal community composition related to total sediment copper, lead and zinc concentrations, extracted from the 500 µm fraction of the sediment (Anderson et al. 2006).

In 2010-2011, another model was developed, this time to determine health relative to sediment mud content (**BHMmud**, Hewitt & Ellis 2010). At the time of the development of this model it was determined that, while there was some crossover between community compositions found in response to high mud and high contaminants, the two effects could still be separated.

Both models are based on the community composition observed at 84 intertidal sites in the Auckland Region between 2002 and 2005. The sites are within tidal creeks, estuaries or harbours, but do not include exposed beaches. They cover a range of contaminant concentrations and mud content. The models use Canonical Analysis of Principal Coordinates (CAP, Anderson & Willis 2003) of square root transformed Bray-Curtis dissimilarities to extract variation related to a single environmental variable and produce a score of community composition related to that variable. For the metal model, the concentrations of the three metals have been used in a Principal Component Analysis to create a single axis (PC1) that explains >90% of the variability in contaminant differences between the sites. For the mud model, the percentage mud content of sediment at the time of sampling is used.

The macrofaunal community composition of sites and sampling times not in the models are compared to model data (using the "*add new samples*" routine in CAP*, PermANOVA addon,* Primer 7). The samples are then allotted to five different groups related to health (see Table 4).

Table 4 Conversion of CAPmetals and CAPmud scores into health groups (1 is most healthy). Cut off point is equal or less than. These groups are then converted (along with TBI scores) into values of similar scale (0 to 1) that run in the same direction (higher values indicating more degraded conditions), to facilitate their combination into overall health scores.

Health Group	CAPmetals		CAPmud	
	Cut off	Value	Cut off	Value
1	≤-0.16	0.2	≤-0.12	0.2
2	-0.16 to -0.067	0.4	-0.12 to -0.05	0.4
3	-0.067 to 0.023	0.6	-0.05 to 0.02	0.6
4	0.023 to 0.10	0.8	0.02 to 0.10	0.8
5	>0.10	1.0	>0.10	1.0

2.5.3 Combined Indices

Hewitt et al. (2012) recommended the use of the three indices above (TBI index, BHMmud score (CAPmud) and BHMmetals score (CAPmetals)) to provide a complementary assessment of health. Average health values are determined for each site in the following way:

1. If the CAPmud score is ≤ -0.12, the site is allocated to Mud group 1 (Table 4), and the combined Health score is calculated as the average CAPmetals and CAPmud group values. The TBI is not used in the combined score in this case, as it does not work well when mud content is extremely low (Hewitt et al. 2012).

2. If the CAPmetals score is ≥0.10, the site is allocated to group 4 or 5, and the combined Health score is equal to the TBI group value. At this level of contaminants, the TBI score itself fully reflects health.

3. Otherwise, Health is the average of the CAPmetals, CAPmud and TBI group values.

Health scores, “x”, are then translated as $x \leq 0.2$ “extremely good”; $0.2 < x \leq 0.4$ “good”; $0.4 < x \leq 0.6$ “moderate”; $0.6 < x \leq 0.8$ “poor” and $x > 0.8$ “unhealthy with low resilience”. It is important to recognise that the health scores are from particular sites within each estuary, and do not necessarily represent the health status of the estuary as a whole. There may be locations in each estuary that are significantly healthier, or less healthy, than the monitored sites.

3.0 Present status of benthic communities in Mahurangi Estuary

This programme was designed to monitor the ecological status and trends of change in macrobenthic communities in Mahurangi Estuary. An important process in detecting trends is determining temporal variability, as knowledge of cyclic patterns of recruitment aids in detection of long-term trends (Hewitt et al. 1994). In this section of the report we ask the following questions:

1. Have there been any changes in site environmental characteristics?
2. Which species are exhibiting predictable and consistent temporal variation?
3. Are any species exhibiting similar patterns in abundance at all sites?
4. Have any changes in sediment characteristics, or macrofaunal communities, led to sites becoming more or less similar to each other?

3.1 Have there been any changes in site characteristics?

3.1.1 Cowans Bay (CB)

Site Cowans Bay is located in the upper reaches of the estuary, approximately 10m from an oyster farm (Figure 1; Plate 1 in section 9). CB is on a large mud flat, and at low tide is separated from the main channel by a deep mud flat (making access to the site difficult). The sediment texture is characteristic of an upper estuary site with lower tidal flow, with an approximately 20cm thick layer of surficial mud being present since sampling was resumed in July 2016. The sediment surface is generally homogenous and textured with high densities of crustacea burrows, and low densities of spionid tube worms. Whelks are commonly observed in low to medium densities (i.e., *Cominella glandiformis* and *C. adspersa,* as well as the invasive whelk, *Nassarius burchardi*).

Sediment grain size, chlorophyll *a* and organic content have not changed significantly, either over the whole sampling period, or since sampling was re-established at this site in 2016. Fine sand and mud are consistently the only sediment size class fractions represented (Appendix B). Mud content was lowest in July 2002 (7.81%) and highest in January 2004 (31.93%) (Figure 2). Sediment chl*a* content at CB is consistently higher than at all other monitored sites (Figure 3). Chl*a* content was lowest in January 2004, highest in October 2000, ranging from 10.66 to 23.08µg/g sediment. Sediment organic content has remained low and seasonally variable, except in July 2010 when an unusually high organic content (4.46%) was noted for this site (Figure 4).

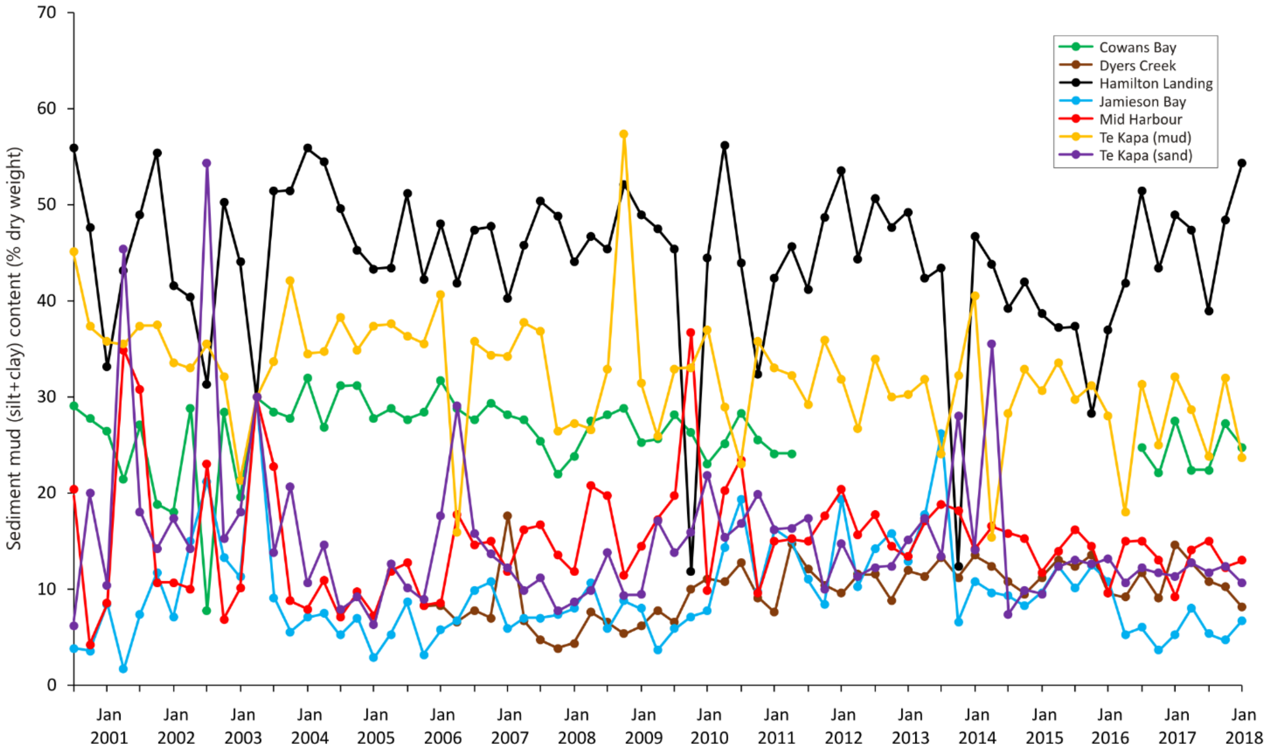

Figure 2 Sediment mud content (< 62.5µm) at each site on all sampling occasions (% of sediment dry weight). Full results given in Appendix B.

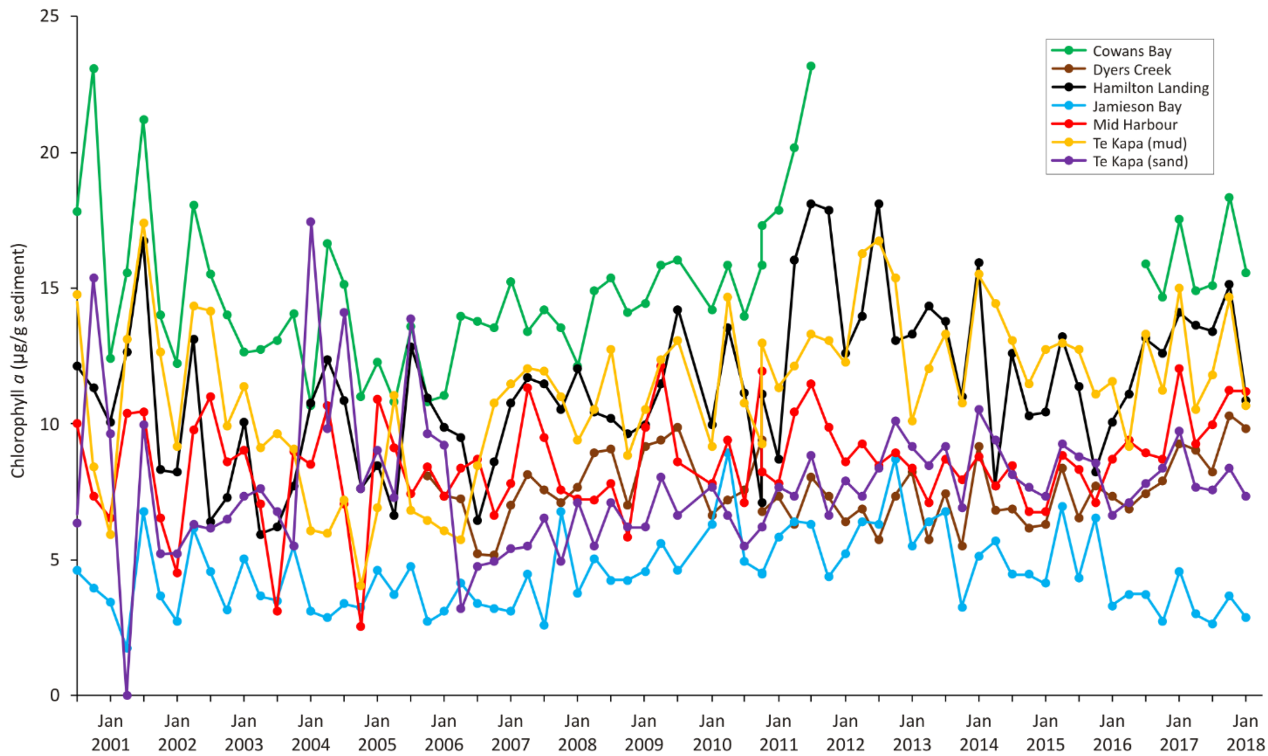

Figure 3 Sediment chlorophyll *a* content at each site on all sampling occasions (µg/g sediment). Full results given in Appendix B.

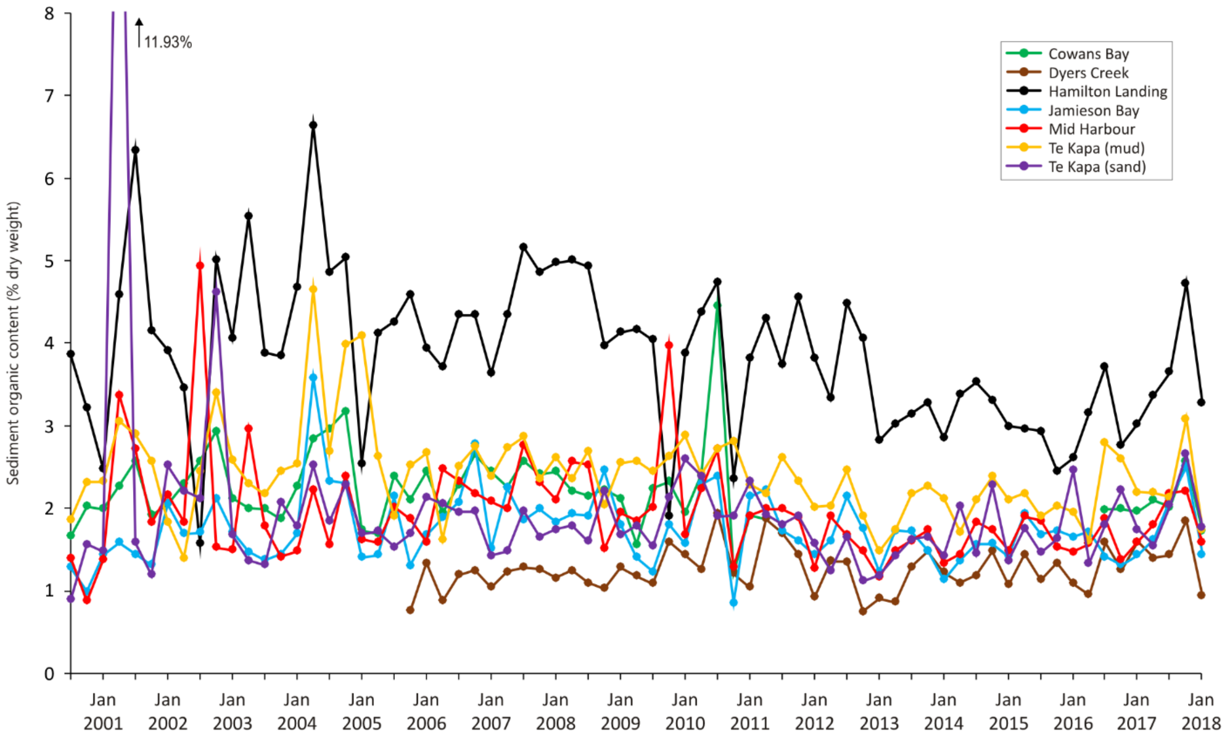

Figure 4 Sediment organic content at each site on all sampling occasions (% of sediment dry weight). Full results given in Appendix B.

3.1.2 Dyers Creek (DC)

Site Dyers Creek is located on a large intertidal flat fringed by mangroves on the western side (Figure 1). Since October 2016, a small sub-channel draining from the mangroves runs diagonally across the site, from its north end towards the main channel. The sediment composition at DC is sandy with low levels of surficial mud varying over sampling occasions from 2 to 5cm in depth (Figure 2, Plate 2). Crustacean burrows are present in low densities at all times with the exception of October 2017 where crustacea burrows were the dominant surface feature. The occasional mangrove seedling found does not persist between sampling times. The whelks *Zeacumantus lutulentus, Cominella glandiformis* and *Diloma subrostrata* are consistently found, and range in abundance from rare to medium densities (1-20 per 0.25 m^2). The invasive whelk *Nassarius burchardi* has been recorded at this site in medium to high densities (10-20 per 0.25 m^2) since October 2016. Field staff accessing the site have also noted that, since October 2017, the sediments between the oyster racks and the site have become muddier and harder to walk through.

A statistically significant increase in the mud content at DC ($p = 0.0032$) continues to be observed (Cummings et al. 2016), as well as a related significant decrease in the total sand content ($p = 0.0009$). Mud content peaked at 17.66% in January 2007 and was lowest in October 2007with only 3.86% (Figure 2). Organic content at DC is consistently lower than all other sites (~1.2%) (Figure 4). Chl*a* continues to range from 5.16 to

10.31µg/g sediment with no significant increase or decrease over the sampling period (Figure 3).

3.1.3 Hamilton Landing (HL)

Site Hamilton Landing is the northern most site sampled in the upper reaches of the estuary (Figure 1). The sediment texture is characteristic of an upper estuary site with lower tidal flows, with surficial mud being so deep and soft that mudders (mud shoes) are needed to safely access the site (Plate 3). As previously reported, site HL is consistently muddy and always dominated by crustacean burrows. In July 2016, a patchy layer of green algae was observed covering <10% of the site, but this was not evident by the next sampling date (October 2016). Low densities of the invasive whelk *Nassarius burchardi* were observed in January 2016.

HL consistently has the highest mud content of all monitored sites, ranging between 11.8 and 56.26% of the total sediment content (Figure 2). Chl*a* content at this site over time is showing a small but statistically significant increasing trend ($p = 0.0122$), although concentrations are variable and within the range of those observed at other sites (Figure 3). The sediment organic content is higher and more variable than the other monitored sites (ranging from 1.58 to 6.65, average of 3.38%, Figure 4), and a statistically significant ($p = 0.0076$) decreasing trend is present. Sediment mud has not changed significantly at this site over the monitoring period.

3.1.4 Jamieson Bay (JB)

Site Jamieson Bay is a steeply sloping site and is the most heterogeneous monitoring site within Mahurangi Estuary (Figure 1; Plate 4). The sediments at this site vary depending on their proximity to the shore. The seaward third of the site has a 2-5cm layer of sticky surficial mud, is dominated by spionid tube worm mats, and contains low numbers of gastropods. The gastropods *Cominella glandiformis, C. adspersa* and *Zeacumantus lutulenus* have been observed in low numbers in the seaward portion of the site, but rarely found higher up the shore. The landward section has a high component of shell hash and cobble, and rocky shore animals have been observed here including the gastropod black nerita (*Nerita melanotragus*). The middle portion of the site is relatively sandy, and contains high number of infaunal bivalves *Austrovenus stutchburyi* and *Paphies australis.*

No significant trends were apparent in sediment characteristics at JB. The sediment particle size is variable, mainly due to the three portions of the site being so different. The percentage of gravel (>2000µm) has varied considerably over the sampling period, ranging from 0 to 45.9%. Fine sand (63-250µm) is commonly the dominant size class fraction ranging from 31.69 to 87.57% over the monitoring period. Mud content is lower ranging from 1.71 to 26.23% (Figure 2). Chla content at JB is consistently lower than at all other monitoring sites, ranging from 1.76 to 8.94µg/g of sediment (Figure 3). Sediment organic content ranges from 0.86 to 3.59% (Figure 4).

3.1.5 Mid Harbour (MH)

Site Mid Harbour is located on the eastern side of the main channel of Mahurangi Estuary (Figure 1). The sediment is homogenous with little change apparent over the monitored period (Plate 5). Small ripples occur on the sediment surface (wave height 0.5 cm, wave length 2-5 cm), and medium to high densities of crustacean burrows are often present (5-10 and >10 burrows per 0.25m^2, respectively). Surficial mud layer thickness has varied over sampling times, ranging from 1 to 7cm. Small spionid worm tubes are evenly distributed across the site. The whelk *Cominella glandiformis* has consistently been found in low densities (1-2 per 0.25 m^2), while the invasive *Nassarius burchardi* is more numerous (medium densities) since first observed by field staff in July 2016.

There are no significant trends in sediment characteristics at MH. Fine sand and mud are the dominant sediment size class fractions, with fine sand ranging from 59.49 to 88.30% and mud ranging from 4.25 to 36.69% (Figure 2). Chl*a* content ranges from 2.53 to 12.15μg/g sediment over the sampling period, with larger peaks and troughs in Chl*a* occurring in the first half, and becoming less variable over the second half of sampling (Figure 3). No significant change has occurred in the sediment organic content, which ranges from 0.88 to 4.94% over the whole sampling period (Figure 4).

3.1.6 Te Kapa Inlet (TK)

Site Te Kapa Inlet covers two discrete areas which have different sediment properties (Figure 1; Plate 6). The south western corner of the site (referred to as TKsand) is sandy in appearance and shell hash is commonly observed. This sandy section changes in extent seasonally but on average reaches 45m along the x-axis, and 19m along the y-axis of the site. The whelks *Cominella glandiformis, Diloma subrostrata* and *Zeacumantus lutulentus* are consistently found in low densities (1-2 per 0.25m^2) on all sampling occasions, while the invasive whelk *Nassarius burchardi* ranged from absent to medium abundances since first noted by field staff in July 2016. The rest of the site (referred to as TKmud) is muddy in appearance and has a sticky surficial mud layer of 10-30 cm, making sampling more difficult. Medium densities of crustacean burrows occur in the TKmud section, along with spionid tube worms in low to medium densities (6-10 per 0.25 m^2). The sediment surface is homogenous with very little shell hash. These two distinct sections are sampled separately for sediment characteristics, to determine if there is any change within them.

In the muddy section of the site, TKmud, there is a statistically significant decreasing trend in the mud content (slope -0.1295, $p = 0.0003$) and an increasing trend in the total sand content (slope 0.1226, $p = 0.0005$), as well as a corresponding decreasing trend in the organic content (slope -0.0084, $p = 0.0409$). Chl*a* over the monitored period has ranged from 4.03 to 17.41, and 3.20 to 17.43μg/g of sediment, respectively, for the muddy and sandy sections (Figure 3). Despite the similar range over this long time period, Chl*a* has clearly been higher in the TKmud area of the site than in the TKsand area since October 2006 (Figure 3). No trends were found in sediment grain size or organic content in the sandy section of the site TKsand.

3.1.7 Summary of changes in site sediment characteristics

3.1.7.1 Statistically significant trends

The sediment grain size composition of the original intertidal sites (all those excluding Dyers Creek which started in 2005) continues to contain a higher proportion of fine sand and a lower amount of medium sand compared with the very early years of monitoring.

There are very few statistically significant positive or negative linear trends in sediment characteristics. Chl*a* content at site HL over time is showing a small but statistically significant increasing trend and site DC is still displaying a decreasing trend in sand and an increase in the mud content. TKmud is displaying the opposite trend of increasing sand and decreasing mud content, together with a decrease in organic content. The mud content at CB since sampling recommenced is similar to that recorded prior to the five year rest period.

3.1.7.2 Variability based on standard deviation

Sites HL and TKsand have the highest annual variability in mud content (measured as average annual standard deviation), while site DC has the lowest variability in percentage mud (Table 5A). Unsurprisingly, JB is the most variable in sand content with fine sand displaying 14.77% variability over the monitored period (Table 5A).

Annual variability in Chl*a* across sites is relatively low and consistent, with TKmud and HL displaying the highest percent variability (2.88 and 2.87%, respectively) and site DC the lowest (1.25%).Overall the average sediment organic content variability is low across sites however, TKsand had the highest variability of 1.30% (driven by larger numbers early in the monitored period).

By comparing the standard deviation of data from the initial sampling to January 2015 (last reported) with the standard deviation of data from the initial sampling to January 2018 (Table 5B), it is clear that there has been minimal change in variation of the sediment characteristics measured across all sites. The percentage mud and organic content has become more stable, with less seasonal variability at all sites. All other sediment characteristics at all sites have also increased in stability except for the slight increased variability for percentage fine sand and chlorophyll *a* at DC, medium sand at HL and TKmud, and coarse sand at TKmud (Table 5B). It is important to mention that CB continues to remain stable; there has been no increase in variability since sampling recommenced.

Table 5 Analysis of temporal variability in sediment characteristics at the monitored sites between July 2000 and January 2018 (except DC: October 2005-January 2018). A) Average annual variability (or standard deviation) of sediment mud, fine, medium and coarse sand, and organic content, and chlorophyll *a* concentration. B) Changes in the standard deviation in the data last reported in January 2015 and the data up to January 2018. Negative values indicate increased variability over the last three years, whereas positive values indicate increased stability.
Note: standard deviation of site CB was calculated from data collected from July 2000 until April 2011, after which the site was suspended from sampling until this site was reinstated in July 2016.

Table A: Average annual variability

Site	Mud (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Organic Content (%)	Chla (µg/g sed.)
CB	4.11	3.16	2.04	0.65	0.49	2.58
DC	2.93	4.01	0.45	0.09	0.27	1.25
HL	8.25	7.53	0.92	0.39	0.94	2.87
JB	4.62	14.77	8.86	4.44	0.44	1.46
MH	6.11	6.29	2.67	0.93	0.63	1.84
TKmud	6.42	6.00	0.51	0.12	0.55	2.88
TKsand	8.04	7.99	0.60	0.19	1.30	2.38

Table B: Change in SD between pre-January 2015 and pre-January 2018

Site	Mud (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Organic Content (%)	Chla (µg/g sed.)
CB	0.18	0.01	0.15	0.05	0.02	0.10
DC	0.13	-0.41	0.03	0.00	0.00	-0.04
HL	0.17	0.16	-0.04	0.03	0.00	0.13
JB	0.20	0.28	0.46	0.14	0.02	0.00
MH	0.49	0.45	0.24	0.09	0.05	0.03
TKmud	0.02	0.09	-0.10	-0.02	0.02	0.16
TKsand	0.65	0.19	0.04	0.01	0.12	0.20

3.2 Which species are exhibiting predictable and consistent temporal variation?

This section describes predictable/consistent patterns, cycles (seasonal and multi-year) and trends in monitored species abundances at each site. Trends and step trends are tested for significance when assessing abundance of monitored taxa at each site.

3.2.1 Cowans Bay (CB)

Since April 2010, the three most abundant taxa at CB have remained the same (see Appendix D for most abundant taxa at all sites at each sampling time). *Cossura consimilis, Heteromastus filiformis* and *Arthritica bifurca* have remained the most dominant taxa, although which is most abundant differs over time. Polydorids, *Linucula hartvigiana* and *Torridoharpinia hurleyi* are the only other taxa which have been numerically dominant over the monitored period.

3.2.1.1 Seasonality and Multi-year cycles

Table 6 Monitored taxa of all sites displaying seasonal (S) patterns and multi-year (MY) cycles in abundance between July 1994 and January 2018. (var) = variable timing of annual peaks/troughs; (Month/s) = month where peaks/troughs are consistently observed; (Number/s) = number of years of the multi-year cycle observed; * = a new pattern emerging since the last report (Halliday et al. 2013; Cummings et al. 2016). Where cells are empty, no seasonal pattern or multi-year cycle was observed.

Taxa	Cowans Bay	Dyers Creek	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa Inlet
Aonides trifida						
Aricidea sp.	MY(5-7)				S(Jul/Oct)	S(Jul/Oct)
Arthritica bifurca		S(var)				
Austrovenus stutchburyi		S(Oct/Jan)* MY(7-8)*				S(Oct)
Cossura consimilis		MY(5-6)				
Hemiplax hirtipes	S(Oct/Jan)		S(Apr/Jul)			
Heteromastus filiformis	S(Jul/Oct)		MY(8-10)			
Linucula hartvigiana	S(Oct/Jan)				S(Jan)	S(Jan)
Macomona liliana	S(Jul/Oct)			MY(10)		
Nemertea	MY(>10)	S(var)* MY(>10)*	MY(>10)		MY(>10)	MY(>10)
Notoacmea scapha		S(Oct)		MY(8)		
Oligochaetes					S(Jul/Oct)	
Owenia petersenae						
Paracalliope novizealandiae		S(Oct/Jan)				
Perinereis vallata						
Polydorids		MY(8-9)		MY(6-10)	MY(>10)	S(Jul/Oct)
Prionospio aucklandica	MY(5-7)	S(var) MY(8)	S(Oct/Jan)			MY(7)
Scoloplos cylindrifer	S(var)		S(Jul)			
Torridoharpinia hurleyi	S(var)	MY(2)*				

Seasonal (or annual) cycles in abundance are apparent for six taxa at CB (Table 6). *Hemiplax hirtipes* and *Linucula* display annual peaks in October or January, while *Heteromastus* and *Macomona liliana* display peaks in abundance in July or October most years. *Scoloplos cylindrifer* and *Torridoharpinia* also display annual peaks but peak height and timing is more variable. Multi-year patterns are present in the abundances of *Aricidea,* Nemertea and *Prionospio.* Every ~ 5-7 years *Aricidea* sp. and *Prionospio aucklandica* show higher recruitment success and have larger peaks in abundance persisting for 1-2 years, before returning to baseline. Nemertea is displaying a >10 year cycle which is also seen at all other monitored sites except MH.

3.2.1.2 Statistically significant trends

Five of the monitored taxa at Cowans Bay (*Arthritica, Cossura, Hemiplax,* Oligochaetes and *Scoloplos*) exhibit statistically significant ($p < 0.05$) linear trends in abundance (Table 7). A decreasing trend in *Cossura,* first observed in 2007, has continued (Table 7). Increasing trends in abundance were detected for Oligochaetes and *Scoloplos* (Table 7). Increasing step trends have also become apparent in the abundances of *Arthritica* and *Hemiplax.* Unfortunately these take place between April 2011 and July 2016 during which time no sampling was conducted, so we are therefore unable to determine the exact month/year these occurred (Figure 5). The ecological significance of these trends is discussed in section 3.3.

There are no statistically significant trends in the size classes of the monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana. Austrovenus* numbers are very low at this site, with juvenile recruits making up the majority of the individuals. *Macomona* numbers are higher with annual peaks in abundance (Figure 6).

Table 7 Magnitude of trends detected for monitored taxa at Cowans Bay in 2018 compared to other years. Numbers are the slope of linear trends or the size of the step trend (ST). For ST the date of the step is also given. Empty cells indicate that no trend was found.

CB: Monitored taxa	2018	2011	2009
Aonides trifida			
Aricidea sp.			
Arthritica bifurca	158.01 ST Jul-11 & Jul-16		
Austrovenus stutchburyi			
Cossura consimilis	-4.39	-5.06	-4.47
Hemiplax hirtipes	9.34 ST Jul-11 & Jul-16		
Heteromastus filiformis			
Linucula hartvigiana			
Macomona liliana			
Nemertea			-0.09
Notoacmea scapha			
Oligochaetes	0.05		
Owenia petersenae			
Paracalliope novizealandiae			
Perinereis vallata			
Polydorids			
Prionospio aucklandica			
Scoloplos cylindrifer	0.03		
Torridoharpinia hurleyi			

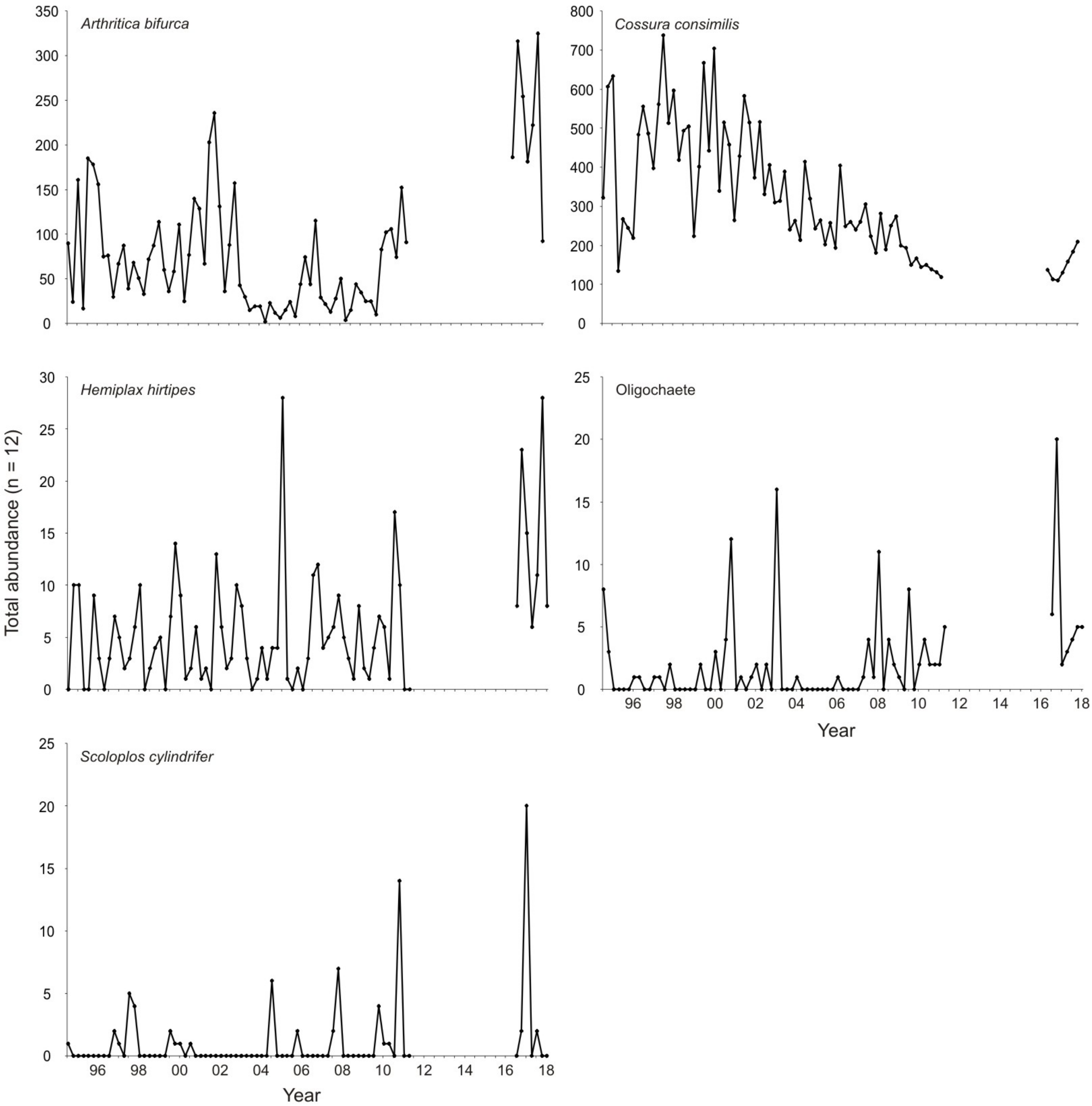

Figure 5 Monitored taxa at Cowans Bay displaying increasing (*Arthritica bifurca*, *Hemiplax hirtipes*, Oligochaetes and *Scoloplos cylindrifer*) and decreasing (*Cossura consimilis*) linear trends in abundance over the monitoring programme

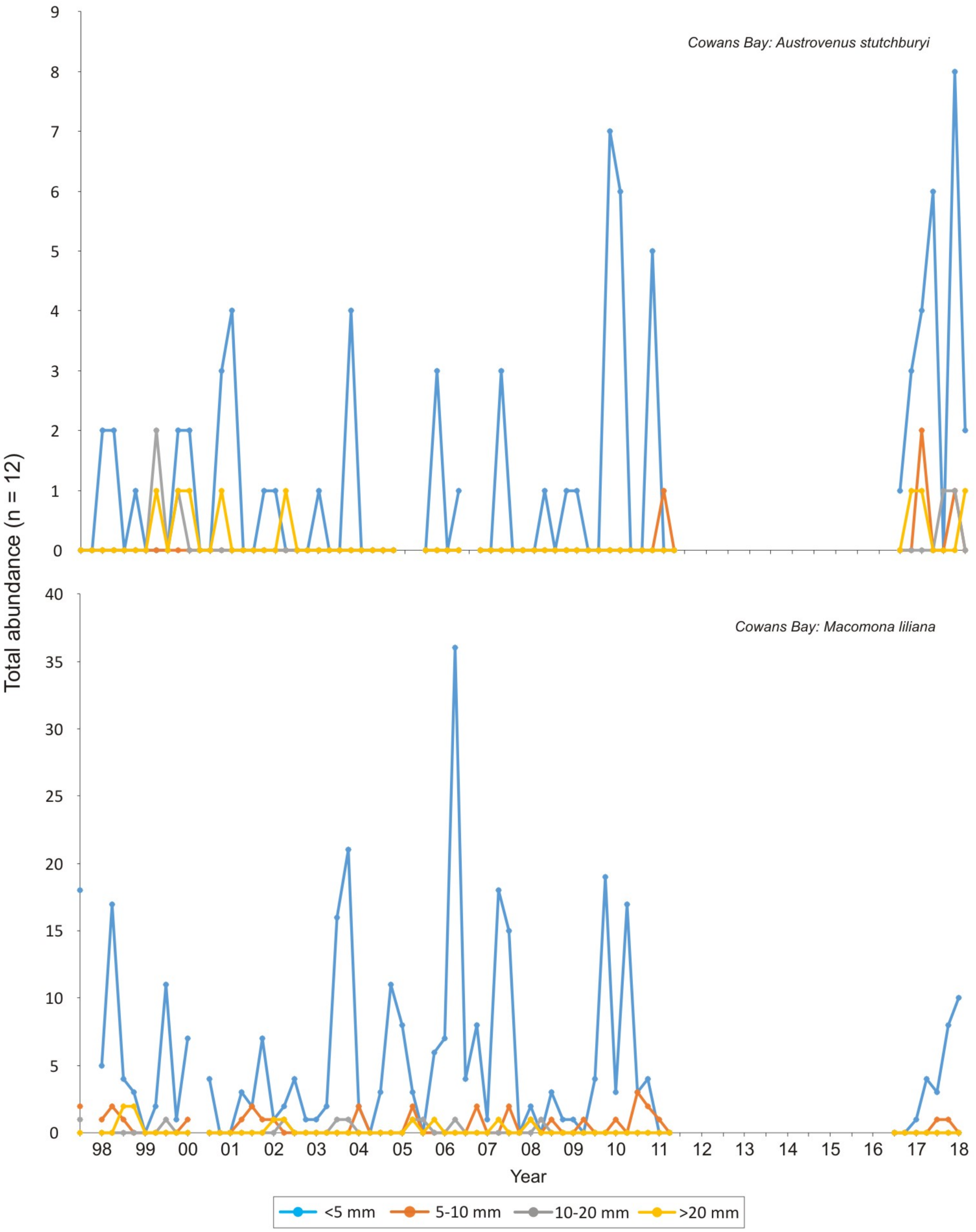

Figure 6 Size class structure of monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana* at Cowans Bay between July 1997 and January 2018.

3.2.2 Dyers Creek (DC)

Austrovenus and *Aricidea* have been the first and second most abundant taxa at DC since January 2014 (Appendix D). *Linucula, Prionospio, Arthritica, Paracalliope novizealandiae,* Oligochaetes and Polydorids all feature as the third most abundant.

3.2.2.1 Seasonality and Multi-year cycles

Six taxa at DC are showing seasonal cycles in abundance, and another six taxa display multi-year or greater than annual cycles. Annual peaks in abundance are displayed by *Arthritica,* Nemertea and *Prionospio* (variable timing), *Austrovenus* and *Paracalliope* (October or January), and *Notoacmea scapha* (October). *Cossura,* Polydorids, *Prionospio* and *Torridoharpinia* are displaying greater than annual patterns in abundance with cycles between 2 and 9 years (Table 6). As well as displaying annual peaks, *Austrovenus* and Nemertea also display multiyear cycles of 7-8 and 10 years, respectively.

3.2.2.2 Statistically significant trends

Ten of the monitored taxa at Dyers Creek are exhibiting significant ($p < 0.05$) trends in abundance (Table 8). Increasing trends in *Hemiplax* and *Scoloplos* abundances have been newly identified since last reported, although *Hemiplax* did display an increasing trend in 2011 which was not detected in 2013 or 2015. The increasing abundance of *Scoloplos* only occurs since 2014. New step trends have also become apparent in the abundances of *Arthritica (*increasing step; Figure 7)*,* and *Heteromastus* and *Notoacmea* (both decreasing step; Figure 7 and Figure 8*,* respectively). These changes were apparent previously, but significant differences were not detected. Increasing trends continue to be significant in abundances of Oligochaetes and *Prionospio*. A decreasing trend in *Macomona* abundance continues to be observed. Step trends observed in 2015 in the abundances of *Aricidea* and *Linucula* are still significant in 2018, with *Aricidea* increasing and *Linucula* decreasing. The ecological significance of these trends is discussed in section 3.3.

Trends that were previously apparent in the abundance of seven monitored taxa are no longer significant with the additional three years of data. The increasing trends in *Austrovenus, Cossura, Paracalliope* and *Perinereis vallata,* and the decreasing trends in Polydorids and *Torridoharpinia* are no longer significant (Table 8). The increasing abundances of *Austrovenus* and *Cossura* detected in 2015 are now clearly part of a multi-year pattern, with numbers decreasing in abundance after peaking in 2013-14. The trend observed in 2015 for *Paracalliope* was driven by an unusually large recruitment peak in 2014, with numbers returning to baseline in the following years. Similarly, the low numbers of *Perinereis* found throughout the sampling period allowed smaller peaks in abundance in the summer of 2014 and 2015 to cause a statistically significant trend that has proved, with more data, to be natural variation. Abundances in Polydorids are now exhibiting a multi-year pattern which was displaying as a decreasing trend until 2015, and the increasing step trend in Nemertea is now also part of a multi-year cycle in abundance. The low numbers of *Torridoharpinia* were displaying a decreasing trend, but we have always pointed out that this is only driven by two unusually high peaks at the start of the sampling period.

There are no statistically significant trends in the size classes of the monitored bivalves *Austrovenus* and *Macomona* at DC*.* The dominant size classes of *Austrovenus* have continued to be the <5mm and 10-20mm sizes (Figure 9). Abundance peak sizes are variable, with the highest being in October 2013. The >20mm size class of *Macomona* has been decreasing over the monitored period, and the <5mm remains dominant over time with high and variable peaks.

Table 8 Magnitude of trends detected for monitored taxa at Dyers Creek in 2018 compared to other years. Numbers are the slope of linear trends or the size of the step trend (ST). For ST the date of the step is also given. Empty cells indicate that no trend was found.

DC: Monitored taxa	2018	2015	2011
Aonides trifida			
Aricidea sp.	$122.79^{\text{ST Jul-12}}$	$122.79^{\text{ST Jul-12}}$	
Arthritica bifurca	$31.66^{\text{ST Apr-11}}$	3.66	
Austrovenus stutchburyi		5.40	
Cossura consimilis		0.380	
Hemiplax hirtipes	0.18		0.26
Heteromastus filiformis	$-45.68^{\text{ST Apr-08}}$	-1.22	-4.00
Linucula hartvigiana	$-378.85^{\text{ST Apr-09}}$	$-378.85^{\text{ST Apr-09}}$	
Macomona liliana	-0.86	-0.85	
Nemertea		$10.99^{\text{ST Jan-10}}$	
Notoacmea scapha	$-33.57^{\text{ ST Oct-09}}$	-1.06	
Oligochaetes	0.67	0.37	0.46
Owenia petersenae			
Paracalliope novizealandiae		0.58	
Perinereis vallata		0.06	
Polydorids		-0.52	
Prionospio aucklandica	1.24	2.88	3.47
Scoloplos cylindrifer	0.34		
Torridoharpinia hurleyi		-0.10	

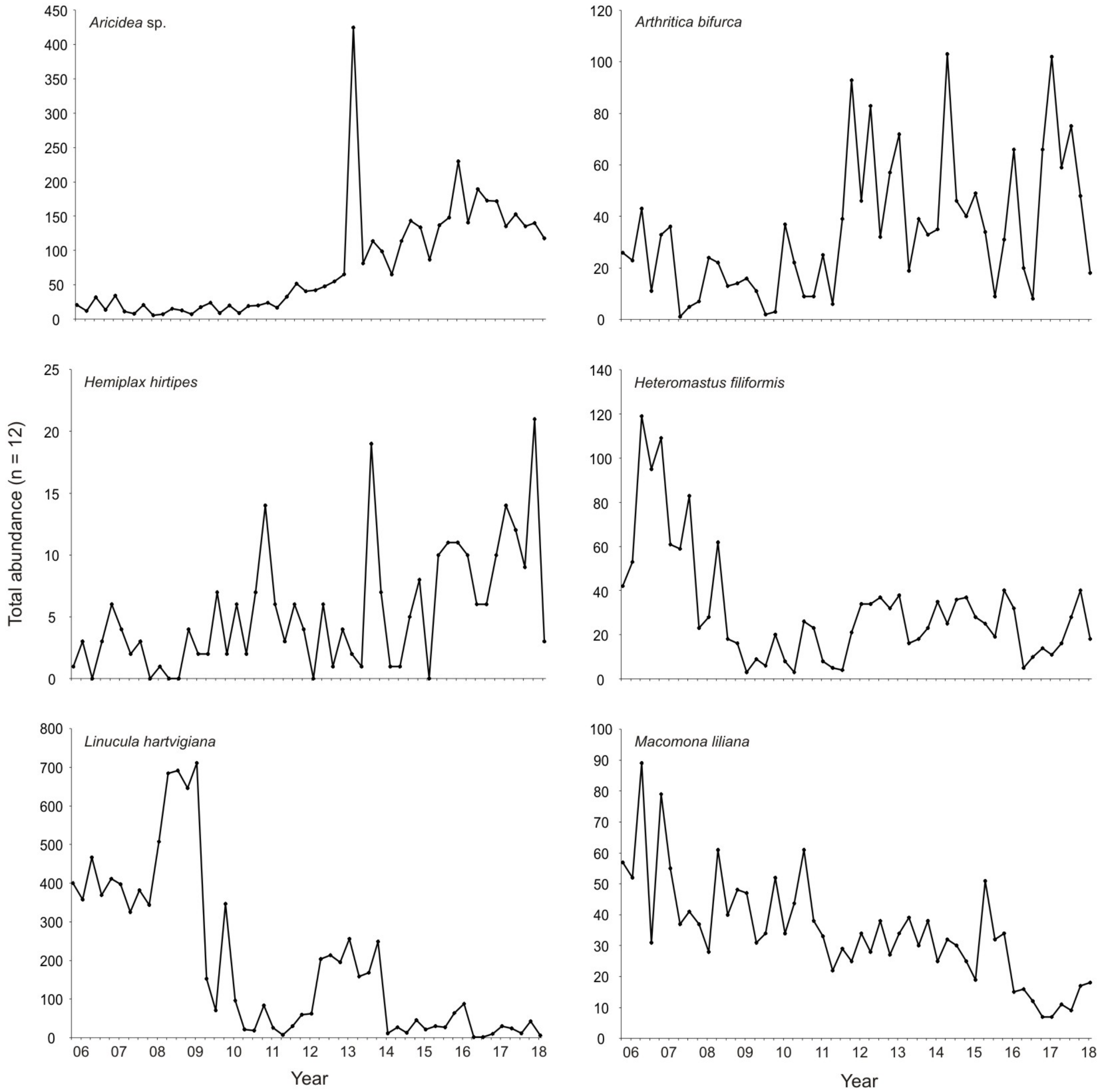

Figure 7 Monitored taxa at Dyers Creek displaying increasing (*Aricidea* sp., *Arthritica bifurca*, *Hemiplax hirtipes*) and decreasing (*Heteromastus filiformis*, *Linucula hartvigiana, Macomona liliana*) linear trends in abundance over the monitoring programme.

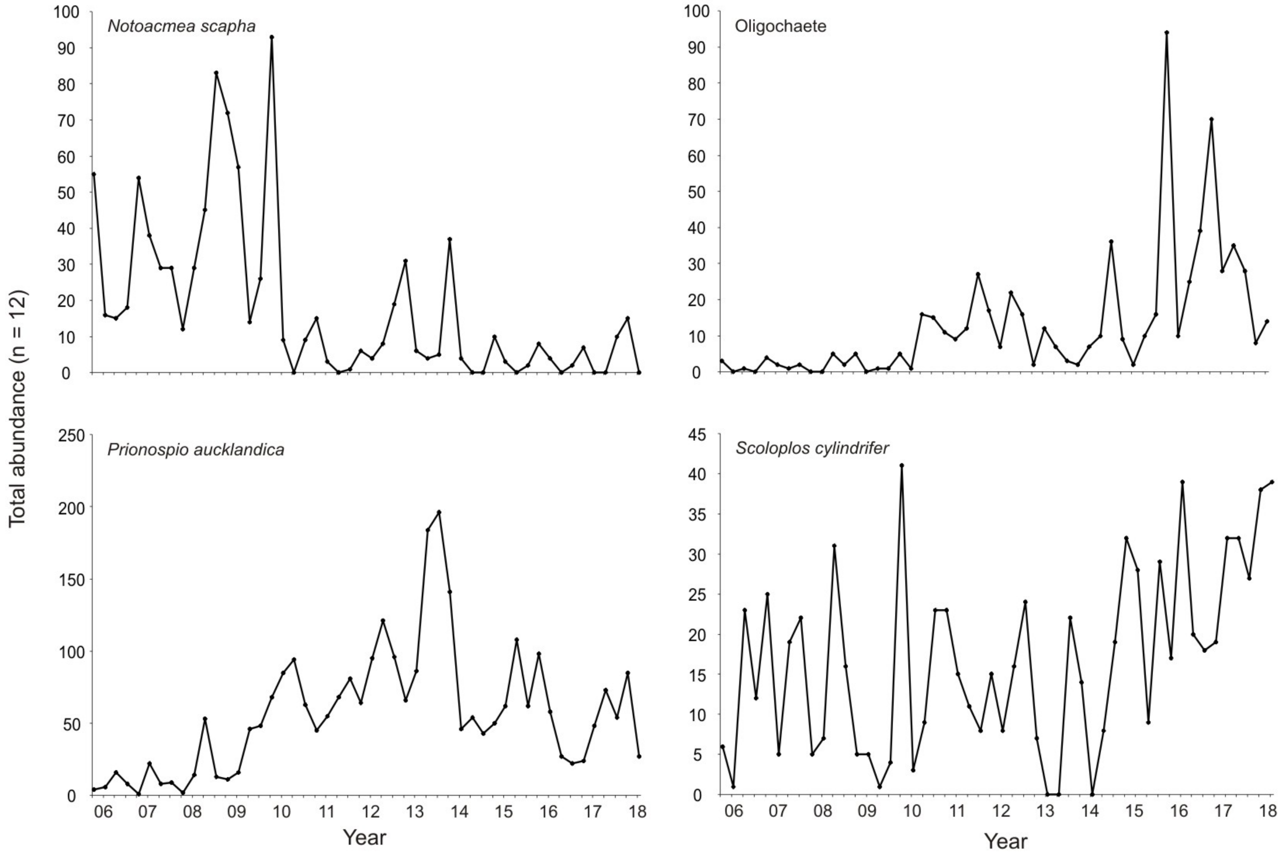

Figure 8 Monitored taxa at Dyers Creek displaying increasing (Oligochaetes, *Prionospio aucklandica*, *Scoloplos cylindrifer*), and decreasing (*Notoacmea scapha)* linear trends in abundance over the monitoring programme.

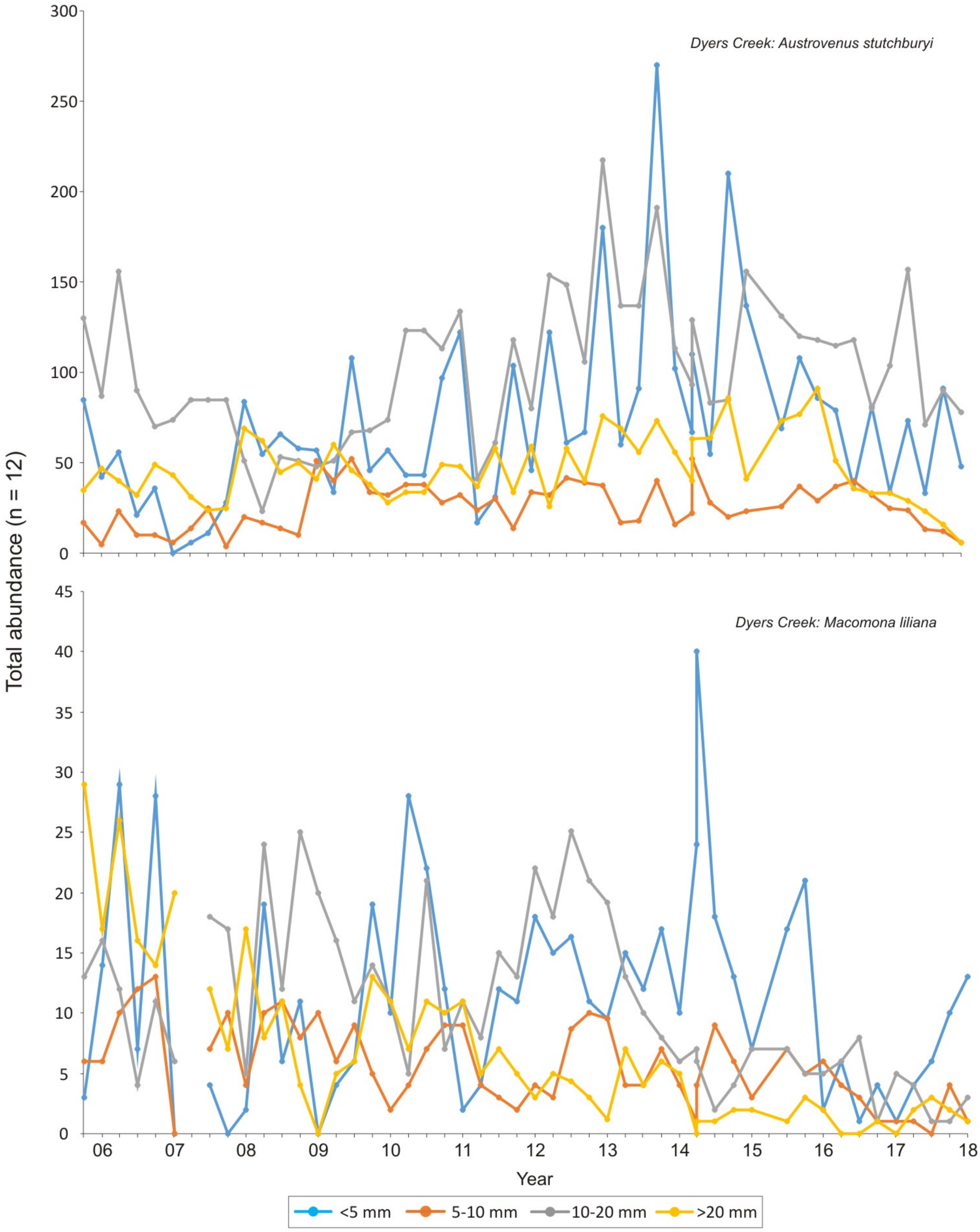

Figure 9 Size class structure of monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana* at Dyers Creek between October 2005 and January 2018.

3.2.3 Hamilton Landing (HL)

Cossura and *Aricidea* have been the first and second most abundant taxa at HL since July 2012 (Appendix D). *Heteromastus, Prionospio* and Oligochaetes are all commonly third most abundant. *Arthritica,* Nemertea and Polydorids were also numerically dominant at this site earlier in the sampling period.

3.2.3.1 Seasonality and Multi-year cycles

Three taxa at HL are showing seasonal cycles in abundance, and two taxa are displaying multi-year patterms. Annual peaks in recruitment are seen in abundances of *Hemiplax* (April or July), *Prionospio* (October or January; Figure 12), and *Scoloplos* (July; Figure 12). An 8-10 year multi-year cycle is observed in the abundance of *Heteromastus,* while Nemertea (Figure 11) is displaying >10 year multi-year cycle (Table 6).

3.2.3.2 Statistically significant trends

Eleven monitored taxa at HL are displaying trends ($p < 0.05$) in abundance (Table 9). Increasing steps have consistently been observed in the abundances of *Cossura* and Nemertea and continue to be significant, while what had previously been observed as linear increases in abundances of *Aricidea,* Oligochaetes and *Prionospio* seem now more likely to be step increases. Decreasing step trends continue to be apparent in the abundances of *Austrovenus, Macomona, Linucula, Perinereis,* Polydorids and *Scoloplos* (Figure 10 and Figure 11). The ecological significance of these trends is discussed in section 3.3.

A majority of step trends occurred between July 1999 (*Macomona*) and July 2000 (*Cossura*), with *Austrovenus, Linucula*, Polydorids and Scoloplos exhibiting step trends in April 2000.

The decreasing trend in *Aonides trifida* reported in 2015 is no longer apparent with three years of additional data. Numbers are low and variable with no discernible trend.

There are no statistically significant linear trends in the size classes of the monitored bivalves *Austrovenus* and *Macomona.* Early in the monitoring period there were higher numbers of larger individuals of both species found, however these populations are now comprised of the <5mm and 5-10mm size classes (Figure 12).

Table 9 Magnitude of trends detected for monitored taxa at Hamilton Landing in 2018 compared to other years. Numbers are the slope of linear trends or the size of the step trend (ST). For ST the date of the step is also given. Empty cells indicate that no trend was found.

HL: Monitored taxa	2018	2015	2011	2009
Aonides trifida		-0.03		
Aricidea sp.	299.48$^{\text{ST Jul-12}}$	3.49	0.96	0.86
Arthritica bifurca				
Austrovenus stutchburyi	-55.84$^{\text{ST Apr-00}}$	-55.84$^{\text{ST Apr-00}}$	-55.84$^{\text{ST Apr-00}}$	-55.84$^{\text{ST Apr-00}}$
Cossura consimilis	707.55$^{\text{ST Jul-00}}$	707.55$^{\text{ST Jul-00}}$	707.55$^{\text{ST Jul-00}}$	707.55$^{\text{ST Jul-00}}$
Hemiplax hirtipes				
Heteromastus filiformis			5.02	8.70
Linucula hartvigiana	-7.53$^{\text{ST Apr-00}}$	-7.53$^{\text{ST Apr-00}}$	-7.53$^{\text{ST Apr-00}}$	
Macomona liliana	-13.26$^{\text{ST Jul-99}}$	-13.26$^{\text{ST Jul-99}}$	-13.26$^{\text{ST Jul-99}}$	-13.26$^{\text{ST Jul-99}}$
Nemertea	-4.57 $^{\text{ST Jan-10}}$	-4.57 $^{\text{ST Jan-10}}$	0.10	
Notoacmea scapha				
Oligochaetes	1.00$^{\text{ST Oct-07}}$	1.01		
Owenia petersenae				
Paracalliope novizealandiae				
Perinereis vallata	-1.86$^{\text{ST Oct-99}}$	-1.86$^{\text{ST Oct-99}}$	-1.86$^{\text{ST Oct-99}}$	-1.86$^{\text{ST Oct-99}}$
Polydorids	-143.81$^{\text{ST Apr-00}}$	-143.81$^{\text{ST Apr-00}}$	-143.81$^{\text{ST Apr-00}}$	-143.81$^{\text{ST Apr-00}}$
Prionospio aucklandica	43.53$^{\text{ST Oct-08}}$	0.56	0.61	
Scoloplos cylindrifer	-9.82$^{\text{ST Apr-00}}$	-9.82$^{\text{ST Apr-00}}$	-9.82$^{\text{ST Apr-00}}$	-9.82$^{\text{ST Apr-00}}$
Torridoharpinia hurleyi				

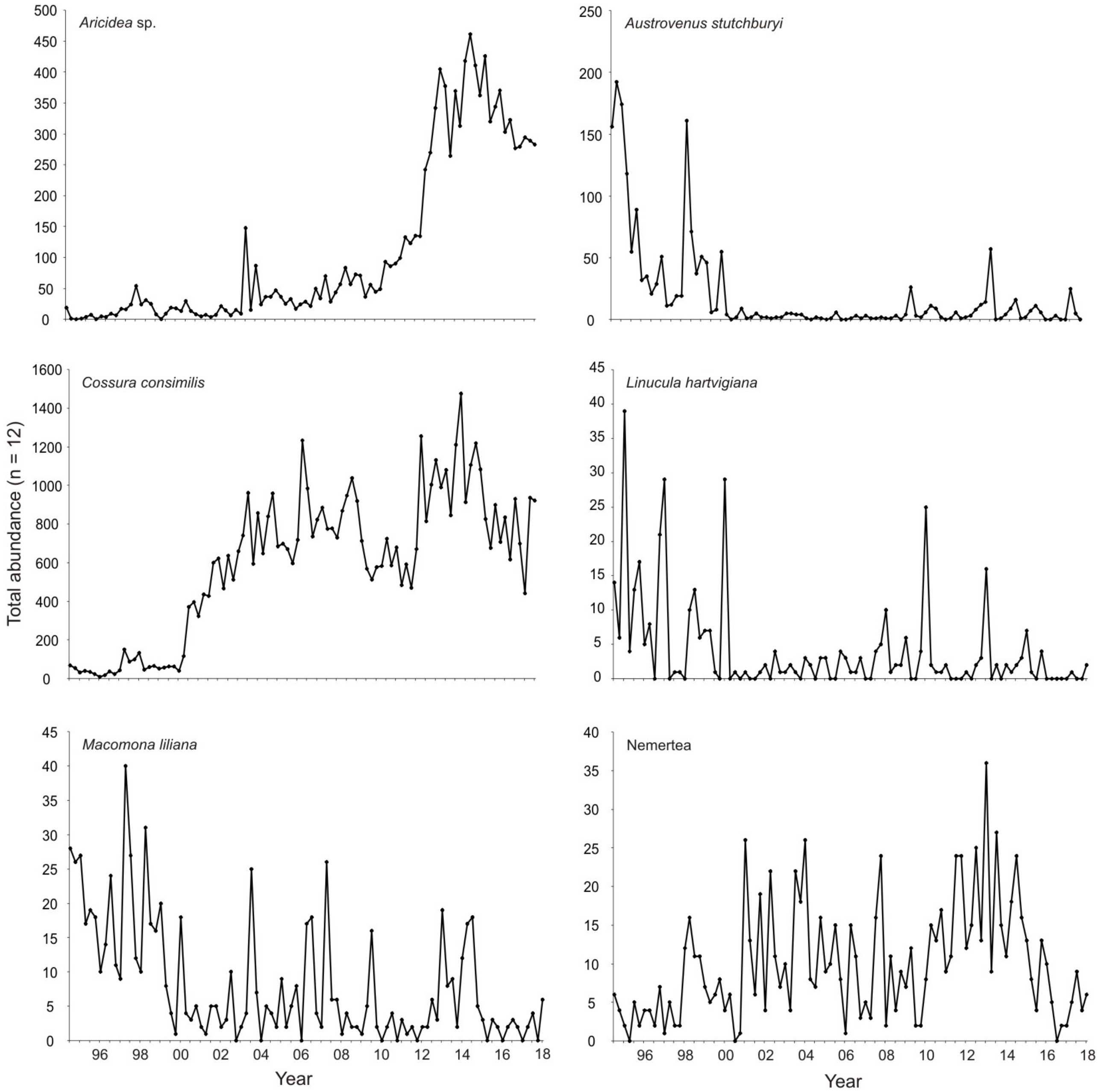

Figure 10 Monitored taxa at Hamilton Landing displaying increasing (*Aricidea* sp., *Cossura consimilis*) and decreasing (*Austrovenus stutchburyi*, *Macomona liliana*, *Linucula hartvigiana*) linear trends in abundance.

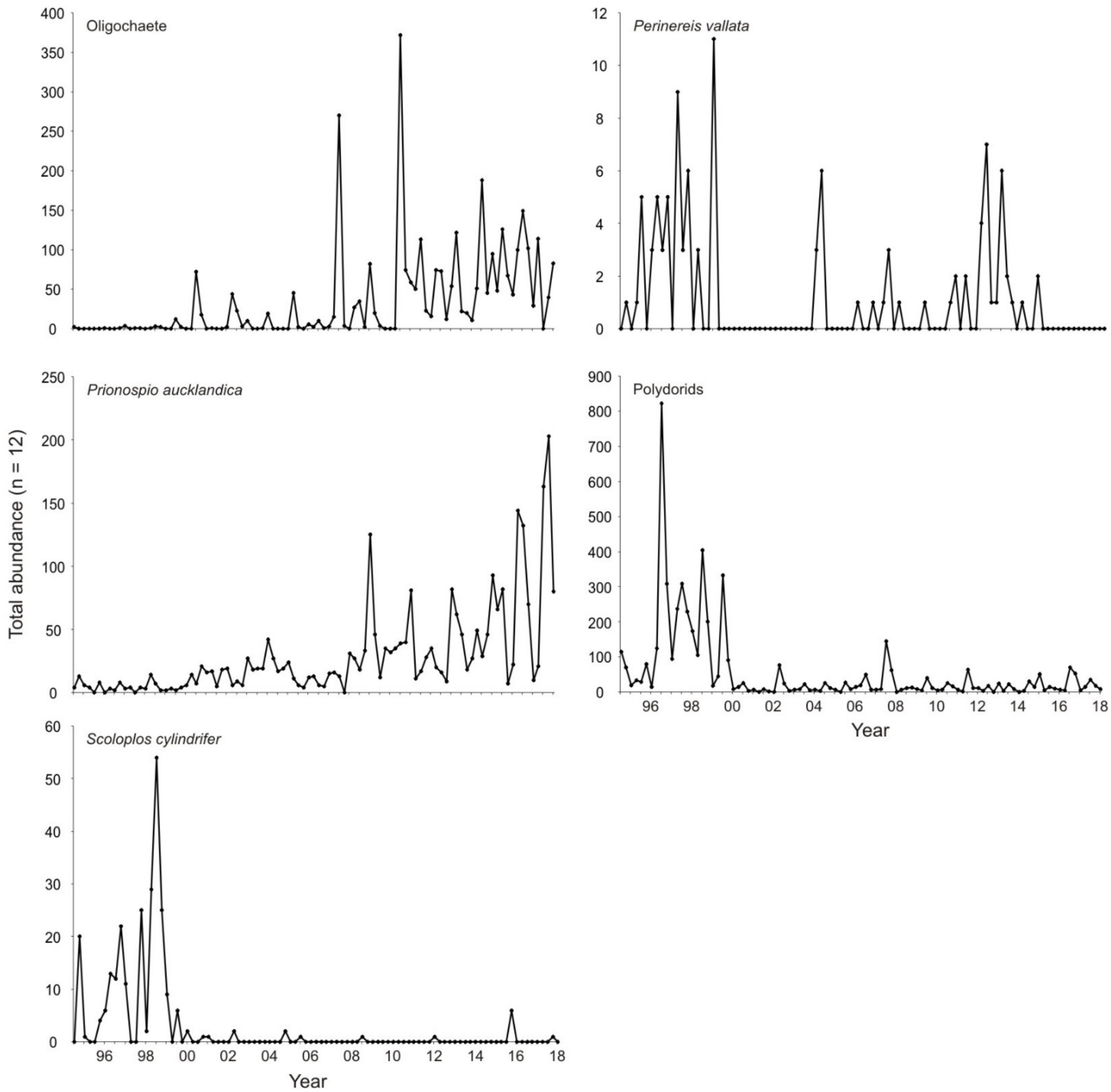

Figure 11 Monitored taxa at Hamilton Landing displaying increasing (Oligochaetes, *Prionospio aucklandica*) and decreasing (*Perinereis vallata*, Polydorids, *Scoloplos cylindrifer*) linear trends in abundance.

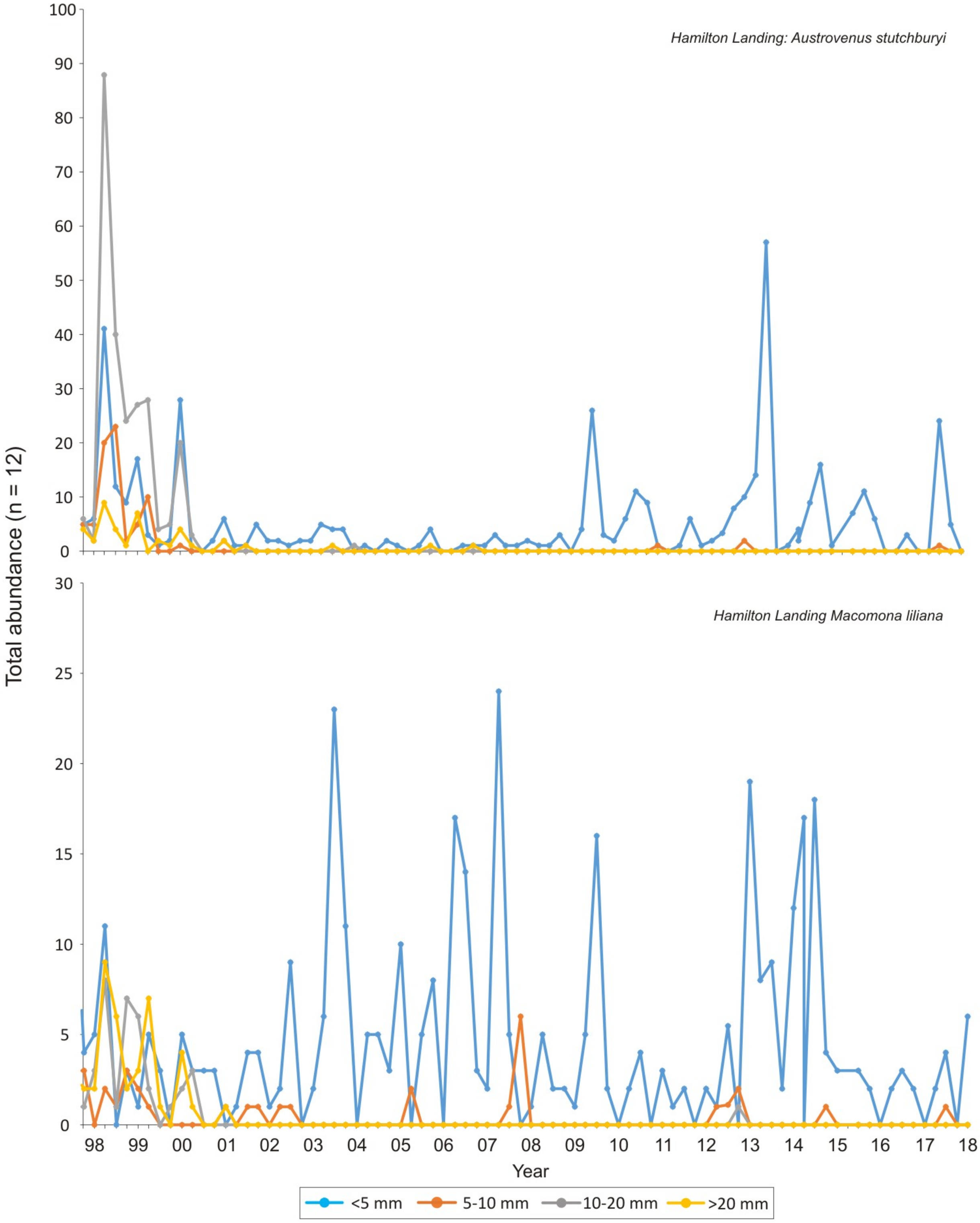

Figure 12 Size class structure of monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana* at Hamilton Landing between July 1997 and January 2018.

3.2.4 Jamieson Bay (JB)

Heteromastus and *Austrovenus* are commonly the most numerically dominant taxa at site JB, although they were out ranked in January 2018 by Oligochaetes and Polydorids (Appendix D). *Aricidea, Linucula, Torridoharpinia* and *Prionospio* are also highly abundant at this site.

3.2.4.1 Seasonality and Multi-year cycles

Three taxa at JB are displaying multi-year cycles in abundance (Table 6). *Notoacmea* and Polydorids are exhibiting cycles in abundance lasting between 6 and 10 years. *Macomona* is displaying larger recruitment peaks on a 10 year cycle (Figure 13).

3.2.4.2 Statistically significant trends

Thirteen of the monitored taxa at Jamieson Bay are exhibiting significant trends in abundance (Table 10).

Increasing linear trends in the abundances of *Aricidea, Arthritica, Austrovenus, Heteromastus,* Oligochaetes, Nemertea and *Paracalliope* continue to be present, although abundances of *Prionospio* now display a step increase. Increasing step trends have also become apparent in the abundances of *Cossura* and *Torridoharpinia* although the detected trend in *Torridoharpinia* is likely to be part of a multi-year cycle. The ecological significance of these trends is discussed in section 3.3.

A decreasing step trend has also become apparent in the abundance of *Linucula* with the additional three years of data (Figure 13 and Figure 14). Decreasing linear trends in *Aonides* and *Macomona* abundance continues to be present, although the size of both of these is decreasing over time, suggesting that the actual decrease is now finished. For *Macomona*, the trend was most likely a step trend occurring in 2000, as with the exception of one high data point in 2007, recruitment peaks have been consistently lower than those occurring in the first years of monitoring.

There are no statistically significant trends in the size classes of the monitored bivalves *Austrovenus* and *Macomona* at JB. Historically, *Austrovenus* numbers have been very low (Figure 15). The >5mm size class has been increasing with larger peaks since 2015. The <5mm sized *Macomona* display recruitment peaks every ~2 years and are much higher in abundance than the larger size classes.

Table 10 Magnitude of trends detected for monitored taxa at Jamieson Bay in 2018 compared to other years. Numbers are the slope of linear trends or the size of the step trend (ST). For ST the date of the step is also given. Empty cells indicate that no trend was found.

JB: Monitored taxa	2018	2015	2011	2009
Aonides trifida	-0.32	-0.40		
Aricidea sp.	0.91	0.58	0.22	
Arthritica bifurca	0.18	0.17		
Austrovenus stutchburyi	0.56	0.09		
Cossura consimilis	49.41 ST Oct-14			
Hemiplax hirtipes				
Heteromastus filiformis	0.63			
Linucula hartvigiana	-155.59 ST Jan-11		2.46	
Macomona liliana	-0.20	-0.26	-27.75 ST Apr-97	
Nemertea	0.14	12.00 ST Jan-10		
Notoacmea scapha				
Oligochaetes	0.49	0.16		
Owenia petersenae				
Paracalliope novizealandiae	0.21	0.28		
Perinereis vallata				
Polydorids				-171.88 ST Jan-00
Prionospio aucklandica	64.51 ST Oct-12	0.44		
Scoloplos cylindrifer				
Torridoharpinia hurleyi	51.54 ST Oct-14			

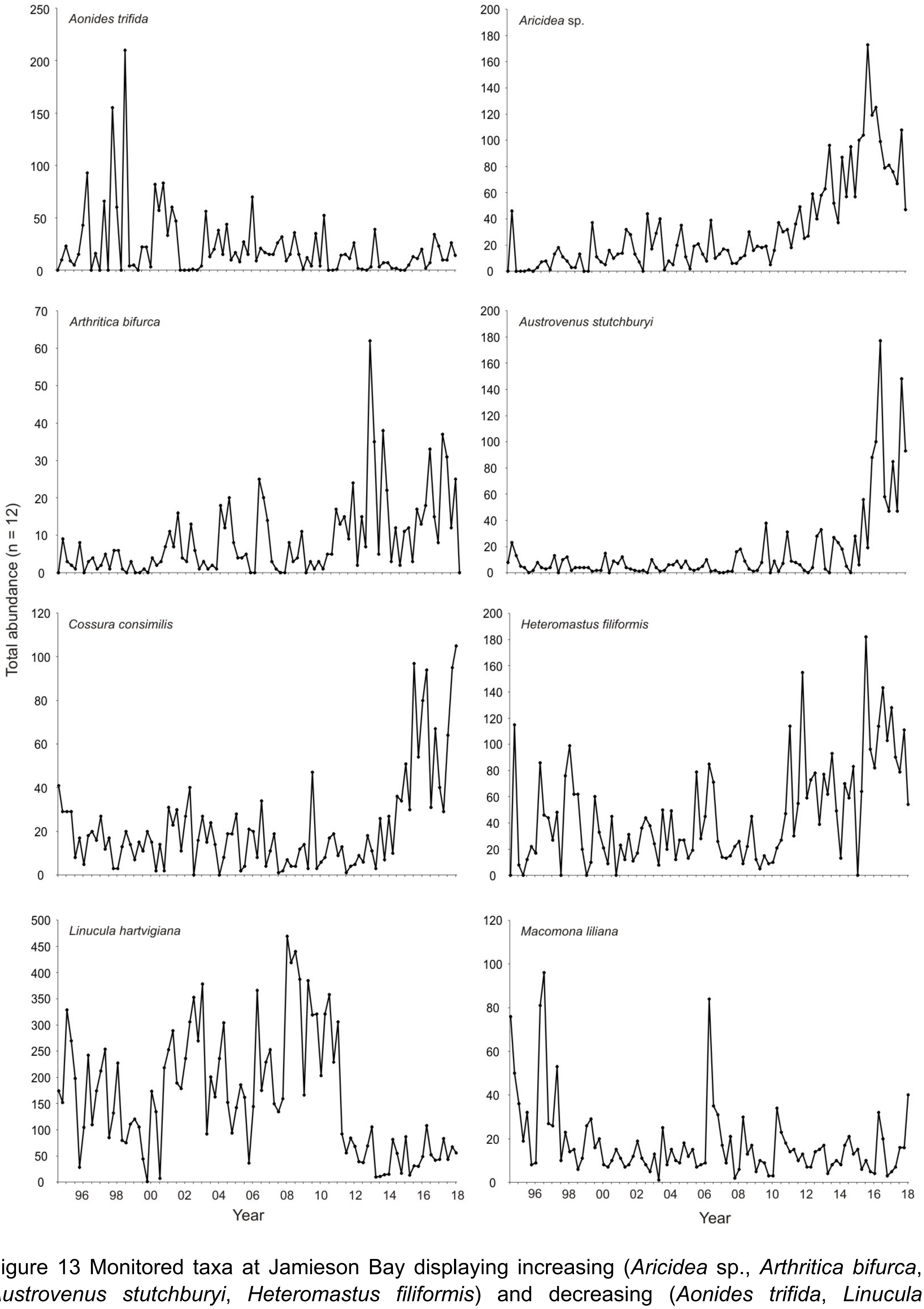

Figure 13 Monitored taxa at Jamieson Bay displaying increasing (*Aricidea* sp., *Arthritica bifurca*, *Austrovenus stutchburyi*, *Heteromastus filiformis*) and decreasing (*Aonides trifida*, *Linucula hartvigiana, Macomona liliana*) linear trends in abundance.

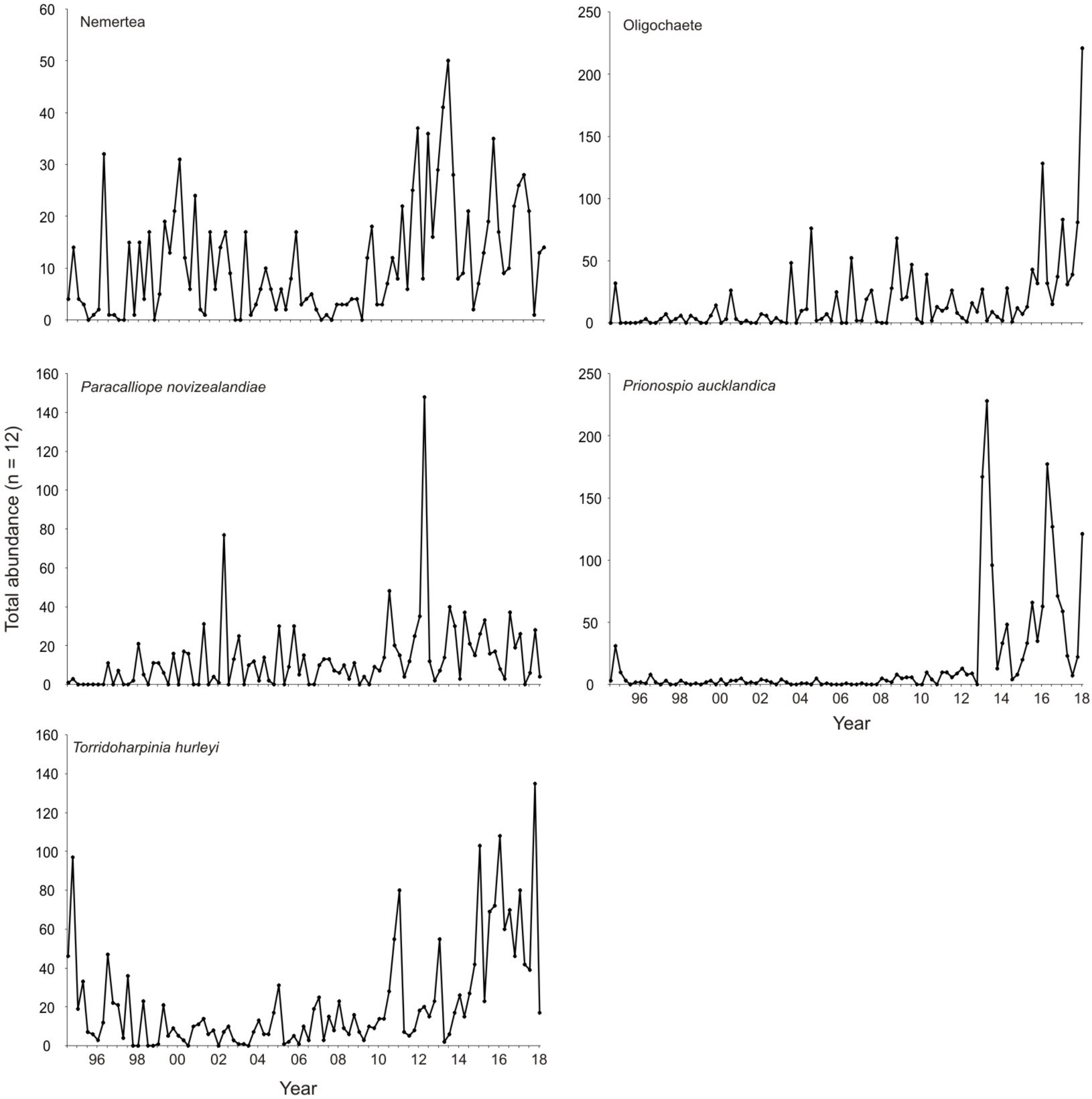

Figure 14 Monitored taxa at Jamieson Bay displaying increasing (Nemertea, Oligochaetes, *Paracalliope novizealandiae*, *Prionospio aucklandica*, *Torridoharpinia hurleyi*) linear trends in abundance over the monitoring programme.

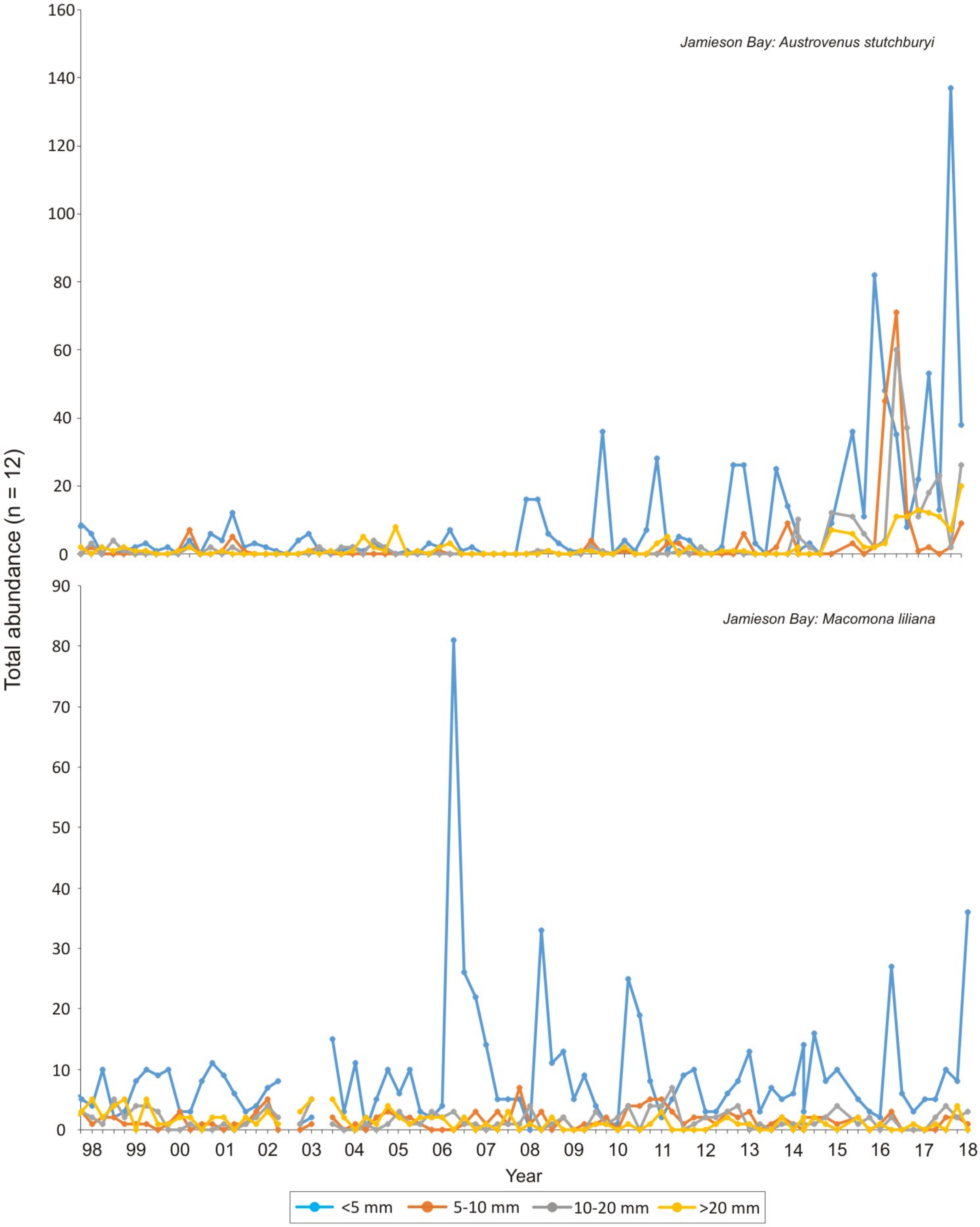

Figure 15 Size class structure of monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana* at Jamieson Bay between July 1997 and January 2018.

3.2.5 Mid Harbour (MH)

Since July 2014, the three most abundant taxa have remained the same (Appendix D). *Cossura,* Polydorids and *Arthritica* have remained the most dominant taxa, but in different combinations over time. *Heteromastus* and *Linucula* are the only other taxa which have been numerically dominant since April 2005.

3.2.5.1 Seasonality and Multi-year cycles

Three taxa at MH are showing seasonal patterns, as well as two taxa displaying a multi-year cycle (Table 6). *Aricidea* and Oligochaetes are displaying annual peaks in July or October. *Linucula* had been displaying consistent annual peaks in January up until 2011 where numbers decreased dramatically. Multi-year cycles lasting more than 10 years can be seen in the abundances of Nemertea and Polydorids at site MH.

3.2.5.2 Statistically significant trends

There are 10 monitored taxa exhibiting statistically significant linear trends ($p < 0.05$) in abundance at Mid Harbour (Table 11). *Aricidea, Arthritica, Cossura,* Nemertea and Oligochaetes are continuing to display increasing trends in abundance, and *Austrovenus* and *Hemiplax* are also now displaying an increasing trend since last reported in 2015 (Cummings et al. 2016; Figure 16). A decreasing trend continues to be apparent in the abundance of *Macomona.* The increasing step trend in *Heteromastus* abundance, occurring in April 2001, continues to be significant, while a decreasing step in the abundance of *Linucula* has become apparent with the additional data since 2015 (Figure 17). The ecological significance of these trends is discussed in section 3.3.

There are no statistically significant trends in the size classes of the monitored bivalves *Austrovenus* and *Macomona* at MH*. Austrovenus* generally had low numbers until 2013, except for a large peak in the <5mm size class in January 2000. Since 2013 there has been a small and steady increase in all size classes. The <5mm size class of *Macomona* is the most abundant with larger recruitment peaks every 4-5 years (Figure 18).

Table 11 Magnitude of trends detected for monitored taxa at Mid Harbour in 2018 compared to other years. Numbers are the slope of linear trends or the size of the step trend (ST). For ST the date of the step is also given. Empty cells indicate that no trend was found.

MH: Monitored taxa	2018	2015	2011	2009
Aonides trifida				
Aricidea sp.	0.51	0.45	0.20	
Arthritica bifurca	2.66	2.62	1.20	0.98
Austrovenus stutchburyi	0.10			
Cossura consimilis	1.09	0.60		
Hemiplax hirtipes	0.07			
Heteromastus filiformis	$20.70^{ST\ Apr-01}$	$21.72^{ST\ Apr-01}$		
Linucula hartvigiana	$-349.09^{ST\ Apr-11}$	-2.10	3.32	3.42
Macomona liliana	-0.16	-0.19	-0.20	-0.20
Nemertea	0.09	0.12		
Notoacmea scapha				
Oligochaetes	0.03			
Owenia petersenae				
Paracalliope novizealandiae				
Perinereis vallata				
Polydorids				
Prionospio aucklandica				
Scoloplos cylindrifer				
Torridoharpinia hurleyi				

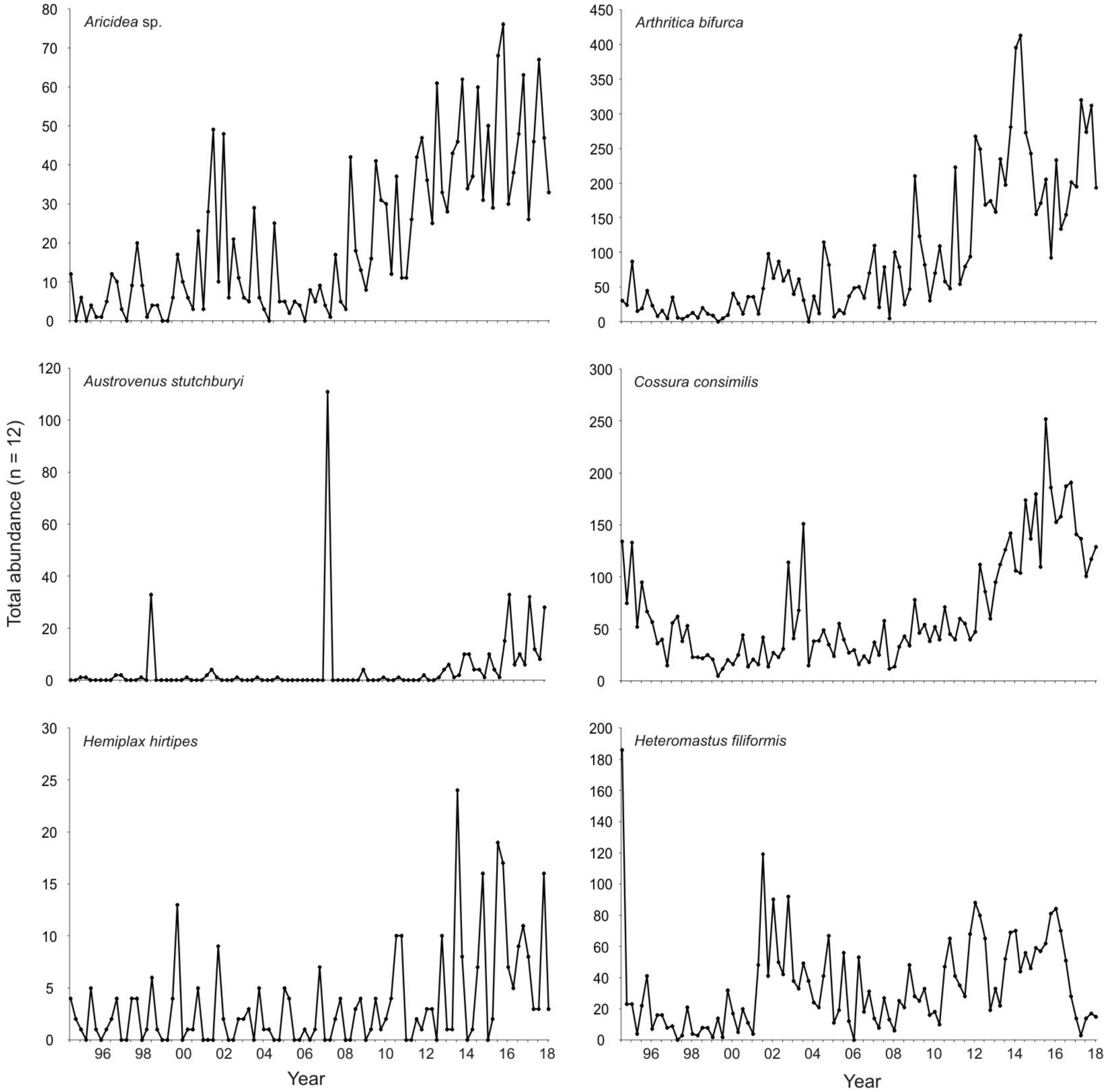

Figure 16 Monitored taxa at Mid Harbour displaying increasing (*Aricidea* sp., *Arthritica bifurca*, *Austrovenus stutchburyi*, *Cossura consimilis*, *Hemiplax hirtipes*, *Heteromastus filiformis*) linear trends in abundance over the monitoring programme.

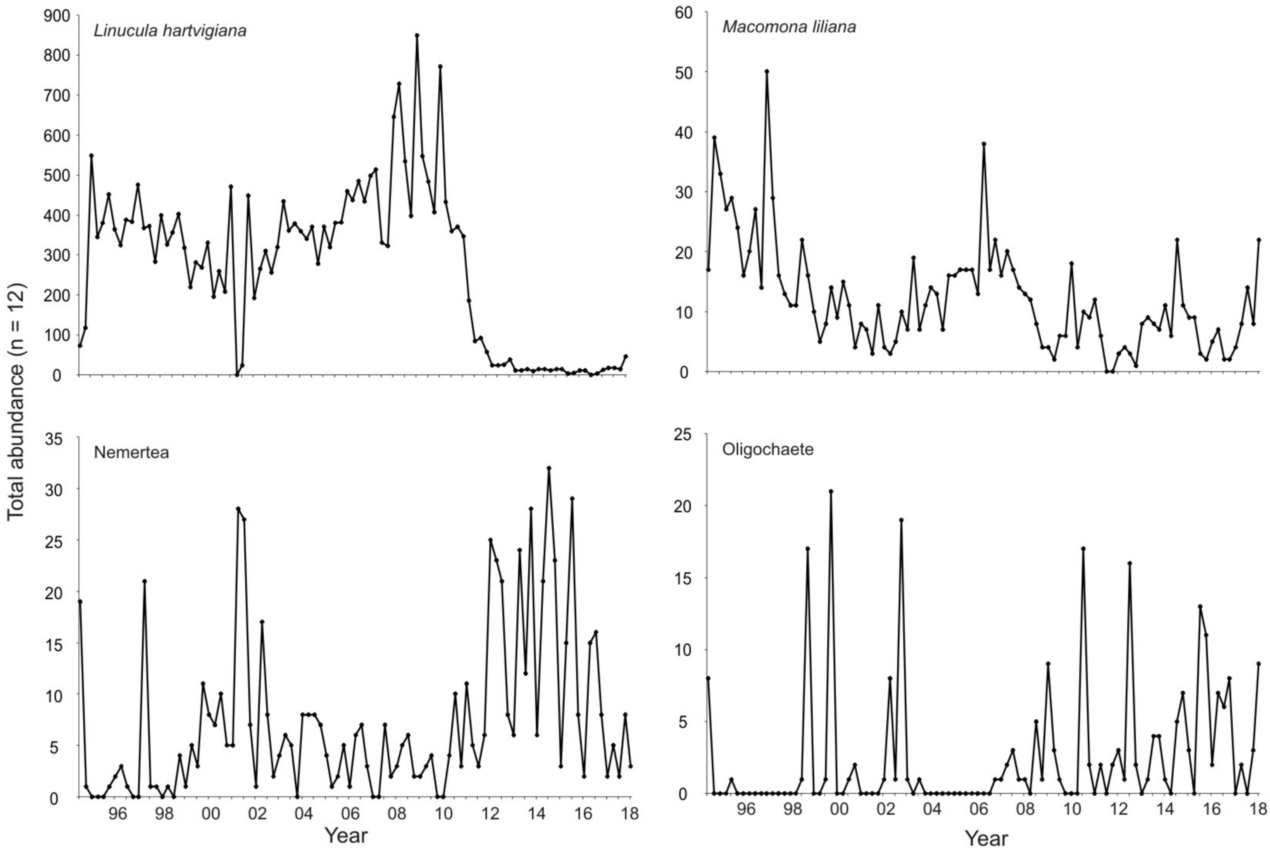

Figure 17 Monitored taxa at Mid Harbour displaying increasing (Nemertea, Oligochaetes) and decreasing (*Macomona liliana*, *Linucula hartvigiana*) linear trends in abundance over the monitoring programme. The abundance of *Linucula hartvigiana* also features a decrease increase in April 2011.

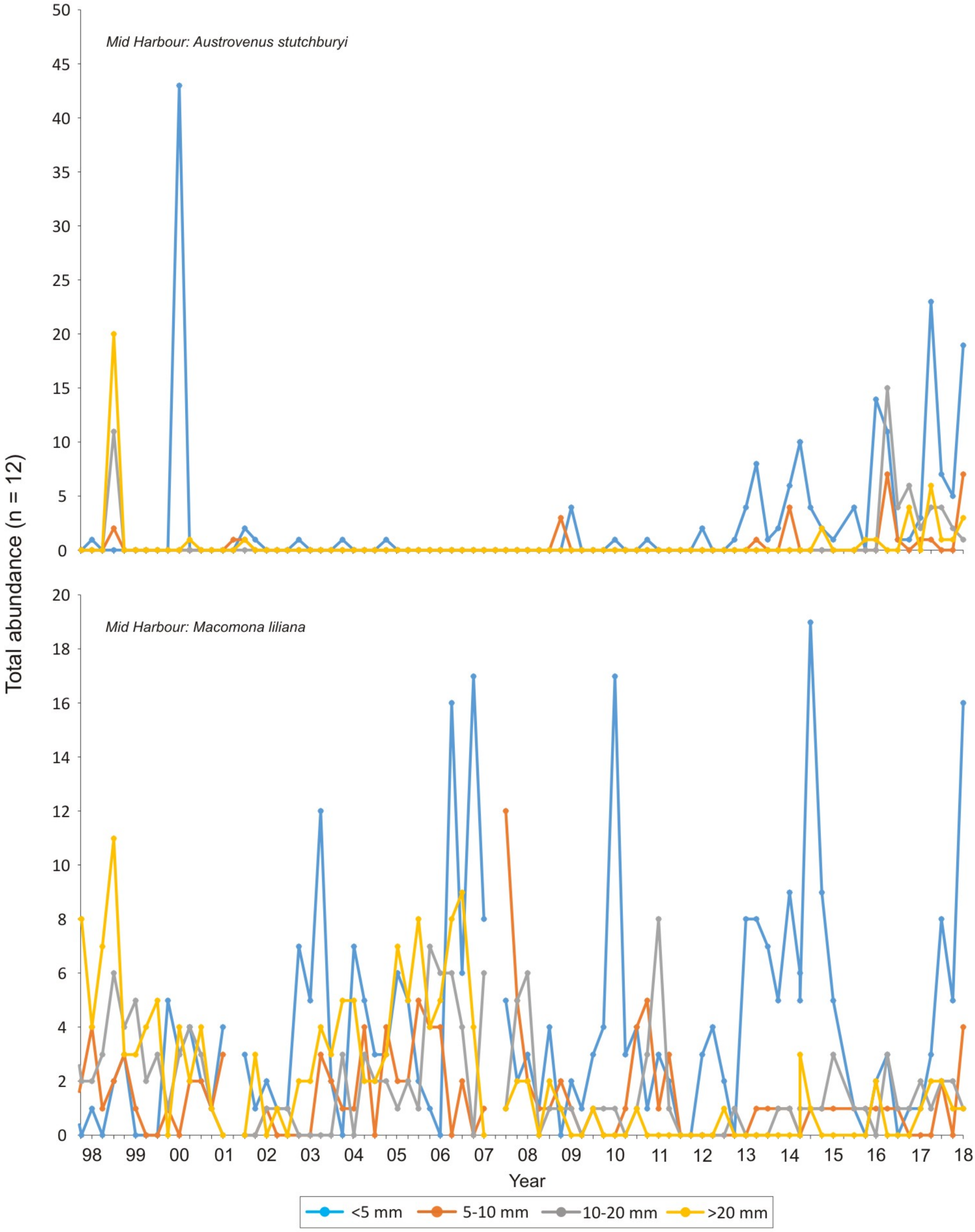

Figure 18 Size class structure of monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana* at Mid Harbour between July 1997 and January 2018.

3.2.6 Te Kapa Inlet (TK)

Cossura, Aricidea and *Heteromastus* have been the three most dominant taxa for the majority of the monitored period at site TK (Appendix D). *Linucula, Prionospio* and *Austrovenus* are the only other taxa that have been amongst the top ranked since July 1994.

3.2.6.1 Seasonality and Multi-year cycles

Four taxa at TK are showing seasonal cycles in abundance, and two taxa are displaying multi-year cycles (Table 6). *Aricidea* and Polydorids display annual peaks in July or October. *Austrovenus* shows consistent annual peaks in October, while *Linucula* peaks in January. Nemertea and *Prionospio* are displaying >10 and 7 year cycles in abundance, respectively.

3.2.6.2 Statistically significant trends

Eleven of the monitored taxa at TK are displaying statistically significant ($p < 0.05$) increasing or decreasing trends in abundance. Increasing step trends are seen in the abundances of *Aricidea, Arthritica, Cossura,* Nemertea and Oligochaetes. A decreasing step trend has become apparent in the abundance of *Linucula*, and a step continues to be apparent in Polydorids. *Macomona* and *Notoacmea* continue to display decreasing trends, while *Paracalliope* and *Perinereis* both continue to display increasing linear trends in abundance (Figure 19 and Figure 20; Table 12). The trends in Nemertea and *Paracalliope* are likely driven by emerging multi-year cycles. The ecological significance of these trends is discussed in section 3.3.

The step trends in abundance observed for *Cossura* and polydorids occurred at the beginning of 2000, matching step changes in abundances observed around this time at HL and MH.

The increasing trend in *Scoloplos* observed in 2015 is no longer significant due to lower numbers over the last three years.

There has been no significant change in the total abundance of *Austrovenus,* but there has been a change in the size class composition. The <5mm size class is displaying an increasing trend (slope 0.0076, p = 0.0002) driven by two large recruitment peaks in January 2013 and October 2017, and there is a decreasing trend (slope -0.0026, p = 0.0019) of the >20mm size class (Figure 21). Consistent annual recruitment peaks can be observed in <5mm juveniles in both *Austrovenus* and *Macomona* abundances (Figure 22).

Table 12 Magnitude of trends detected for monitored taxa at Te Kapa Inlet in 2018 compared to other years. Numbers are the slope of linear trends or the size of the step trend (ST). For ST the date of the step is also given. Empty cells indicate that no trend was found.
Italics indicate a statistically significant trend was only observed using logged data.

TK: Monitored taxa	2018	2015	2011	2009
Aonides trifida				
Aricidea sp.	80.97$^{\text{ST Apr-10}}$	0.87		
Arthritica bifurca	43.80$^{\text{ST Apr-11}}$	43.80$^{\text{ST Apr-11}}$		
Austrovenus stutchburyi			-1.11	-1.51
Cossura consimilis	281.87$^{\text{ST Apr-00}}$	281.87$^{\text{ST Apr-00}}$	281.87$^{\text{ST Apr-00}}$	281.87$^{\text{ST Apr-00}}$
Hemiplax hirtipes				
Heteromastus filiformis				
Linucula hartvigiana	-47.32$^{\text{ST Jan-09}}$	-0.89	-0.95	-0.85
Macomona liliana	-0.15	-0.16	-0.2	
Nemertea	10.39$^{\text{ST Apr-10}}$	10.39$^{\text{ST Apr-10}}$	0.15	
Notoacmea scapha	-0.05		-0.13	
Oligochaetes	10.64$^{\text{ST Apr-08}}$	0.11		
Owenia petersenae			0.11	
Paracalliope novizealandiae	*0.002*	0.04		
Perinereis vallata	0.03	0.04		
Polydorids	-21.55$^{\text{ST Jan-00}}$	-21.55$^{\text{ST Jan-00}}$	-21.55$^{\text{ST Jan-00}}$	-21.55$^{\text{ST Jan-00}}$
Prionospio aucklandica				-1.18
Scoloplos cylindrifer		0.03		
Torridoharpinia hurleyi				

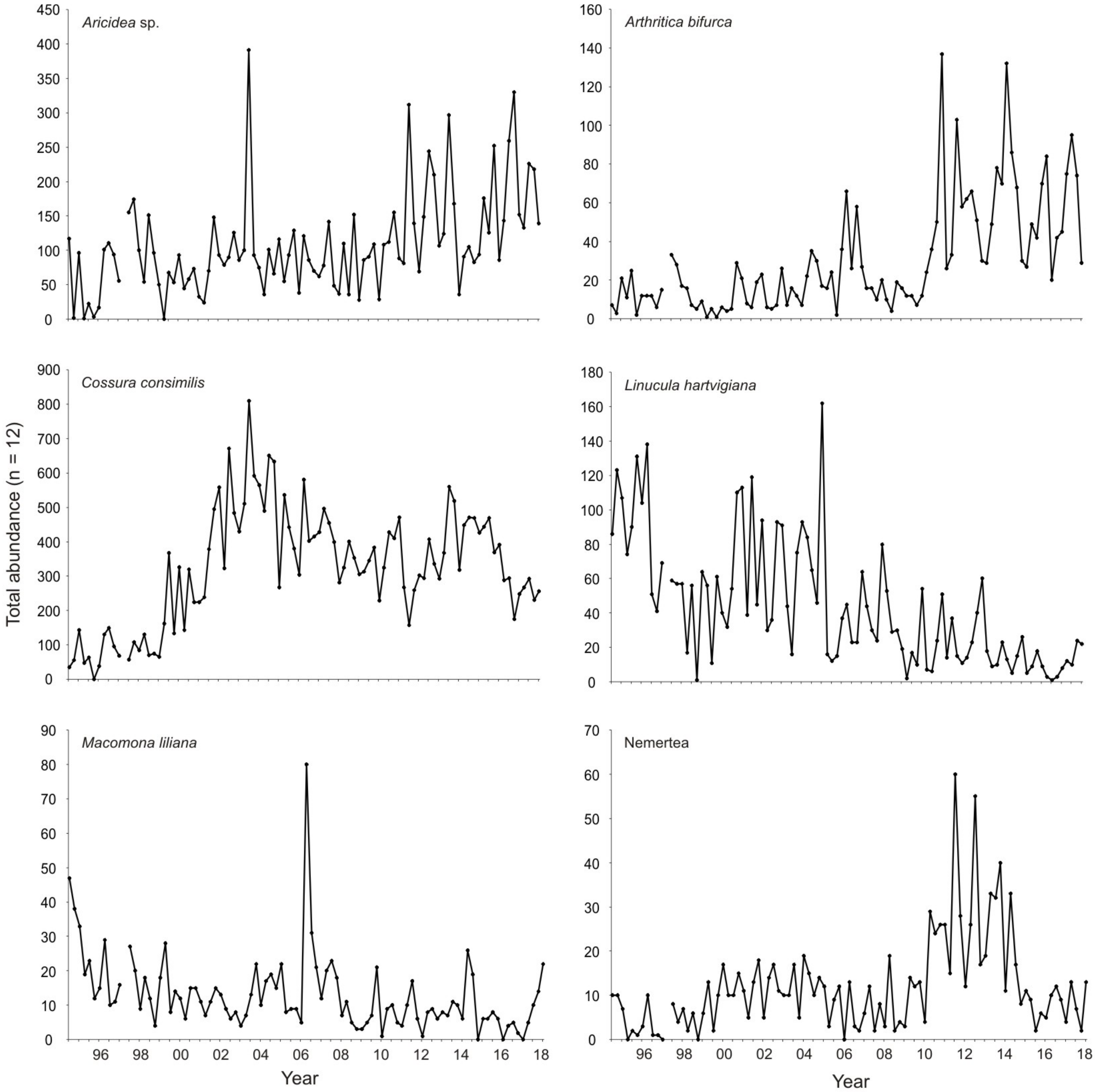

Figure 19 Monitored taxa at Te Kapa Inlet displaying increasing (*Aricidea* sp., *Arthritica bifurca*, *Cossura consimilis*, Nemertea) and decreasing (*Linucula hartvigiana* and *Macomona liliana*) linear trends in abundance of over the monitoring programme

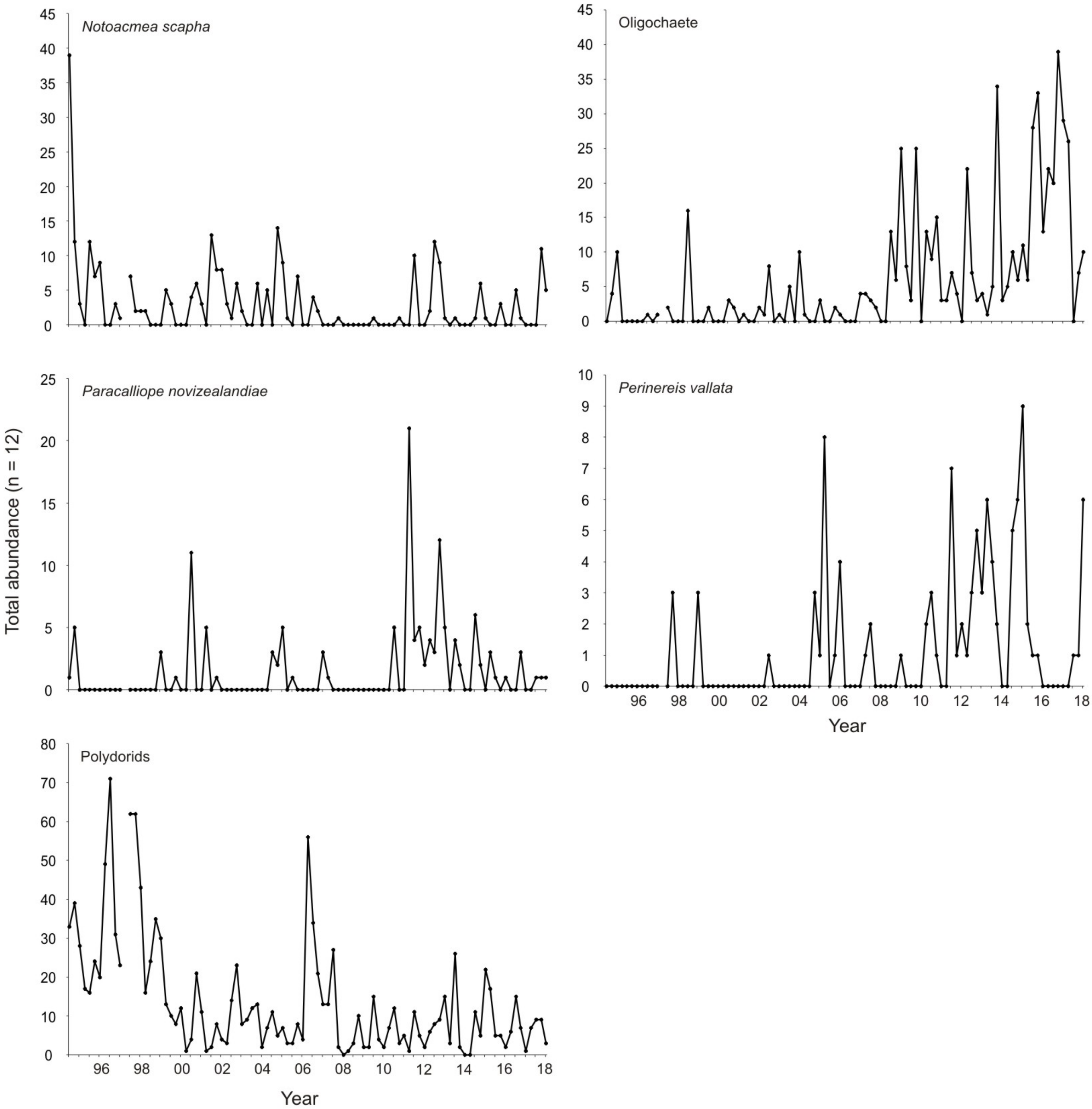

Figure 20 Monitored taxa at Te Kapa Inlet displaying increasing (Oligochaetes, *Paracalliope novizealandiae*, *Perinereis vallata*) and decreasing (*Notoacmea scapha*, Polydorids) linear trends in abundance over the monitoring programme.

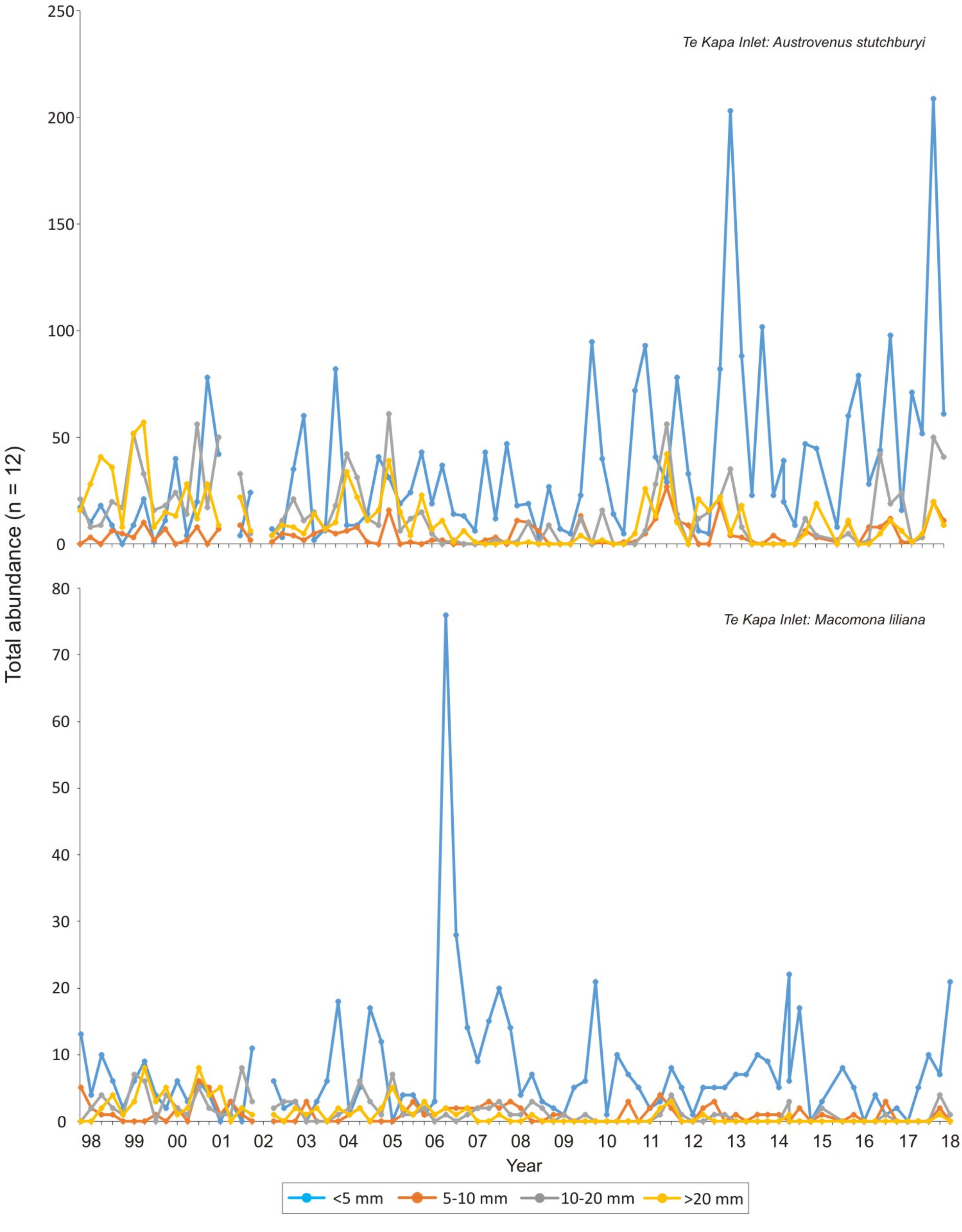

Figure 21 Size class structure of monitored bivalves *Austrovenus stutchburyi* and *Macomona liliana* at Te Kapa Inlet between July 1997 and January 2018.

3.3 Are species abundances exhibiting similar patterns or trends at all sites?

There were some consistent trends and patterns in the abundance of monitored taxa over the six sites monitored in Mahurangi Estuary (Table 13).

Table 13 Comparison of trends in abundances of monitored taxa at all sites in 2018. Numbers are the size of change and a date indicates a step trend. SS = strong preference for sand, S = prefers sand, I = prefers some mud but not in high percentages, MM = strong mud preference

Monitored taxa	Preference	CB	DC	HL	JB	MH	TK
Oligochaetes	MM	↑	↑	↑	↑	↑	↑
Aricidea sp.	I	No trend	↑	↑	↑	↑	↑
Arthritica bifurca	I	↓	↑	No trend	↑	↑	↑
Cossura consimilis	I	↓	No trend	↑	↑	↑	↑
Hemiplax hirtipes	I	↑	↑	No trend	No trend	↑	No trend
Heteromastus filiformis	I	No trend	↓	No trend	↑	↑	No trend
Nemertea	I	No trend	No trend	↑	↑	↑	↑
Perinereis vallata	I	No trend	No trend	↓	No trend	No trend	↑
Prionospio aucklandica	I	No trend	↑	↑	↑	No trend	No trend
Polydorids	I	No trend	No trend	↓	No trend	No trend	↓

Monitored taxa	Preference	CB	DC	HL	JB	MH	TK
Austrovenus stutchburyi	S	No trend	No trend	↓	↑	↑	No trend
Macomona liliana	S	No trend	↓	↓	↓	↓	↓
Linucula hartvigiana	S	No trend	↓	↓	↓	↓	↓
Owenia petersenae	S	No trend	No trend	No trend	No trend	No trend	No trend
Paracalliope novizealandiae	S	No trend	No trend	No trend	↑	No trend	↑
Scoloplos cylindrifer	S	↑	↑	↓	No trend	No trend	No trend
Torridoharpinia hurleyi	S	No trend	No trend	No trend	↑	No trend	No trend
Aonides trifida	SS	No trend	No trend	No trend	↓	No trend	No trend
Notoacmea scapha	SS	No trend	↓	No trend	No trend	No trend	↓

There has been an increasing trend in the abundance of Oligochaetes at all sites. There are also increasing trends in *Aricidea* sp. (Figure 22) at all sites except CB, *Arthritica bifurca* at all sites except HL, *Cossura consimilis* at HL, MH and TK (Figure 22), *Hemiplax hirtipes* at CB, DC and MH, Nemertea at JB, MH and TK, and *Prionospio aucklandica* at DC, HL and JB (Table 13). These species are all considered to be mud tolerant (Table 2), with Oligochaetes having a strong preference for mud (Gibbs and Hewitt 2004). There have also been consistent decreasing trends in abundances of *Macomona liliana* and *Linucula hartvigiana* at all sites except CB (Figure 23). These species have a preference for sand (Table 2).

The mud tolerant species Nemertea, Polydorids and *Prionospio* are the only species displaying multi-year cycles in abundance across multiple sites, and timing of these cycles is fairly consistent (examples; Figure 24). *Linucula* abundances at CB, MH and TK are displaying consistent recruitment peaks in October/January each year and also step trends that occur around the same time at multiple sites (Table 13).

Eleven step trends in the abundance of eight taxa were detected as occurring in 1999/2000 at all but CB; although the majority of these occurred at HL. No similar degree of change has occurred over the monitoring period. A number of step trends were detected in 2008/2009 (6) and 2010/2011 (8); these were dominated by decreases in *Linucula*.

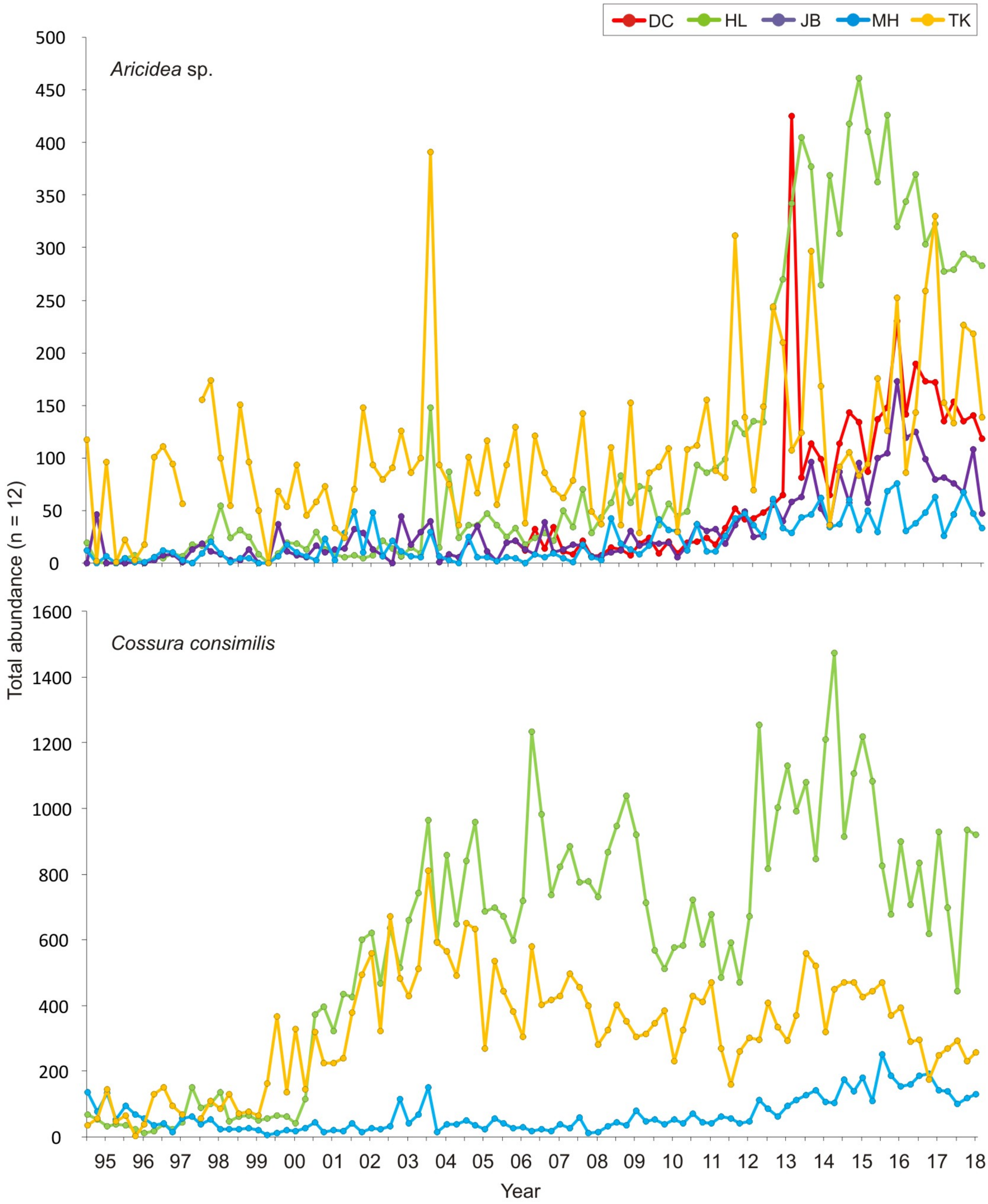

Figure 22 Similar trends of increasing abundances of *Aricidea* sp. and C*ossura consimilis* across multiple sites between July 1994 and January 2018.

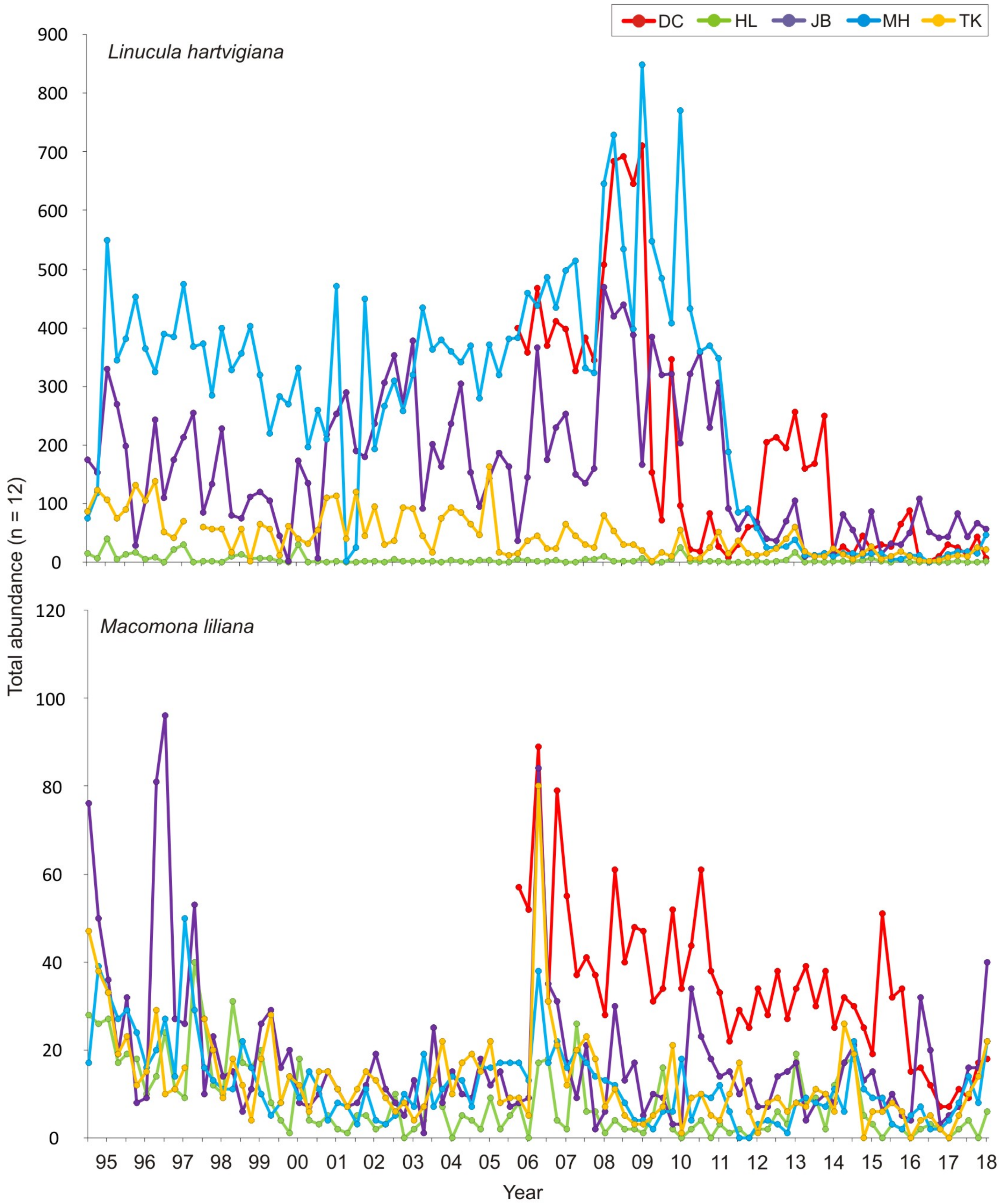

Figure 23 Similar trends of decreasing abundances of *Linucula hartvigiana* and *Macomona liliana* across multiple sites between July 1994 and January 2018.

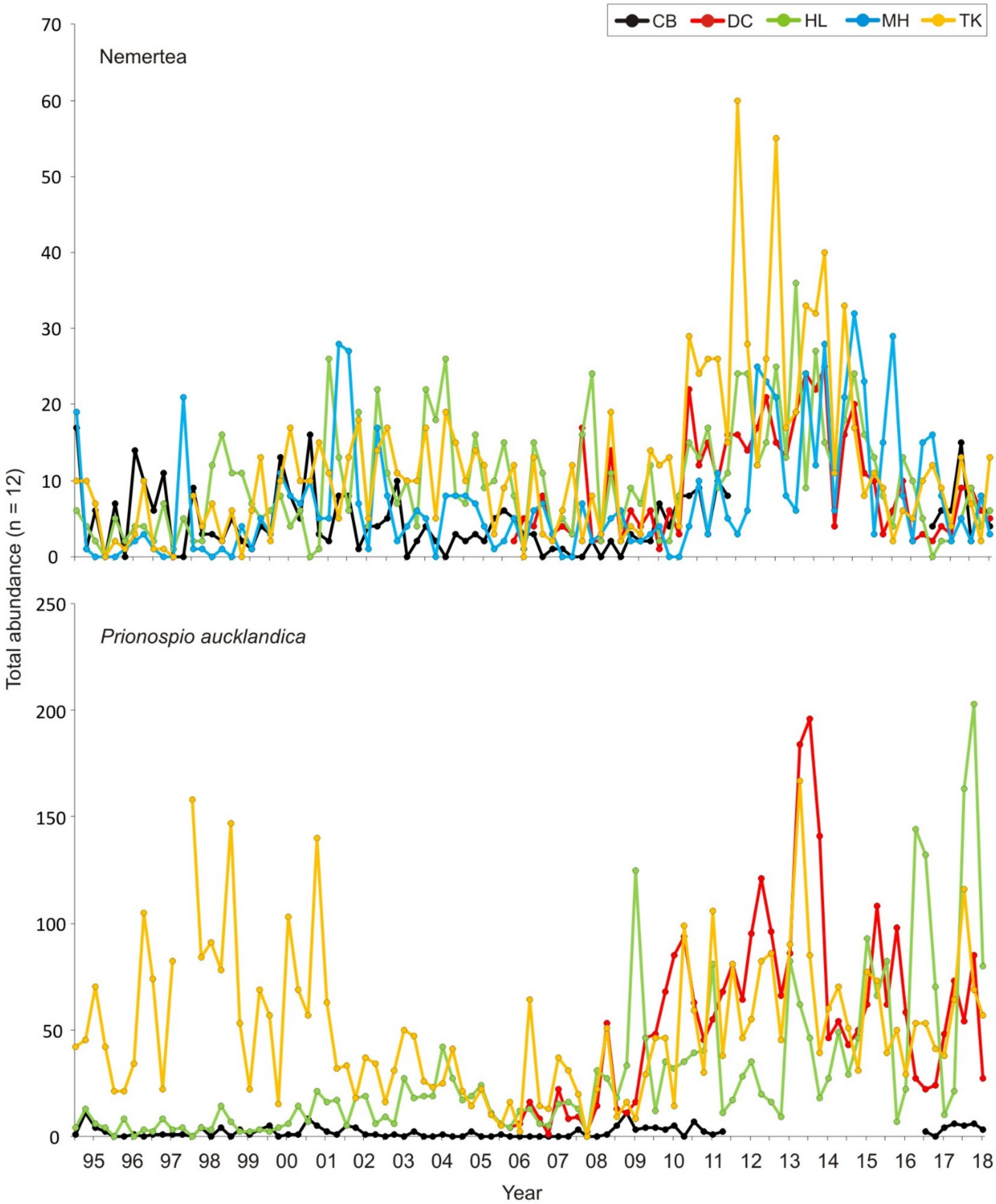

Figure 24 Similar multi-year cycles in the abundances of Nemertea and *Prionospio aucklandica* across multiple sites between July 1994 and January 2018.

3.4 Have any changes in sediment characteristics, or macrofaunal communities, led to sites becoming more or less similar to each other?

3.4.1 Changes in sediment characteristics

Within the last three years, the sediment characteristics at all sites have remained relatively stable, with little change in the variability within and between sites. There have been no recent consistent estuary-wide trends or changes in sediment characteristics. However, the sediment grain size composition of the original intertidal sites continues to contain a higher proportion of fine sand and a lower amount of medium sand compared with the very early years of monitoring.

3.4.2 Changes in communities

A non-metric Multidimensional Scaling analysis (MDS) was conducted on all monitored taxa collected from all monitored sites in the month of October from 1994 until 2017 (Figure 25). The MDS ordination plot shows the relative positions of the sites' communities, represented by the monitored taxa, and the temporal change in these communities, over the monitored period. The closer the points are in ordination space, the more similar the community composition.

All sites, except CB, show a movement towards the right hand side over time (Figure 25). At most sites a change is apparent between the early monitoring period (1994-2000) and post 2000, similar to the step trends observed for many of the taxa (Figure 27). This change is most marked for HL and TK, but also occurs for CB and MH. All four of these sites continue to show change over time post 2000, but this is most marked for CB and MH. JB communities between 1994 and 2000 occupy a central position with communities then moving to the left of the ordination plot and downwards, before moving across to the right in 2009/2010.

Within site comparisons (confirmed using SIMPER analysis) show that macrofaunal communities within each site over the whole monitoring period range between 66% (CB) and 47% (JB) similar. This can be seen graphically in Figure 25, where points for sites CB are more tightly clustered (similar) and more stable, while those for the communities at site JB are more spread out. TK and DC are more tightly clustered (63% and 59% similarity, respectively) than MH and HL which are more spread out (55% and 52% similarity, respectively). HL was more spread out between October 1994-1999 but has become more stable and tightly clustered since October 2000.

When comparing macrofaunal community composition between sites over time, communities at TK and CB are the most similar to each other (53%), mostly due to the high average abundances of *Cossura consimilis*, *Aricidea* sp. and *Heteromastus filiformis* at both locations. Communities at TK are also similar to those at HL (49% similarity) (Figure 25).

All of the communities except JB have remained similar to those noted when we last reported on this monitoring programme three years ago (Figure 25). There has been a recent shift in the community composition at site JB towards a community similar to site TK.

The community sampled at CB in October 2016 shifted drastically and was similar to the community at site TK. This shift in community structure was not maintained and was due to lower than usual abundances of *Torridoharpinia*, and higher abundances of Oligochaetes, which are common at TK. The community sampled in October 2017 was similar to the communities observed prior to 2010. Overall the community exhibits relatively little variability over time compared to sites MH and JB for example.

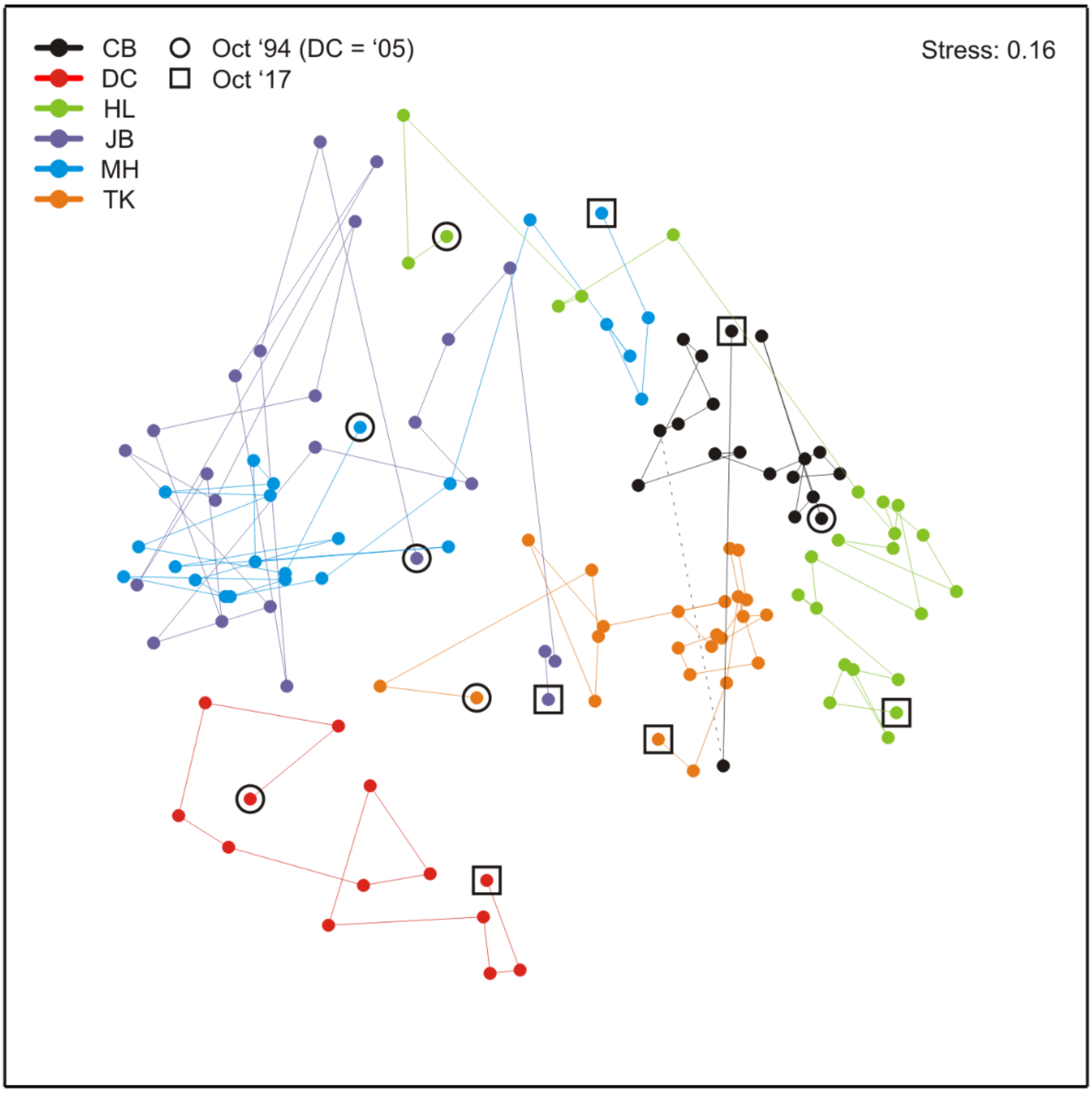

Figure 25 Non-metric Multidimensional Scaling Plot (MDS), displaying the yearly temporal variation in the monitored taxa community composition at each site over the monitored period (October dates only). For each site, the positions of the community on the first October (1994 for all sites except DC which is 2005) and the most recent October (2017) sampling occasions are represented by open circles and squares, respectively. The dashed line between CB October 2010 and October 2016 indicates that sampling was put on hold. CB = Cowans Bay; DC = Dyers Creek; HL = Hamilton Landing; JB = Jamieson Bay; MH = Mid Harbour; TK = Te Kapa Inlet.

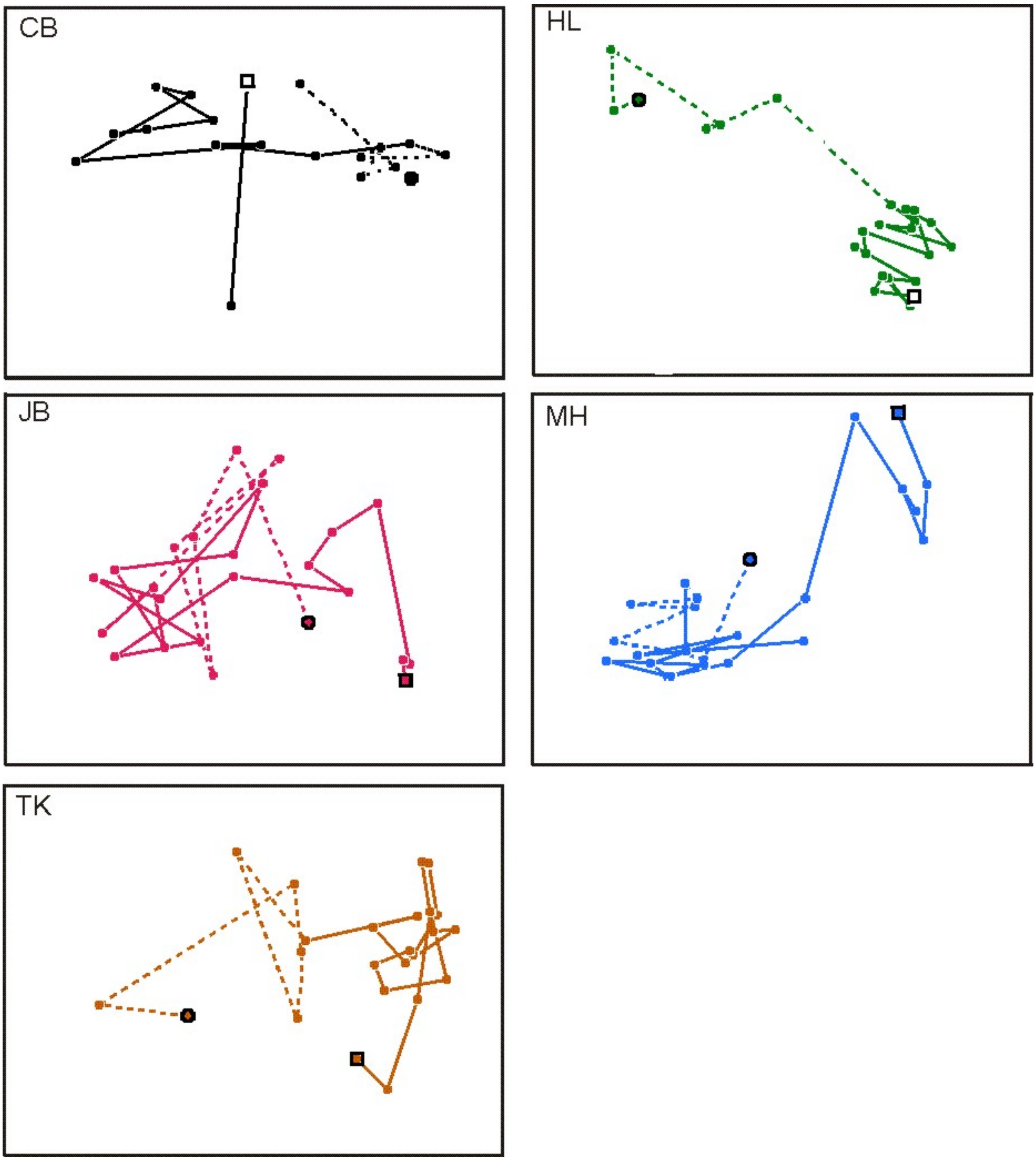

Figure 26 An expansion of Figure 25 for sites sampled from 1994 to 2017. The temporal track of community composition between 1994 and 2000 is shown by a dashed line, post this by a solid line.

4.0 State of the Environment Indicators

4.1 Traits Based Index

The Traits Based Index (TBI) was applied to all macrofaunal community data for every October since sampling began (October 1994-October 2017) (Figure 27). The index was developed to assess the functional redundancy of benthic communities as an indicator of resilience (van Houte-Howes & Lohrer 2010; Lohrer & Rodil 2011). TBI is based on seven broad trait categories and generates a value between 0 and 1. TBI scores <0.3 indicate low levels of functional redundancy and highly degraded sites (Group 3), scores of 0.3-0.4 indicate intermediate conditions (Group 2), and scores >0.4 indicate high levels of functional redundancy (Group 1) (Hewitt et al. 2012).

The functional redundancy/resilience of communities sampled at all monitored sites has improved over the monitored period (difference between first sampling and most recent sampling) (Figure 27, Figure 14). The largest change from start to end is observed at sites JB and MH (difference of 0.18), followed by site DC (0.15), CB (0.12), HL (0.10) and then TK (0.01). The only significant trends observed are for HL and JB.

The community at site JB has the greatest ecological functionality across sites, with a TBI score of 0.89 in October 2017. As suggested by Cummings et al. (2016), this may be in part due to the heterogeneous nature of the sediment at this site and the tidal height it encompasses, thus having a more diverse community composition (Cummings et al. 2016). Compared to scores calculated for October 2014 (October 2010 for site CB), in October 2017 all sites except HL still have good ecological functionality and a high resistance to change (scores >0.4, Group 1). Site HL, with a score of 0.39, only just falls into the group 2 'intermediate' category. However the TBI score for this site has been poor in previous years (Appendix E; Octobers 1994, 1998, 1999, 2001, 2003, 2007, 2009) and is displaying a significant increase over time. There are slight decreases in the TBI scores between October 2014 (October 2010 for CB) and October 2017 at all sites except for JB. However, they are not large changes and the communities are still maintaining their "good" grouping. Generally scores of <0.3 would be concerning and would indicate a strong reduction in functional redundancy.

Table 14 TBI scores for communities sampled in October 2014 (* = October 2010) (Cummings et al. 2016) for all sites and the most recently sampled October 2017 . Additionally, the total difference in TBI scores between October 2017 and the first October sampled at each monitored site (October 2005 for DC, October 1994 for all other sites) is also presented (a positive change in TBI score = increase in functional redundancy). Blue = good functional health (Group 1; TBI score >0.4) and yellow = intermediate functional health (Group 2; TBI score 0.3-0.4). Red colouring indicating poor functional redundancy and resilience (Group 3; TBI score <0.3) is not represented.

	TBI score		
Site	Oct-14	Oct-17	Total change
CB	0.47*	0.45	0.12
DC	0.57	0.53	0.15
HL	0.56	0.39	0.10
JB	0.85	0.89	0.18
MH	0.52	0.45	0.18
TK	0.57	0.51	0.01

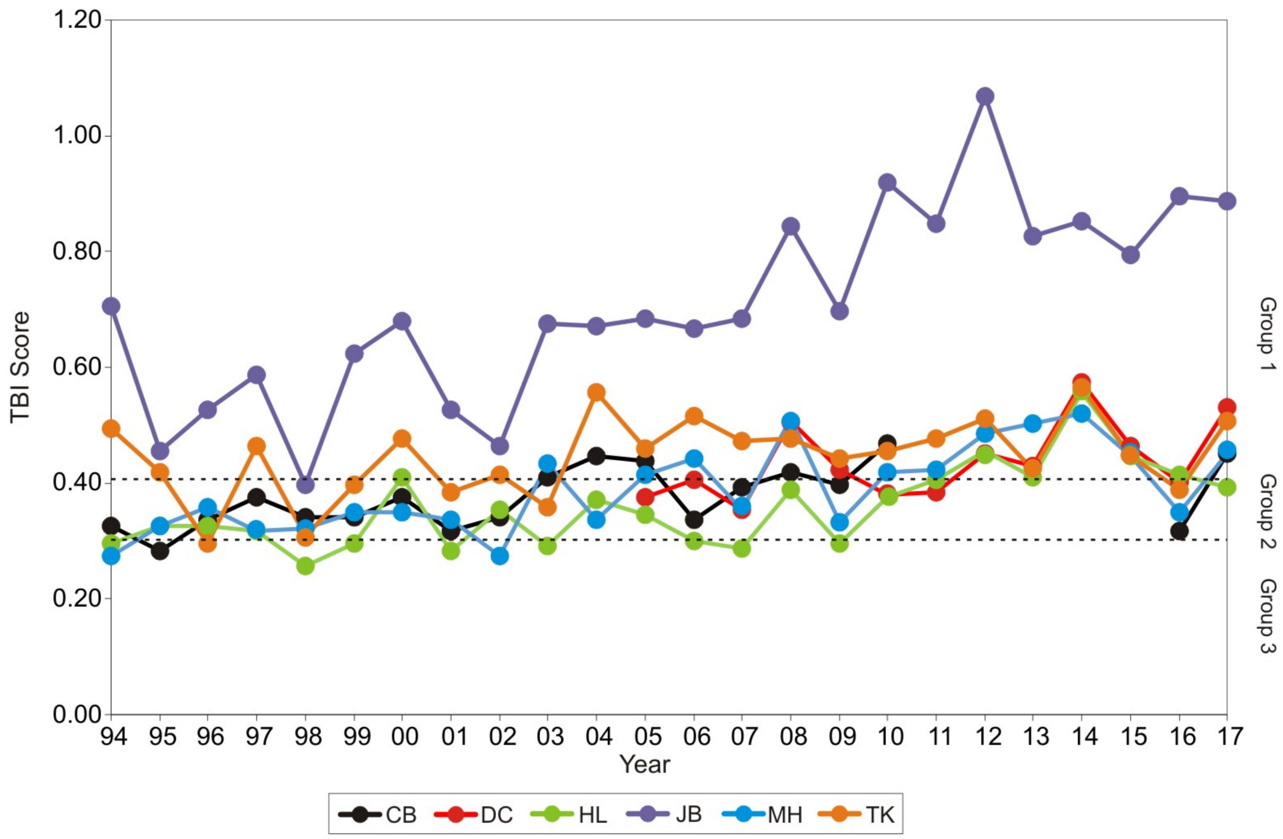

Figure 27 TBI scores (October 1994-October 2017) for the six monitored sites in Mahurangi Estuary TBI scores are calculated from the entire macrobenthic fauna, not just monitored taxa found at each site. Dotted lines show TBI health group thresholds; 1 = good functional redundancy/resilience, 2 = intermediate functional redundancy, 3 = Low functional redundancy

4.2 Benthic Health Model

The BHMmetals and BHMmud models evaluate the health of macrobenthic communities relative to storm water contaminants (total sediment copper, lead and zinc concentrations), and sediment mud content, respectively (Anderson et al. 2006; Hewitt & Ellis 2010). Increases in BHMmetals and BHMmud scores indicate a decrease in benthic health. See Section 2.5.2 for information about how these indices are calculated.

Assessing all monitored and non-monitored taxa from all October sampling occasions (1994-2017), the BHMmetals values are poor to moderate (Groups 4 and 3, respectively) for sites CB, HL and MH, generally moderate (Group 3) for TK, and moderate to good health (Groups 3 and 2, respectively) for sites DC and JB which is consistent with that last reported by Cummings et al. (2016) (Appendix E, Figure 28). The BHMmetals score for the community at site CB is larger than the score calculated in October 2010 and has moved into the poor health group from the moderate health group, although it has also done this on past occasions. A trend of increasing BHMmetal scores is apparent for DC and possibly for HL.

Site HL is the muddiest site, and DC and JB were the least muddy (Figure 2), which corresponds to the BHMmud scores presented. The newly reinstated site CB has a BHMmud score most similar to site HL, and both sites have fluctuated between poor and moderate health groups (4 and 3, respectively) over time, and recently have been of poor health (Appendix E, Figure 28). The BHMmud scores at site CB since sampling was reestablished are some of the highest at this site over the monitored period, and are similar to those for Octobers of 2000 and 2002 (Figure 28). The BHMmud score for TK has remained stable with moderate health (group 3) since 1996. JB generally exhibits good BHMmud scores (group 2), however between October 2014 and October 2016 moderate health levels (group 3) were maintained.

Cummings et al. (2016) reported an increasing trend in BHMmud scores at sites DC and MH (a move towards poorer health), which has persisted with the additional three years of data. This trend has led to site DC declining from very good health in 2013, to moderate health in 2015, and remaining on the threshold between moderate and good health groups in 2017 (Figure 28). Site MH moved from the moderate to poor health groups in 2015 and 2016, and in 2017 is on the threshold between moderate and poor health (Figure 28). Trends of increasing BHMmud scores are also obvious at HL, and possibly at JB.

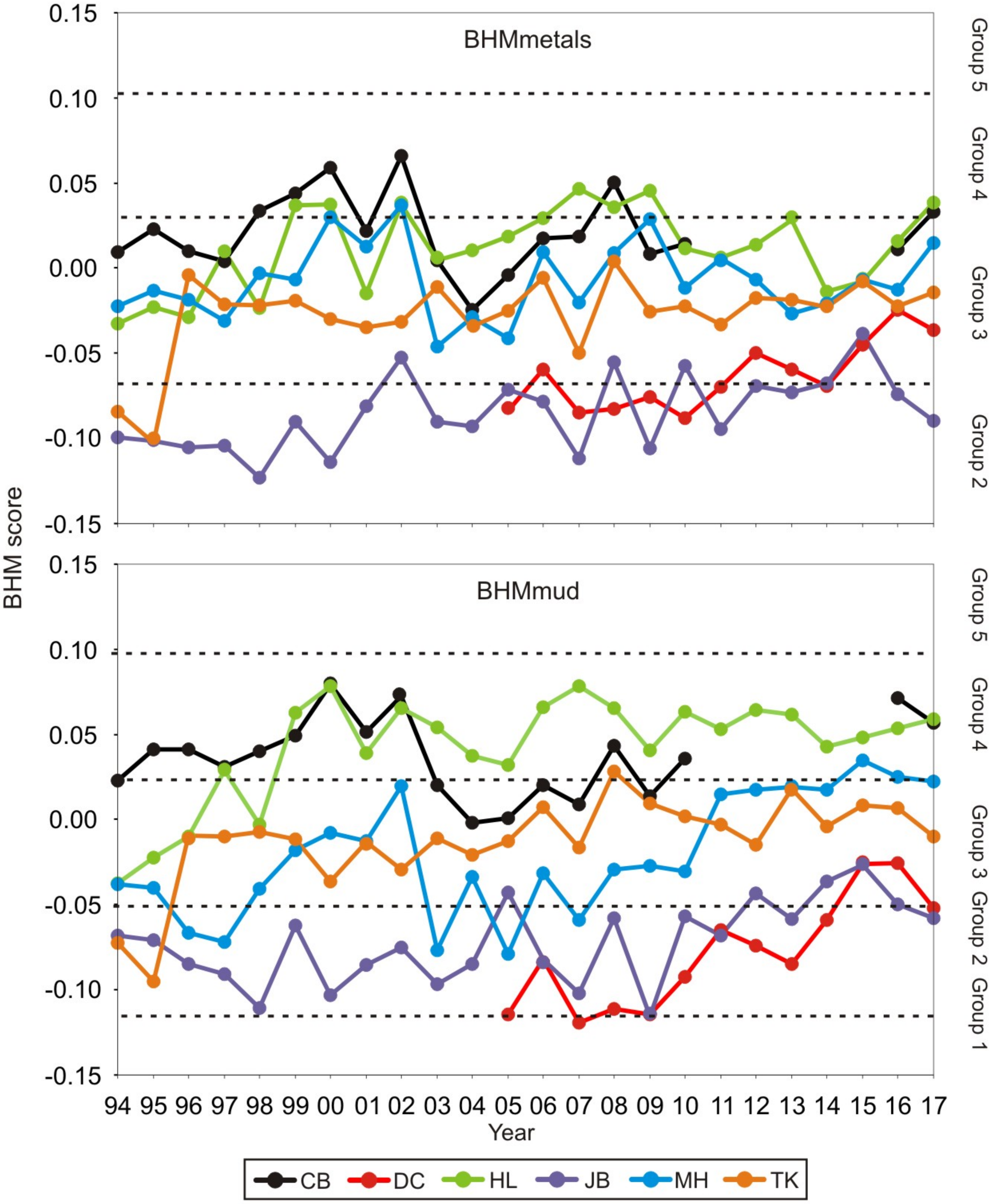

Figure 28 BHM scores for storm-water contaminants (BHMmetals) and mud content (BHMmud) for all Octobers since the beginning of monitoring . Health groups are given for each BHM, Group 1 = very good health, Group 2 = good, Group 3 = moderate, Group 4 = poor and Goup 5 = unhealthy. Note that the threshold for group 1 (very good health) for BHMmetals is -0.16 and is below the minimum limit of the y-axis and is therefore not displayed.

4.3 Combined Health Index

The Combined Health score for each of the monitored sites was calculated using the TBI and Benthic Health scores (see Combined Indices 2.5.3 for explanation; Appendix E). A decrease in the combined health score indicates an increase in site health. The combined scores calculated for data collected in October 2017 show that sites CB and JB have good health (green), DC, MH and TK have moderate health (yellow) and site HL has poor health (orange) (Figure 29, Table 15).

The total change in combined health scores at all sites since sampling began is promising, with four of the six sites improving in health (Table 15, Appendix E). CB is the most improved site with a difference between the initial sampling and October 2017 of -0.36, and has shifted from poor health to good health (Table 15), although the site has been variable over time (ranging from unhealthy to good, Appendix E). Site MH is also variable over time generally moving between poor to moderate health. Site DC is generally of moderate health, although occasionally it exhibits good health. Site HL generally exhibits poor health, while JB varies between moderate and good. Site TK was healthier on the first two sampling occasions (good health); since then it has generally only achieved moderate health.

Table 15 Benthic Health Model scores for storm water contaminants (BHMmetals) and mud content (BHMmud), and the Combined Health scores for all sites, sampled October 2017. Additionally, the difference between October 2017 and when last reported (October 2014, or * October 2010), and the total difference between October 2017 and the first October sampled at each monitored site (October 2005 for DC, October 1994 for all other sites) for each index is presented. A positive change in BHM or Combined score = decrease in site health. Green = good health (Group 2); yellow = moderate health (Group 3); orange = poor health (Group 4). Groups 1 (extremely good health, blue) and 5 (unhealthy, red) are not represented.

	BHMmetal			BHMmud			Combined score		
Site	Oct-17	Change since last report	Total Change	Oct-17	Change since last report	Total Change	Oct-17	Change since last report	Total Change
CB	0.033	0.019*	0.024	0.057	0.021*	0.034	0.33	-0.25*	-0.36
DC	-0.037	0.033	-0.084	-0.052	0.007	0.063	0.44	0.07	-0.05
HL	0.039	0.053	0.071	0.059	0.016	0.097	0.67	0.09	-0.06
JB	-0.090	-0.022	0.010	-0.058	-0.021	0.010	0.38	-0.07	0.00
MH	0.015	0.035	0.037	0.022	0.004	0.060	0.58	0.07	-0.16
TK	-0.014	0.009	0.070	-0.010	-0.006	0.063	0.51	0.00	0.13

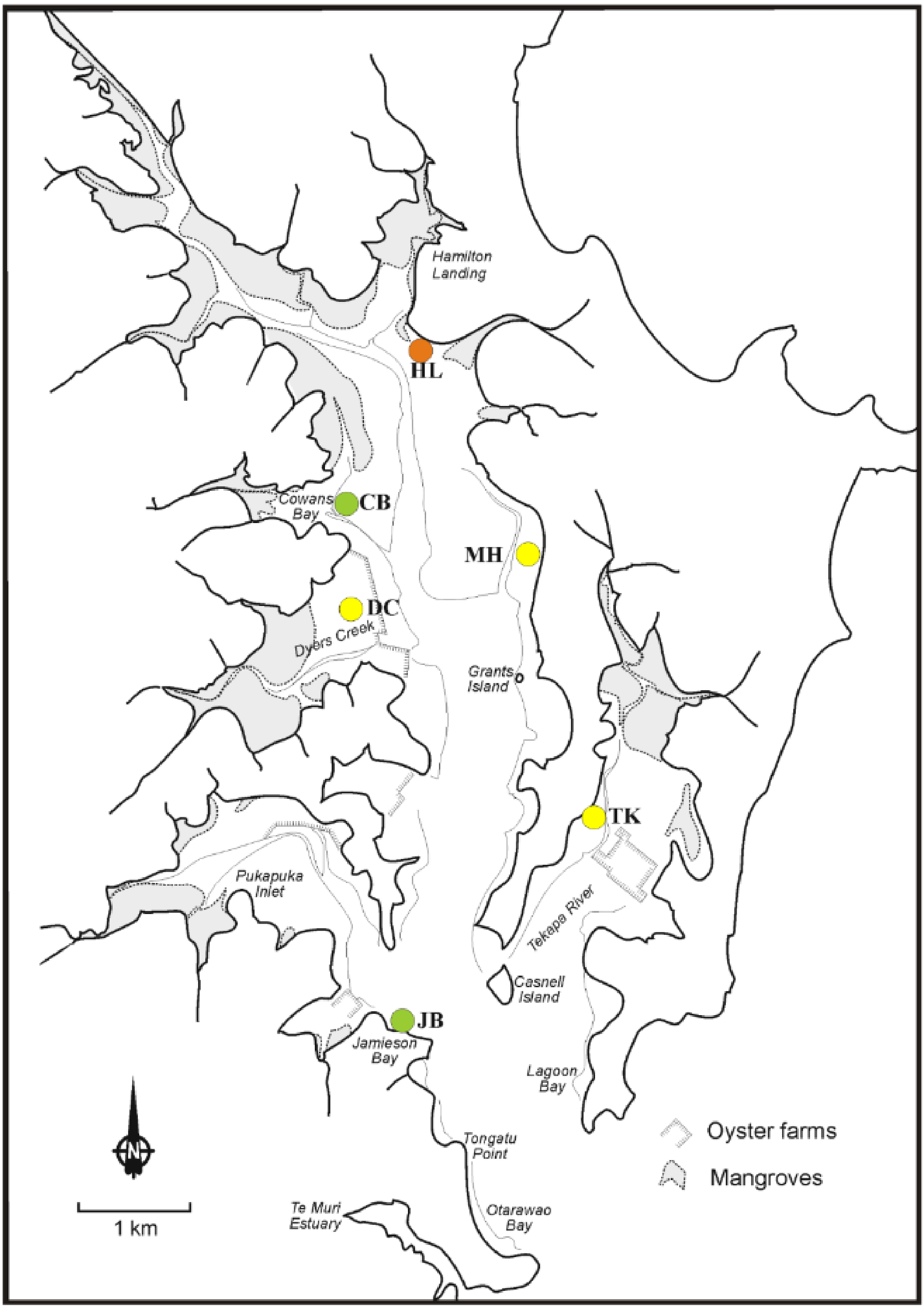

Figure 29 Map of Mahurangi Estuary displaying the Combined Health scores (calculated using the BHM and TBI) for all monitored sites The colours green, yellow and orange translate to good, moderate and poor health, respectively.

5.0 Conclusions

Long-term ecological monitoring was established in Mahurangi Harbour in 1994 (Cummings et al. 1994). Estuary-wide changes in the abundance of some macrofaunal taxa and the horse mussel *Atrina zelandica*, and increases in the proportion of fine sand present in the sediments, were noted over the initial six years of monitoring (Cummings et al. 2001, 2003). An independent peer review of these findings concluded that there were (i) very broad scale (estuary wide) declines in the abundance of some sedimentation-intolerant taxa, and (ii) general increases in the abundance of other groups, and that (iii) these changes are consistent with a model of large scale increases in sedimentation and benthic resuspension across the estuary (ARC 2004).

With ongoing monitoring and additional data points, it was established that the changes observed in earlier monitoring years were 'step' changes in abundance, where the mean abundances before and after the event are significantly different. These step changes were still consistent with those predicted in response to an increase in sediment mud content, given our knowledge of species sensitive to mud (Halliday and Cummings 2009). This report provides an update on the ecological health of Mahurangi Harbour following these step changes.

5.1 Have there been any new changes in the environmental characteristics of each monitored site?

There has been minimal change in the sediment characteristics of the six monitored sites in recent years. Seven statistically significant trends in sediment particle size composition, chlorophyll *a* and/or organic content have been observed over all sites (Table 16), which are restricted to Dyers Creek, Hamilton Landing and Te Kapa Inlet sites and are not consistent or large (very low rate of change: slopes range from 0.008 to 0.142). Of note is the significant increase in sediment mud content at Dyers Creek and the decrease in sediment mud content at Te Kapa Mud. No other sites showed significant changes in mud content over the monitored period.

The variability in the sediment characteristics measured is generally decreasing over the monitored period, and sites are becoming more stable (Table 5).

5.2 Are there any changes of concern in the monitored benthic communities?

Increasing or decreasing trends of mud sensitive species can potentially be of concern when considering changes in benthic communities. In general, across all sites there have been increases in the abundance of mud tolerant species and decreases in species with a preference for sand. Seven taxa considered sensitive to increased suspended sediment concentrations, sedimentation rates or sediment mud content have changed in abundance (generally decreasing trends, especially for the two species that are most sensitive) (Table 13, Table 16). Nine taxa which prefer intermediate amounts of mud and sand have changed (generally increasing abundances), and one taxa with a preference for muddy sediments has increased in abundance (Table 13). While some of these changes occurred around 1999/2000, changes in abundances of some taxa are ongoing at all sites.

The combined health scores indicate little change in health at all sites over the monitored period. Cowans Bay has showed some improvement from poor to good health, but is generally variable. The Dyers Creek and Mid Harbour sites continue to be in moderate health, and the Hamilton Landing site has remained in the poor health category. The site at Jamieson Bay has shown no change in health score when compared with initial sampling (good health). The site at Te Kapa Inlet is the only site demonstrating a slight degradation in overall health with a shift from good to moderate health (Table 16).

Cowans Bay is the site of least concern, with no decrease in the abundance of mud sensitive species and increases in the abundance of only three species that prefer some mud. Another site where there are few signs of immediate concern is Hamilton Landing. While it is in poor health with changes in abundance of eight species that would be expected to reflect terrigenous sediment impacts, six of these changes occurred prior to 2001.

Table 16 A summary of the important changes in sediment characteristics, trends in abundance and State of the Environment Indicators between 1994 and 2017 (except for DC which is between 2005 and 2017). inc = significantly increased, dec = significantly decreased, the number inside brackets denotes how many species at each site are displaying the trend; imp = Improved, decl = Declined.

	Change in sediment Characteristics				Trends in abundance of monitored taxa		State of the Environment Indicators			
Site	Chla	OC	Sand	Mud	Mud preference	Mud sensitive	TBI	BHM metals	BHM mud	Com-bined Index
CB					inc(1)	inc(1) dec(0)				imp
DC			dec	inc	inc(1)	inc(1) dec(3)		decl	decl	imp
HL	inc	dec			inc(1)	inc(0) dec(4)	imp		decl	imp
JB					inc(1)	inc(3) dec(3)	imp	decl	decl	stable
MH					inc(1)	inc(1) dec(2)			decl	imp
TK		dec	inc	dec	inc(1)	inc(1) dec(3)				decl

The sites of greatest concern are Jamieson Bay and Dyers Creek. Dyers Creek is the only site where an increase in mud content has been observed. *Notoacmea scapha* has a strong preference for sand, and has decreased in abundance at this site. *Macomona liliana* and *Linucula hartvigiana* are known to be sensitive to mud, and these have also decreased in abundance. Altogether there are changes in abundance of eight species that would be expected to reflect terrigenous sediment impacts and increases in contaminant- and mud-indexed health scores (i.e., decreasing health). The site at Jamieson Bay shows similar trends in contaminant- and mud-indexed health scores and changes in abundance of 10 species that would be expected to reflect terrigenous sediment impacts (Table 13, Table 16).

The sites at Mid Harbour and Te Kapa Inlet show some trends that are concerning. At Mid Harbour, there are changes in abundance of nine species that would be expected to reflect terrigenous sediment impacts and an increase in the mud-indexed health score. At Te Kapa Inlet, there are also changes in abundance of nine species that would be expected to reflect terrigenous sediment impacts, but no trends over time in health scores (Table 13, Table 16).

5.3 Do observed changes reflect an estuary-wide change?

There have been consistent trends in the abundance of some monitored taxa at sites across the estuary suggesting estuary wide change (Table 13). Increasing trends in the abundance of *Aricidea* sp. and Oligochaetes are seen at all sites. There are also increasing trends in *Arthritica bifurca* at all sites except Hamiltons Landing, *Cossura consimilis* at Hamiltons Landing, Mid Harbour and Te Kapa, *Hemiplax hirtipes* at Cowans Bay, Dyers Creek and Mid Harbour, Nemertea at Jamiesons Bay, Mid Harbour and Te Kapa, and *Prionospio aucklandica* at Dyers Creek, Hamiltons Landing and Jamieson Bay. These five species are mud tolerant with Oligochaetes having a strong preference for mud. There have also been consistent decreasing trends in abundances of *Macomona liliana* and *Linucula hartvigiana* at all sites except Cowans Bay; both species have a preference for sand.

5.4 Has the reinstated sampling at Cowans Bay revealed any changes of concern that suggests it needs to be monitored more regularly?

Sampling at Cowans Bay was reinstated in July 2016 (Cummings et al. 2016). With the following observations in mind it was determined it was not necessary to continue to monitor Cowan’s Bay regularly after 2018.

Sediment characteristics (particle size, chlorophyll *a* and organic content) remain stable and were less variable in the last two years of sampling than previous data. Multi-year cycles, linear trends and step trends in benthic macrofaunal communities observed are similar to those at other sites (i.e., >10 year cycle of Nemertea, increasing trends in *Aricidea, Arthritica* and Oligochaetes), giving confidence that any significant change that may occur in the five year rest period could be seen when sampling is reinstated. Thirteen of the nineteen monitored taxa are displaying no significant trends at this site. Cowans Bay has the highest within-site similarity and has consistently been dominated by *Cossura, Heteromastus* and *Arthritica*. The combined health scores at Cowans Bay have been variable over time, but have also indicated a shift from poor to good health.

5.5 Summary

This monitoring programme has continued to provide useful information on cycles and trends in monitored taxa populations and sediment characteristics within Mahurangi Estuary. With three more years of data, monitoring continues to show increased abundances of mud tolerant species across all sites, and a general decrease in mud sensitive species. Concerns that were initially generated by the number of changes noted in 1999/2000, still apply particularly in light of the increased abundances of mud tolerant species across all sites, the general decrease in mud sensitive species, and the lack of any recovery post the 1999/2000 changes.

6.0 Acknowledgements

We acknowledge the NIWA Hamilton benthic marine ecology team for conducting fieldwork, macroinvertebrate sorting and identification, and Geoff Read (NIWA Wellington) for confirmation of polychaete taxonomy. The contribution through peer reviewer of Tarn Drylie and Anna Madarasz-Smith is gratefully acknowledged.

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8.0 Plates

Plate 1: The intertidal flat at Cowans Bay (top), with a close up of sediment from within the site (bottom). Photos taken July 2016.

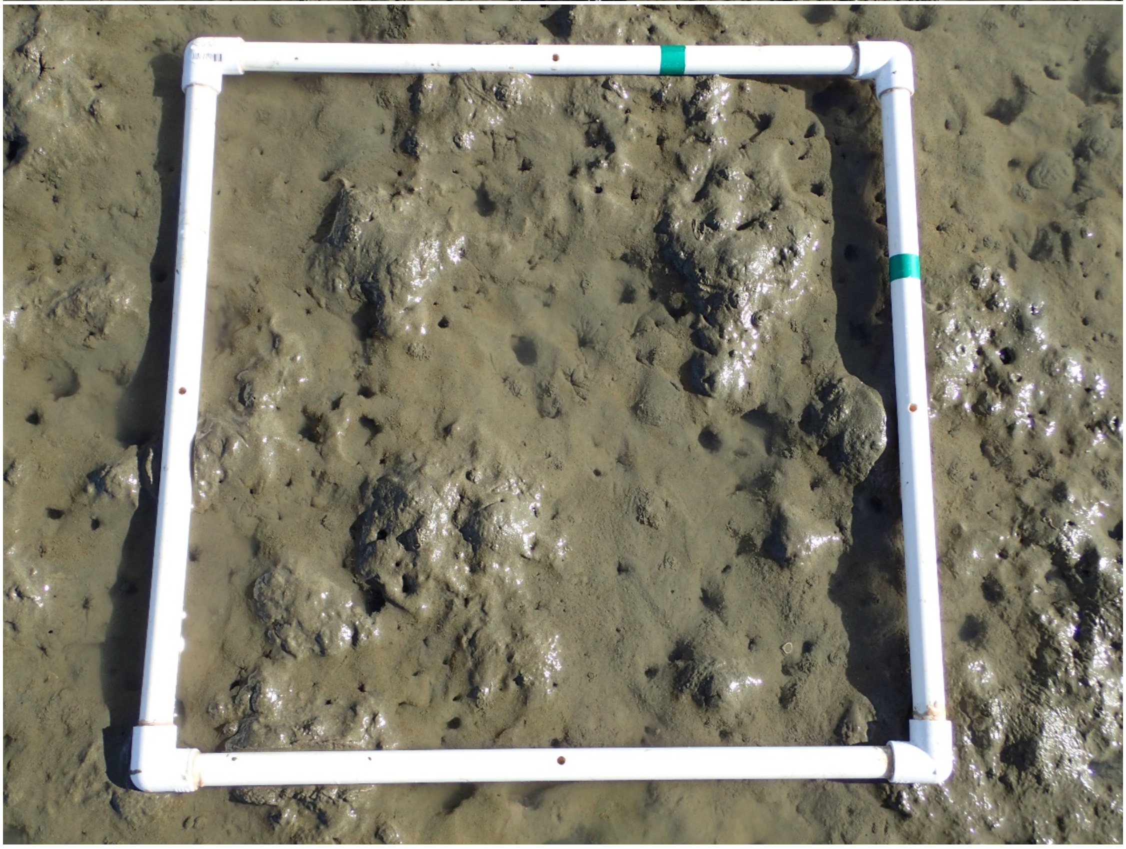


Plate 2: The intertidal flat at Dyers Creek (top), with a close up of sediment from within the site (bottom). Photos taken July 2016 and October 2016.

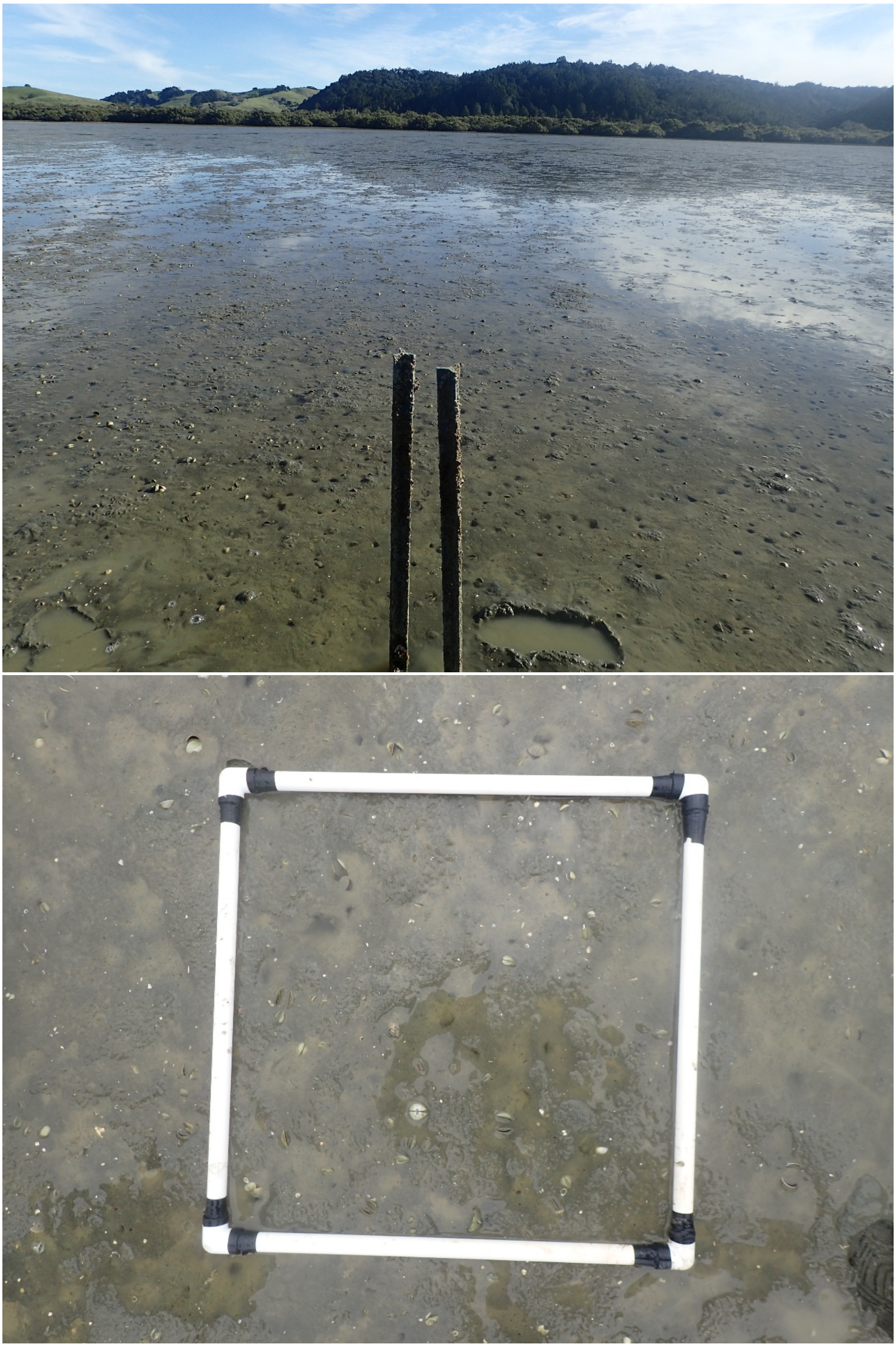


Plate 3: The intertidal flat at Hamilton Landing (top), with a close up of sediment from within the site (bottom). Photos taken July 2016 and April 2016.

Plate 4: The intertidal flat at Jamieson Bay (top), with a close up of the different sediment types within the site (bottom four panels). Photos taken July 2016 and October 2016.

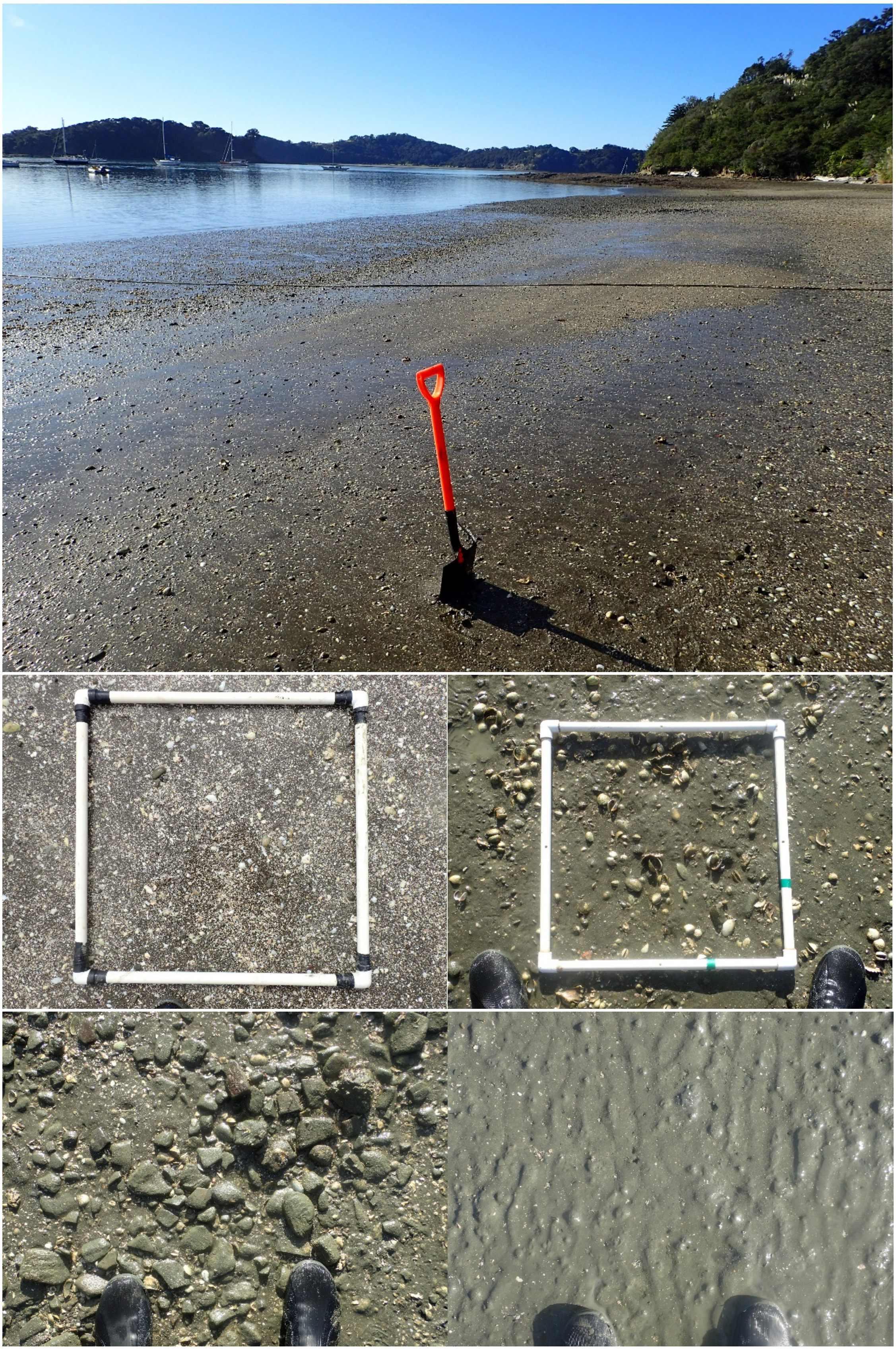
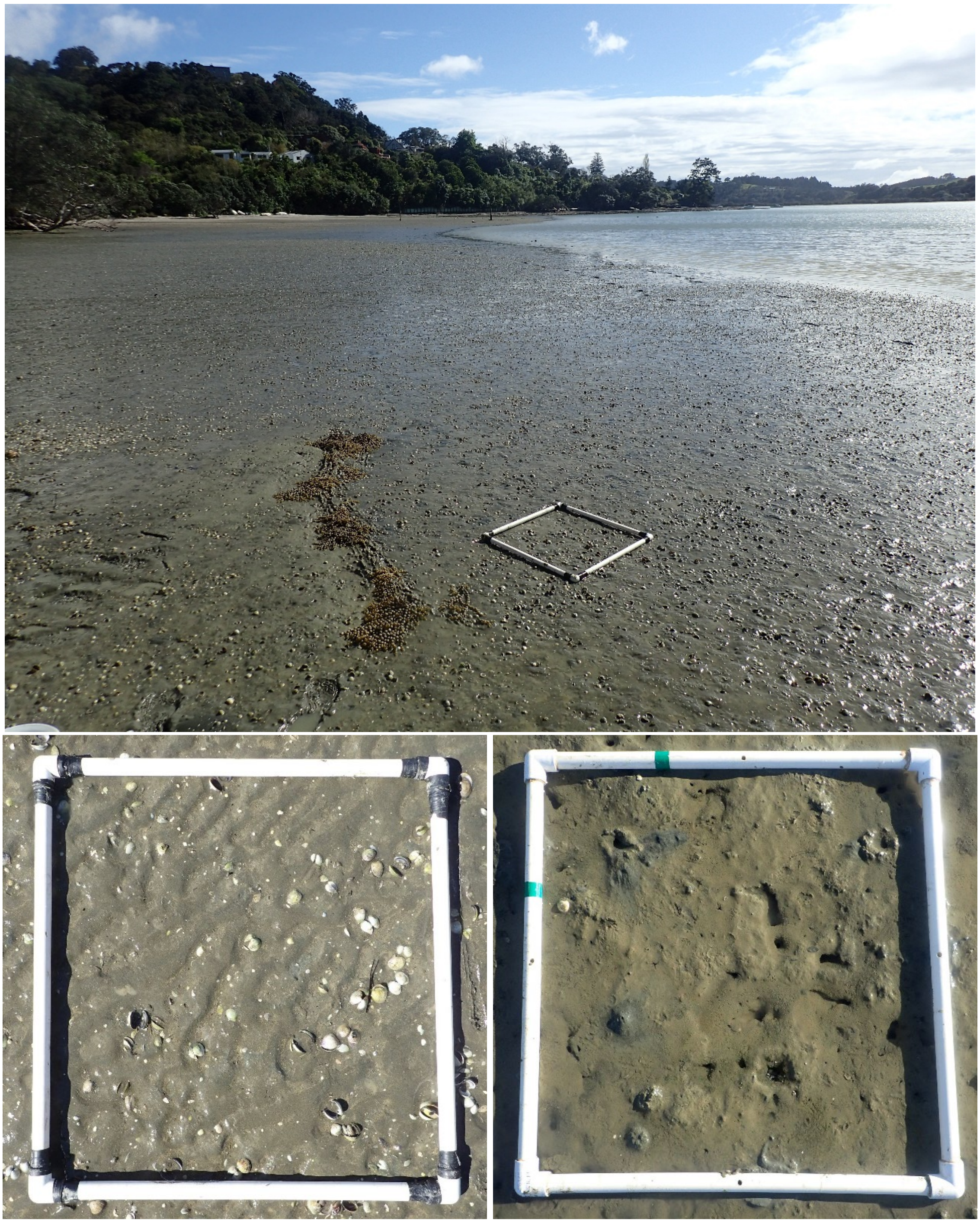


Plate 5: The intertidal flat at Mid Harbour (top), with a close up of sediment from within the site (bottom). Photos taken July 2016.

Plate 6: The intertidal flat at Te Kapa Inlet (top), with a close up of sediment from within the sandy and muddy sections of the site (bottom panels). Photos taken July 2016 and October 2016.

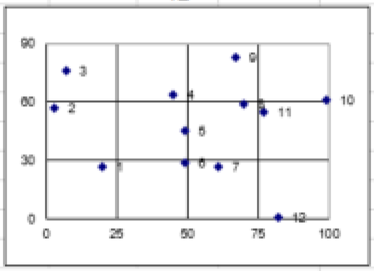


9.0 Appendices

Appendix A: Sampling coordinates

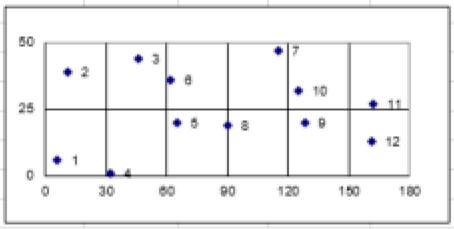
Example site maps displaying the 12 macrofaunal coring positions in January 2018. Each site is divided into 12 equal sectors from which one core is randomly collected from each and is not positioned within 5m from another core collected in the six preceding sampling occasions. Paces along the x and y axis of the site originate from a stake marking the 0, 0m coordinate of each site. Note the need for different sampling coordinates at different shaped sites.

x-coord	y-coord	#	paces x	paces y
20	27	1	20	27
3	57	2	-17	30
7	76	3	4	19
45	64	4	38	-12
49	45	5	4	-19
49	29	6	0	-16
61	27	7	12	-2
70	59	8	9	32
67	83	9	-3	24
99	61	10	32	-22
77	55	11	-22	-6
82	1	12	5	-54



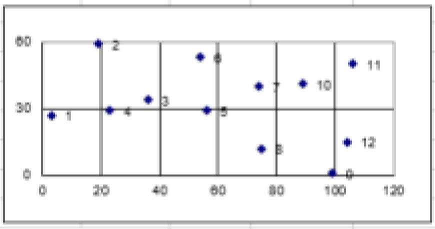
Te Kapa Dyers Crk Cowens Bay
Time = Jan-18

x-coord	y-coord	#	paces-x	paces-y
6	6	1	6	6
11	39	2	5	33
46	44	3	35	5
32	1	4	-14	-43
65	20	5	33	19
62	36	6	-3	16
115	47	7	53	11
90	19	8	-25	-28
128	20	9	38	1
125	32	10	-3	12
162	27	11	37	-5
161	13	12	-1	-14



Hamilton Landing Mid Harbour
Time = Jan-18

x-coord	y-coord	#	paces-x	paces-y
3	27	1	3	27
19	59	2	16	32
36	34	3	17	-25
23	29	4	-13	-5
56	29	5	33	0
54	53	6	-2	24
74	40	7	20	-13
75	12	8	1	-28
99	1	9	24	-11
89	41	10	-10	40
106	50	11	17	9
104	15	12	-2	-35



Jameson Bay
Time = Jan-18

Appendix B: Sediment characteristics

Sediment characteristics including particle size as gravimetric % (G/SH = gravel/shell hash; CS = coarse sand; MS = medium sand; FS = fine sand; VFS = very fine sand; silt; clay and mud (silt+clay)), organic content (OC; %) calculated from loss on ignition and chlorophyll *a* (Chla; g/g sediment) at the intertidal sites on each sampling occasion since July 2000 until January 2018. * = highest recorded value at each site. - = no data where sampling was suspended at site CB between July 2011 and April 2016 and where sampling at DC did not commence until October 2005.

Cowans Bay (CB)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	17.81	1.67	0.07	0.07	0.60	70.18	70.85	29.01*	0.08	29.09
Oct-00	26	23.08*	2.03	0.05	0.06	0.90	71.24	72.20	22.02	5.74	27.76
Jan-01	27	12.40	2.00	0.43	0.14	0.83	72.19	73.16	22.22	4.19	26.41
Apr-01	28	15.54	2.28	0.00	0.06	0.72	77.79	78.57	18.98	2.45	21.43
Jul-01	29	21.21	2.58	0.00	0.51	0.67	71.76	72.94	26.93	0.13	27.06
Oct-01	30	14.01	1.92	0.00	0.00	0.57	80.53	81.10	7.84	11.05	18.89
Jan-02	31	12.23	2.06	0.00	0.02	0.43	81.51*	81.96	17.60	0.44	18.04
Apr-02	32	18.07	2.30	0.02	0.14	0.66	70.34	71.14	22.31	6.53	28.84
Jul-02	33	15.52	2.58	1.63*	4.70*	15.14*	70.72	90.56*	5.68	2.13	7.81
Oct-02	34	14.02	2.94	0.00	0.06	0.52	70.99	71.57	23.51	4.92	28.43
Jan-03	35	12.63	2.13	0.00	0.06	0.95	79.42	80.43	15.15	4.43	19.58
Apr-03	36	12.72	2.01	0.02	0.13	0.65	69.19	69.97	23.21	6.79	30.00
Jul-03	37	13.08	2.00	0.00	0.07	0.44	71.03	71.54	22.25	6.21	28.46
Oct-03	38	14.04	1.88	0.00	0.02	0.49	71.70	72.21	23.60	4.19	27.79
Jan-04	39	10.66	2.27	0.00	0.00	0.69	67.38	68.07	22.54	9.39	31.93*
Apr-04	40	16.65	2.85	0.00	0.00	0.56	72.59	73.15	15.66	11.19	26.85
Jul-04	41	15.13	2.97	0.00	0.00	0.38	68.43	68.81	23.17	8.02	31.19
Oct-04	42	11.02	3.18	0.02	0.06	0.61	68.08	68.75	24.99	6.25	31.24
Jan-05	43	12.28	1.74	0.00	0.00	0.92	71.24	72.16	18.56	9.28	27.84
Apr-05	44	10.80	1.70	0.00	0.07	0.40	70.70	71.17	23.39	5.44	28.83
Jul-05	45	13.57	2.40	0.00	0.08	0.93	71.32	72.33	19.60	8.07	27.67
Oct-05	46	10.82	2.11	0.00	0.10	0.70	70.78	71.58	22.96	5.47	28.43
Jan-06	47	11.05	2.45	0.00	0.04	0.59	67.69	68.32	24.70	6.97	31.67
Apr-06	48	13.98	1.95	0.00	0.07	0.40	70.70	71.17	23.39	5.44	28.83
Jul-06	49	13.76	2.29	0.00	0.04	0.54	71.78	72.36	20.17	7.47	27.64
Oct-06	50	13.53	2.66	0.00	0.00	0.70	69.95	70.62	21.86	7.51	29.37
Jan-07	51	15.24	2.45	0.00	0.04	0.67	71.11	71.82	22.66	5.51	28.17
Apt-07	52	13.42	2.26	0.00	0.01	0.60	71.77	72.38	20.79	6.82	27.61
Jul-07	53	14.22	2.58	0.00	0.00	0.61	73.95	74.56	18.63	6.80	25.43
Oct-07	54	13.52	2.42	0.02	0.03	0.80	77.18	78.01	15.51	6.46	21.97
Jan-08	55	12.15	2.45	0.24	0.22	1.09	74.57	75.88	18.45	5.43	23.88
Apr-08	56	14.90	2.22	0.00	0.04	0.74	71.75	72.53	19.64	7.86	27.50
Jul-08	57	15.36	2.16	0.00	0.00	0.39	71.46	71.85	20.95	7.20	28.15
Oct-08	58	14.10	2.23	0.00	0.03	0.49	70.58	71.10	22.05	6.84	28.89
Jan-09	59	14.44	2.13	0.01	0.04	0.60	74.06	74.70	21.08	4.22	25.30
Apr-09	60	15.82	1.57	0.02	0.05	0.52	73.79	74.36	18.19	7.44	25.63
Jul-09	61	16.05	2.25	0.00	0.00	0.39	71.46	71.85	27.49	0.66	28.15
Oct-09	62	15.82	2.33	0.00	0.00	0.76	72.92	73.68	22.78	3.53	26.31
Jan-10	63	14.22	1.96	0.00	0.06	0.84	76.04	76.94	14.96	8.10	23.06
Apr-10	64	15.82	2.42	0.00	0.12	0.61	74.08	74.81	20.66	4.52	25.18
Jul-10	65	13.99	4.46*	0.00	0.25	0.48	70.93	71.66	22.11	6.22	28.33
Oct-10	66	17.31	1.23	0.08	0.18	0.78	73.39	74.35	25.57	0.00	25.57
Jan-11	67	17.88	1.91	0.00	0.02	0.45	75.40	75.87	21.65	2.47	24.12
Apr-11	68	20.18	1.88	0.00	0.07	0.56	75.27	75.90	11.57	12.53*	24.10
Jul-11	69	-	-	-	-	-	-	-	-	-	-
Oct-11	70	-	-	-	-	-	-	-	-	-	-

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jan-12	71	-	-	-	-	-	-	-	-	-	-
Apr-12	72	-	-	-	-	-	-	-	-	-	-
Jul-12	73	-	-	-	-	-	-	-	-	-	-
Oct-12	74	-	-	-	-	-	-	-	-	-	-
Jan-13	75	-	-	-	-	-	-	-	-	-	-
Apr-13	76	-	-	-	-	-	-	-	-	-	-
Jul-13	77	-	-	-	-	-	-	-	-	-	-
Oct-13	78	-	-	-	-	-	-	-	-	-	-
Jan-14	79	-	-	-	-	-	-	-	-	-	-
Apr-14	80	-	-	-	-	-	-	-	-	-	-
Jul-14	81	-	-	-	-	-	-	-	-	-	-
Oct-14	82	-	-	-	-	-	-	-	-	-	-
Jan-15	83	-	-	-	-	-	-	-	-	-	-
Apr-15	84	-	-	-	-	-	-	-	-	-	-
Jul-15	85	-	-	-	-	-	-	-	-	-	-
Oct-15	86	-	-	-	-	-	-	-	-	-	-
Jan-16	87	-	-	-	-	-	-	-	-	-	-
Apr-16	88	-	-	-	-	-	-	-	-	-	-
Jul-16	89	15.91	1.99	0.00	0.00	0.44	74.81	75.24	17.38	7.37	24.76
Oct-16	90	14.67	2.00	0.00	0.03	0.64	77.27	77.94	17.34	4.73	22.07
Jan-17	91	17.53	1.97	0.01	0.03	0.57	71.84	72.43	21.57	5.99	27.56
Apr-17	92	14.90	2.10	0.04	0.03	0.64	76.88	77.55	17.50	4.92	22.42
Jul-17	93	15.11	2.02	0.00	0.03	0.69	76.89	77.60	16.80	5.60	22.40
Oct-17	94	18.34	2.58	0.00	0.01	0.56	72.24	72.81	25.53	1.66	27.19
Jan-18	95	15.56	1.73	0.00	0.02	0.57	74.60	75.20	17.47	7.33	24.80

Dyers Creek (DC)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	-	-	-	-	-	-	-	-	-	-
Oct-00	26	-	-	-	-	-	-	-	-	-	-
Jan-01	27	-	-	-	-	-	-	-	-	-	-
Apr-01	28	-	-	-	-	-	-	-	-	-	-
Jul-01	29	-	-	-	-	-	-	-	-	-	-
Oct-01	30	-	-	-	-	-	-	-	-	-	-
Jan-02	31	-	-	-	-	-	-	-	-	-	-
Apr-02	32	-	-	-	-	-	-	-	-	-	-
Jul-02	33	-	-	-	-	-	-	-	-	-	-
Oct-02	34	-	-	-	-	-	-	-	-	-	-
Jan-03	35	-	-	-	-	-	-	-	-	-	-
Apr-03	36	-	-	-	-	-	-	-	-	-	-
Jul-03	37	-	-	-	-	-	-	-	-	-	-
Oct-03	38	-	-	-	-	-	-	-	-	-	-
Jan-04	39	-	-	-	-	-	-	-	-	-	-
Apr-04	40	-	-	-	-	-	-	-	-	-	-
Jul-04	41	-	-	-	-	-	-	-	-	-	-
Oct-04	42	-	-	-	-	-	-	-	-	-	-
Jan-05	43	-	-	-	-	-	-	-	-	-	-
Apr-05	44	-	-	-	-	-	-	-	-	-	-
Jul-05	45	-	-	-	-	-	-	-	-	-	-
Oct-05	46	8.10	0.76	1.83	0.24	1.65	88.03	89.92	5.25	3.00	8.25
Jan-06	47	7.36	1.34	0.15	0.28	2.06	89.15	91.49	5.18	3.19	8.37
Apr-06	48	7.23	0.88	0.80	0.25	2.07	90.25	92.57	3.62	3.01	6.63
Jul-06	49	5.22	1.20	0.78	0.14	2.16	89.10	91.40	5.85	1.95	7.80
Oct-06	50	5.16	1.25	1.51	0.12	1.97	89.37	91.46	5.37	1.65	7.02
Jan-07	51	6.99	1.05	1.46	0.15	1.25	79.48	80.88	12.79*	4.87	17.66*
Apt-07	52	8.14	1.24	0.67	0.16	1.80	90.65	92.61	2.55	4.18	6.73
Jul-07	53	7.56	1.29	0.41	0.36	2.92	91.60	94.88*	2.36	2.36	4.72
Oct-07	54	7.10	1.27	2.22	0.30	1.91	91.71	93.92	2.08	1.78	3.86
Jan-08	55	7.68	1.16	1.03	0.32	2.42	91.83	94.57	0.34	4.06	4.40
Apr-08	56	8.94	1.25	2.56	0.25	2.31	87.25	89.81	4.48	3.15	7.63
Jul-08	57	9.06	1.10	1.65	0.31	2.47	89.01	91.79	3.28	3.28	6.56
Oct-08	58	6.99	1.03	0.19	0.14	2.07	92.24*	94.45	2.68	2.68	5.36
Jan-09	59	9.17	1.29	0.99	0.24	2.44	90.14	92.82	2.89	3.30	6.19
Apr-09	60	9.40	1.19	0.90	0.16	1.88	89.25	91.29	4.30	3.52	7.82
Jul-09	61	9.86	1.10	1.65	0.31	2.47	89.01	91.79	6.39	0.18	6.57
Oct-09	62	9.40	1.60	0.63	0.38*	3.61*	85.31	89.30	7.55	2.52	10.07
Jan-10	63	6.65	1.44	1.02	0.25	2.76	84.89	87.90	6.16	4.93	11.09
Apr-10	64	7.22	1.27	0.84	0.16	2.33	85.91	88.40	6.28	4.48	10.76
Jul-10	65	7.57	1.94*	1.70	0.29	1.81	83.45	85.55	8.06	4.70	12.76
Oct-10	66	6.76	1.21	1.32	0.19	1.65	87.74	89.58	8.40	0.70	9.10
Jan-11	67	7.34	1.05	0.00	0.10	2.82	89.47	92.39	5.50	2.12	7.62
Apr-11	68	6.31	1.88	0.35	0.12	1.52	83.26	84.90	9.11	5.64	14.75
Jul-11	69	8.02	1.71	0.14	0.37	2.82	84.54	87.73	6.42	5.71	12.13
Oct-11	70	7.34	1.45	0.11	0.20	1.88	87.39	89.47	5.21	5.21	10.42
Jan-12	71	6.42	0.93	1.25	0.12	2.67	86.36	89.15	5.40	4.20	9.60
Apr-12	72	6.88	1.36	0.67	0.14	1.85	85.75	87.74	8.43	3.16	11.59
Jul-12	73	5.73	1.36	0.74	0.27	2.19	85.24	87.70	5.61	5.96	11.57
Oct-12	74	7.34	0.75	0.45	0.20	1.88	88.59	90.67	3.17	5.71	8.88
Jan-13	75	8.25	0.91	0.57	0.17	2.11	85.20	87.48	4.95	7.01	11.96
Apr-13	76	5.73	0.87	1.65	0.30	2.38	84.32	87.00	4.76	6.59	11.35
Jul-13	77	7.45	1.30	0.67	0.13	2.22	83.60	85.95	9.93	3.44	13.37
Oct-13	78	5.49	1.49	8.12	0.19	1.67	78.81	80.67	7.21	4.00	11.21
Jan-14	79	9.19	1.23	0.31	0.11	1.63	84.44	86.18	0.00	13.52*	13.52
Apr-14	80	6.81	1.10	0.80	0.17	2.61	83.99	86.77	9.06	3.36	12.42
Jul-14	81	6.87	1.19	8.20	0.08	1.40	79.55	81.03	5.38	5.38	10.76
Oct-14	82	6.18	1.49	8.97	0.20	1.75	79.56	81.51	5.44	4.08	9.52
Jan-15	83	6.30	1.08	0.30	0.07	1.69	86.69	88.45	6.43	4.82	11.25

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Apr-15	84	8.39	1.45	0.10	0.27	2.12	84.42	86.81	7.27	5.82	13.09
Jul-15	85	6.56	1.14	0.27	0.05	1.47	85.88	87.40	6.78	5.55	12.33
Oct-15	86	7.74	1.34	0.86	0.20	1.95	83.38	85.53	9.36	4.25	13.61
Jan-16	87	7.34	1.10	0.17	0.26	2.25	87.74	90.25	4.42	5.16	9.58
Apr-16	88	6.87	0.96	0.45	0.22	1.69	88.45	90.37	5.30	3.89	9.19
Jul-16	89	7.44	1.60	1.65	0.14	1.98	84.49	86.61	7.23	4.52	11.74
Oct-16	90	7.90	1.26	0.00	0.08	1.94	88.95	90.96	5.02	4.02	9.04
Jan-17	91	9.28	1.60	1.18	0.09	1.97	82.09	84.14	9.93	4.75	14.67
Apr-17	92	9.04	1.40	0.07	0.12	1.79	85.28	87.20	11.63	1.11	12.73
Jul-17	93	8.25	1.44	0.00	0.07	1.79	87.30	89.16	6.19	4.65	10.84
Oct-17	94	10.31*	1.86	17.40*	0.16	1.50	70.66	72.32	7.71	2.57	10.28
Jan-18	95	9.85	0.95	0.15	0.13	1.99	89.58	91.69	4.53	3.63	8.16

Hamilton Landing (HL)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	12.14	3.87	0.00	0.23	1.08	42.73	44.04	54.62	1.34	55.96
Oct-00	26	11.32	3.22	0.00	0.08	0.74	51.56	52.38	41.08	6.54	47.62
Jan-01	27	10.04	2.49	0.04	0.17	4.52*	62.16	66.85	28.10	5.02	33.12
Apr-01	28	12.63	4.60	0.00	0.06	0.70	56.02	56.78	40.19	3.04	43.23
Jul-01	29	16.74	6.35	0.00	0.15	0.81	50.02	50.98	47.46	1.55	49.01
Oct-01	30	8.32	4.16	0.00	0.00	0.13	44.40	44.53	48.63	6.83	55.46
Jan-02	31	8.21	3.92	0.00	0.00	0.61	57.74	58.35	35.24	6.41	41.65
Apr-02	32	13.13	3.47	0.00	0.10	2.74	56.77	59.61	36.52	3.87	40.39
Jul-02	33	6.41	1.58	0.79*	3.28*	1.98	62.68	67.94	18.57	12.71	31.27
Oct-02	34	7.27	5.02	0.06	0.06	0.34	49.23	49.63	38.81	11.50	50.31
Jan-03	35	10.07	4.07	0.01	0.12	0.26	55.57	55.95	35.03	9.01	44.04
Apr-03	36	5.93	5.54	0.00	0.09	2.41	49.97	52.47	27.12	2.88	30.00
Jul-03	37	6.19	3.89	0.00	0.26	0.53	47.82	48.61	45.58	5.82	51.40
Oct-03	38	7.70	3.85	0.00	0.12	0.25	48.10	48.47	47.52	4.00	51.52
Jan-04	39	10.78	4.69	0.00	0.00	0.23	43.87	44.10	54.95*	0.95	55.90
Apr-04	40	12.35	6.65*	0.00	0.12	0.35	45.03	45.50	33.74	20.77	54.51
Jul-04	41	10.86	4.87	0.00	0.02	0.30	50.00	50.32	44.03	5.64	49.67
Oct-04	42	7.62	5.04	0.02	0.22	0.37	54.08	54.67	33.05	12.24	45.29
Jan-05	43	8.48	2.55	0.47	0.00	0.18	55.98	56.16	30.17	13.20	43.37
Apr-05	44	6.62	4.13	0.00	0.00	0.86	55.64	56.50	29.00	14.50	43.50
Jul-05	45	12.82	4.27	0.00	0.10	0.38	48.36	48.84	33.36	17.79	51.15
Oct-05	46	10.94	4.60	0.00	0.21	0.47	57.06	57.74	22.14	20.13	42.27
Jan-06	47	9.87	3.95	0.00	0.08	0.32	51.57	51.97	38.42	9.61	48.03
Apr-06	48	9.50	3.72	0.00	0.11	0.27	57.74	58.12	33.00	8.88	41.88
Jul-06	49	6.44	4.35	0.39	0.07	0.24	51.92	52.23	33.06	14.33	47.39
Oct-06	50	8.60	4.35	0.00	0.12	0.24	51.85	52.21	32.49	15.29	47.78
Jan-07	51	10.78	3.64	0.00	0.04	0.34	59.35	59.73	31.68	8.58	40.26
Apt-07	52	11.69	4.35	0.00	0.04	0.29	53.82	54.15	25.01	20.84	45.85
Jul-07	53	11.47	5.17	0.00	0.00	0.28	49.34	49.62	35.03	15.37	50.40
Oct-07	54	10.54	4.87	0.00	0.00	1.27	49.86	51.13	40.92	7.96	48.88
Jan-08	55	12.03	4.99	0.09	0.12	0.55	55.20	55.87	36.59	7.45	44.04
Apr-08	56	10.43	5.02	0.00	0.14	0.38	52.75	53.27	36.91	9.84	46.75
Jul-08	57	10.20	4.94	0.00	0.11	0.25	54.27	54.63	31.84	13.53	45.37
Oct-08	58	9.63	3.98	0.00	0.06	0.19	47.58	47.83	45.36	6.80	52.16
Jan-09	59	9.97	4.14	0.00	0.17	0.48	50.32	50.97	41.05	7.98	49.03
Apr-09	60	11.46	4.17	0.03	0.10	0.39	51.95	52.44	29.71	17.83	47.54
Jul-09	61	14.22	4.05	0.00	0.11	0.25	54.27	54.63	44.33	1.04	45.37
Oct-09	62	7.11	1.92	0.14	0.27	4.33	83.46	88.06*	8.21	3.59	11.80
Jan-10	63	9.97	3.89	0.00	0.00	0.33	55.13	55.46	31.26	13.28	44.54
Apr-10	64	13.52	4.39	0.00	0.08	0.20	43.46	43.74	46.39	9.87	56.26*
Jul-10	65	11.12	4.75	0.00	0.28	0.30	55.41	55.99	33.65	10.35	44.00
Oct-10	66	11.12	2.37	0.08	0.17	0.34	67.02	67.53	28.79	3.60	32.39
Jan-11	67	8.71	3.83	0.00	0.18	0.15	57.22	57.55	42.45	0.00	42.45
Apr-11	68	16.05	4.31	0.00	0.12	0.33	53.93	54.38	30.99	14.63	45.62
Jul-11	69	18.11*	3.75	0.00	0.13	1.29	57.37	58.79	32.80	8.41	41.21
Oct-11	70	17.88	4.56	0.00	0.02	0.09	51.18	51.29	36.22	12.49	48.71
Jan-12	71	12.61	3.83	0.00	0.03	0.13	46.32	46.48	48.73	4.78	53.51
Apr-12	72	13.99	3.34	0.00	0.11	0.39	55.12	55.62	33.82	10.57	44.39
Jul-12	73	18.11*	4.49	0.00	0.01	0.13	49.18	49.32	30.88	19.80	50.68
Oct-12	74	13.07	4.07	0.00	0.05	0.16	52.13	52.34	32.93	14.73	47.66
Jan-13	75	13.30	2.83	0.00	0.03	0.16	50.55	50.74	28.15	21.11	49.26
Apr-13	76	14.33	3.03	0.00	0.03	0.39	57.23	57.65	27.28	15.07	42.35
Jul-13	77	13.75	3.15	0.00	0.05	0.17	56.30	56.52	36.33	7.15	43.48
Oct-13	78	11.00	3.29	0.00	0.00	0.33	87.22*	87.55	9.78	2.67	12.45
Jan-14	79	15.93	2.86	0.03	0.03	0.15	53.01	53.19	15.60	31.19*	46.79
Apr-14	80	7.72	3.38	0.00	0.01	0.29	55.85	56.15	35.99	7.85	43.84
Jul-14	81	12.59	3.54	0.00	0.12	0.27	60.38	60.77	25.17	14.06	39.23
Oct-14	82	10.32	3.32	0.00	0.01	0.19	57.80	58.00	31.91	10.08	41.99
Jan-15	83	10.43	3.00	0.00	0.01	0.20	61.09	61.30	24.74	13.96	38.70

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Apr-15	84	13.21	2.97	0.00	0.02	0.76	61.99	62.77	25.39	11.85	37.24
Jul-15	85	11.37	2.94	0.00	0.05	0.27	62.35	62.67	24.08	13.25	37.33
Oct-15	86	8.25	2.46	0.06	0.44	4.20	67.03	71.67	19.85	8.42	28.27
Jan-16	87	10.09	2.61	0.00	0.03	0.16	62.79	62.98	28.51	8.51	37.02
Apr-16	88	11.12	3.17	0.00	0.07	0.32	57.72	58.11	27.93	13.96	41.89
Jul-16	89	13.16	3.72	0.00	0.00	0.15	48.39	48.54	34.06	17.39	51.46
Oct-16	90	12.61	2.77	0.00	0.01	0.55	56.04	56.60	37.41	5.99	43.40
Jan-17	91	14.09	3.03	0.00	0.03	0.19	50.83	51.05	42.18	6.77	48.95
Apr-17	92	13.63	3.38	0.00	0.02	0.44	52.11	52.57	28.07	19.36	47.43
Jul-17	93	13.41	3.66	0.29	0.08	0.39	60.26	60.73	28.19	10.80	38.98
Oct-17	94	15.13	4.73	0.00	0.00	0.27	51.30	51.57	45.54	2.89	48.43
Jan-18	95	10.88	3.28	0.00	0.03	0.19	45.40	45.61	47.18	7.21	54.39

Jamieson Bay (JB)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	4.59	1.29	18.69	9.33	11.94	56.13	77.40	3.79	0.11	3.90
Oct-00	26	3.97	1.00	7.98	4.37	33.67	50.38	88.42	3.06	0.53	3.59
Jan-01	27	3.44	1.44	0.65	0.65	6.08	84.19	90.92	8.00	0.45	8.45
Apr-01	28	1.76	1.59	8.50	18.88*	39.23*	31.69	89.80	0.04	1.67	1.71
Jul-01	29	6.76	1.45	0.13	0.30	5.01	87.15	92.46	7.36	0.05	7.41
Oct-01	30	3.65	1.32	3.27	2.80	10.89	71.37	85.06	11.09	0.58	11.67
Jan-02	31	2.75	2.06	1.79	7.48	19.77	63.83	91.08	6.75	0.37	7.12
Apr-02	32	6.15	1.70	2.40	0.18	2.78	79.56	82.52	9.80	5.28	15.08
Jul-02	33	4.58	1.71	0.35	0.96	0.90	76.53	78.39	14.17	7.09	21.26
Oct-02	34	3.14	2.13	0.02	0.11	3.11	83.39	86.61	9.88	3.49	13.37
Jan-03	35	5.04	1.72	0.51	0.49	3.44	84.26	88.19	8.66	2.64	11.30
Apr-03	36	3.66	1.48	0.17	1.31	7.25	80.34	88.9	7.29	3.64	10.9
Jul-03	37	3.50	1.38	2.88	2.27	26.98	58.73	87.98	7.53	1.61	9.14
Oct-03	38	5.50	1.45	19.72	10.22	18.79	45.71	74.72	2.78	2.78	5.56
Jan-04	39	3.09	1.70	17.17	12.67	20.72	42.37	75.76	6.70	0.37	7.07
Apr-04	40	2.86	3.59*	12.01	7.69	16.03	56.77	80.49	3.74	3.74	7.48
Jul-04	41	3.38	2.34	5.34	10.69	24.34	54.36	89.39	3.36	1.92	5.28
Oct-04	42	3.23	2.31	8.03	7.54	15.02	62.39	84.95	4.82	2.19	7.01
Jan-05	43	4.61	1.41	45.90*	5.46	12.12	33.66	51.24	1.43	1.43	2.86
Apr-05	44	3.74	1.44	3.04	11.18	33.90	46.57	91.65	4.25	1.06	5.31
Jul-05	45	4.76	2.15	5.70	5.78	15.21	64.64	85.63	4.34	4.34	8.68
Oct-05	46	2.71	1.31	7.14	16.07	30.88	42.74	89.69	1.06	2.12	3.18
Jan-06	47	3.09	1.68	9.30	11.48	22.64	50.78	84.90	3.12	2.68	5.80
Apr-06	48	4.13	1.89	17.44	10.14	19.59	46.08	75.81	4.70	2.06	6.76
Jul-06	49	3.38	2.08	2.64	4.78	13.44	69.24	87.46	6.85	3.05	9.90
Oct-06	50	3.21	2.78	22.54	5.83	13.25	47.61	66.69	3.32	7.46	10.78
Jan-07	51	3.10	1.52	8.72	12.73	21.34	51.26	85.33	3.78	2.16	5.94
Apt-07	52	4.47	2.26	4.20	6.69	27.39	54.71	88.79	3.71	3.30	7.01
Jul-07	53	2.58	1.86	18.05	12.22	21.59	41.09	74.90	4.02	3.02	7.04
Oct-07	54	6.76	2.00	10.93	7.95	14.94	58.84	81.73	3.67	3.67	7.34
Jan-08	55	3.78	1.84	6.34	7.27	13.55	64.84	85.66	5.46	2.55	8.01
Apr-08	56	5.04	1.94	0.79	3.08	10.52	74.92	88.52	9.16	1.53	10.69
Jul-08	57	4.24	1.92	0.70	5.44	15.39	72.55	93.38*	4.51	1.41	5.92
Oct-08	58	4.24	2.47	18.04	5.59	16.73	50.84	73.16	5.86	2.93	8.79
Jan-09	59	4.58	1.81	3.32	3.03	12.56	73.07	88.66	5.10	2.91	8.01
Apr-09	60	5.62	1.41	10.69	6.97	19.45	59.24	85.66	1.82	1.82	3.64
Jul-09	61	4.59	1.24	0.70	5.44	15.39	72.55	93.38	5.70	0.22	5.92
Oct-09	62	4.53	1.81	3.01	5.82	23.85	60.16	89.83	4.38	2.79	7.17
Jan-10	63	6.30	1.58	0.00	0.59	4.05	87.57*	92.21	4.28	3.50	7.78
Apr-10	64	8.94*	2.30	0.55	1.18	7.69	76.20	85.07	9.42	4.96	14.38
Jul-10	65	4.93	2.40	0.01	0.40	2.94	77.32	80.66	14.00	5.33	19.33
Oct-10	66	4.47	0.86	1.24	0.72	5.10	83.22	89.04	9.71	0.00	9.71
Jan-11	67	5.85	2.15	0.92	0.74	3.91	78.19	82.84	14.21	2.03	16.24
Apr-11	68	6.42	2.23	1.11	0.30	2.60	80.86	83.76	11.64	3.49	15.13
Jul-11	69	6.31	1.74	11.46	8.07	16.77	52.68	77.52	8.01	3.00	11.01
Oct-11	70	4.36	1.61	3.01	10.30	31.41	46.84	88.55	6.45	1.98	8.43
Jan-12	71	5.22	1.44	0.93	0.82	3.09	75.77	79.68	15.23	4.15	19.38
Apr-12	72	6.42	1.61	0.07	0.98	4.67	83.98	89.63	10.31	0.00	10.31
Jul-12	73	6.31	2.15	8.33	11.87	12.04	53.57	77.48	10.20	3.99	14.19
Oct-12	74	8.71	1.76	0.75	0.26	3.84	79.33	83.43	9.04	6.78	15.82
Jan-13	75	5.50	1.24	3.53	5.38	19.03	59.08	83.49	7.54	5.44	12.98
Apr-13	76	6.42	1.73	3.90	5.12	10.20	62.94	78.26	11.30	6.54	17.84
Jul-13	77	6.76	1.73	0.29	0.53	3.19	69.76	73.48	20.56*	5.67	26.23*
Oct-13	78	3.27	1.49	1.16	4.96	12.73	74.53	92.22	3.73	2.90	6.63
Jan-14	79	5.14	1.14	8.78	7.55	12.05	60.79	80.39	2.17	8.67*	10.84
Apr-14	80	5.69	1.38	2.83	1.19	6.34	80.00	87.53	6.61	3.03	9.64
Jul-14	81	4.45	1.57	1.93	0.67	3.03	85.03	88.73	6.74	2.59	9.33

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Oct-14	82	4.46	1.58	0.05	0.55	8.77	82.32	91.64	5.71	2.60	8.31
Jan-15	83	4.12	1.42	0.91	1.08	4.28	84.07	89.43	5.79	3.86	9.65
Apr-15	84	6.94	1.94	1.76	1.93	5.24	78.65	85.82	9.08	3.35	12.43
Jul-15	85	4.33	1.69	11.99	6.79	18.15	52.96	77.90	7.16	2.95	10.11
Oct-15	86	6.52	1.73	5.12	6.01	15.53	60.87	82.41	9.56	2.91	12.46
Jan-16	87	3.32	1.66	2.22	3.10	8.43	75.39	86.91	7.93	2.94	10.87
Apr-16	88	3.72	1.72	17.78	9.42	14.20	53.31	76.92	3.43	1.87	5.30
Jul-16	89	3.72	1.42	7.99	10.41	24.46	51.11	85.97	3.25	2.79	6.04
Oct-16	90	2.75	1.32	22.35	8.74	22.80	42.44	73.98	1.60	2.06	3.66
Jan-17	91	4.58	1.44	14.75	10.53	22.54	46.88	79.94	3.04	2.28	5.31
Apr-17	92	3.01	1.63	18.62	3.99	9.99	59.29	73.27	6.76	1.35	8.11
Jul-17	93	2.65	2.12	13.69	11.80	18.05	51.07	80.92	3.60	1.80	5.40
Oct-17	94	3.67	2.51	26.97	6.44	14.80	47.05	68.29	2.51	2.23	4.74
Jan-18	95	2.86	1.45	7.37	10.65	20.73	54.46	85.84	3.40	3.40	6.80

Mid Harbour (MH)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	10.03	1.40	0.00	0.13	4.80	74.69	79.62	17.36	3.01	20.37
Oct-00	26	7.33	0.88	0.10	0.62	8.10	86.93	95.65*	3.88	0.37	4.25
Jan-01	27	6.54	1.38	0.19	0.34	5.64	85.25	91.23	7.10	1.47	8.57
Apr-01	28	10.38	3.38	0.33	0.05	2.08	62.62	64.75	31.70*	3.23	34.93
Jul-01	29	10.46	2.72	0.46	0.54	7.40	60.77	68.71	30.22	0.62	30.84
Oct-01	30	6.55	1.83	0.43	0.05	5.04	83.77	88.86	3.31	7.40	10.71
Jan-02	31	4.53	2.17	0.02	0.00	15.08	74.17	89.25	8.09	2.64	10.73
Apr-02	32	9.76	1.84	0.17	1.33	7.32	81.13	89.78	6.71	3.35	10.06
Jul-02	33	10.99	4.94*	0.26	0.14	3.16	73.40	76.70	20.52	2.52	23.04
Oct-02	34	8.59	1.53	4.02	7.86*	19.76*	61.47	89.09	4.14	2.76	6.89
Jan-03	35	9.02	1.50	0.07	0.12	2.75	86.93	89.80	6.75	3.38	10.13
Apr-03	36	7.05	2.96	1.80	0.13	2.08	59.49	61.70	19.50	10.50*	30.00
Jul-03	37	3.09	1.79	0.19	0.20	2.25	74.61	77.06	15.59	7.16	22.75
Oct-03	38	8.98	1.42	0.16	0.05	3.91	87.08	91.04	5.28	3.52	8.80
Jan-04	39	8.49	1.49	0.43	0.26	4.51	86.83	91.60	4.16	3.81	7.97
Apr-04	40	10.67	2.23	4.99*	0.54	2.72	80.87	84.13	3.11	7.77	10.88
Jul-04	41	7.05	1.57	0.51	0.24	7.73	84.43	92.40	3.86	3.22	7.08
Oct-04	42	2.53	2.40	0.56	0.19	3.27	86.23	89.69	5.85	3.90	9.75
Jan-05	43	10.93	1.63	0.97	0.00	3.43	88.30*	91.73	3.13	4.17	7.30
Apr-05	44	9.13	1.59	0.79	0.31	4.03	82.99	87.33	6.99	4.89	11.88
Jul-05	45	7.43	2.02	0.97	0.07	3.43	82.74	86.24	7.10	5.68	12.78
Oct-05	46	8.42	1.88	0.11	0.33	3.65	87.60	91.58	0.00	8.32	8.32
Jan-06	47	7.33	1.60	0.50	0.25	3.69	86.95	90.89	5.33	3.28	8.61
Apr-06	48	8.36	2.48	0.09	0.32	3.38	78.40	82.10	13.50	4.32	17.82
Jul-06	49	8.71	2.34	0.10	0.12	3.12	81.99	85.23	9.77	4.89	14.66
Oct-06	50	6.65	2.19	0.00	0.19	3.67	81.14	85.00	9.29	5.71	15.00
Jan-07	51	7.80	2.09	0.68	0.21	3.82	83.41	87.44	6.16	5.72	11.88
Apt-07	52	11.35	2.00	0.10	0.17	3.02	80.46	83.65	7.56	8.69	16.25
Jul-07	53	9.51	2.78	0.48	0.10	6.33	76.39	82.82	13.50	3.20	16.70
Oct-07	54	7.56	2.32	0.48	0.28	3.42	82.30	86.00	7.37	6.14	13.51
Jan-08	55	7.22	2.11	0.65	0.42	4.78	82.33	87.53	6.82	5.00	11.82
Apr-08	56	7.22	2.57	0.00	0.09	3.26	75.91	79.26	18.60	2.15	20.75
Jul-08	57	7.79	2.54	0.04	0.14	2.87	77.25	80.26	14.29	5.42	19.71
Oct-08	58	5.85	1.52	0.27	0.06	3.24	85.00	88.30	6.43	5.00	11.43
Jan-09	59	9.86	1.95	0.62	0.20	2.86	81.88	84.94	10.67	3.76	14.43
Apr-09	60	12.15*	1.86	0.49	0.10	4.09	78.05	82.24	16.41	0.86	17.27
Jul-09	61	8.60	2.02	0.04	0.14	2.87	77.25	80.26	19.22	0.48	19.70
Oct-09	62	11.92	3.97	0.00	0.05	0.38	62.89	63.32	26.32	10.37	36.69*
Jan-10	63	7.79	1.69	1.32	0.03	3.52	85.18	88.73	3.87	6.08	9.95
Apr-10	64	9.40	2.24	0.00	0.12	2.56	77.06	79.74	15.76	4.50	20.26
Jul-10	65	7.11	2.72	0.06	0.24	3.10	73.13	76.47	15.65	7.83	23.48
Oct-10	66	8.25	1.30	0.09	0.25	4.47	85.61	90.33	5.48	4.11	9.59
Jan-11	67	7.79	1.91	0.00	0.07	3.36	81.59	85.02	12.60	2.36	14.96
Apr-11	68	10.43	2.00	0.05	0.13	2.28	82.26	84.67	9.07	6.21	15.28
Jul-11	69	11.46	2.00	0.00	0.00	3.51	81.49	85.00	11.67	3.33	15.00
Oct-11	70	9.86	1.90	0.00	0.09	2.97	79.30	82.36	12.70	4.94	17.64
Jan-12	71	8.60	1.28	0.00	0.16	2.45	76.99	79.60	17.27	3.14	20.41
Apr-12	72	9.28	1.91	0.01	0.15	3.03	81.09	84.27	10.78	4.94	15.72
Jul-12	73	8.48	1.68	0.00	0.10	3.00	79.14	82.24	10.15	7.61	17.76
Oct-12	74	8.94	1.49	0.00	0.10	2.95	82.46	85.51	8.62	5.87	14.49
Jan-13	75	8.37	1.17	0.15	0.16	3.50	82.79	86.45	6.90	6.50	13.40
Apr-13	76	7.11	1.50	0.14	0.11	3.21	79.49	82.81	10.34	6.72	17.06
Jul-13	77	8.71	1.61	0.00	0.11	3.03	77.96	81.10	14.28	4.62	18.90
Oct-13	78	7.94	1.74	0.00	0.04	2.49	79.28	81.81	12.49	5.71	18.20
Jan-14	79	8.81	1.35	0.40	0.09	2.78	82.50	85.37	5.69	8.53	14.22
Apr-14	80	7.71	1.45	0.08	0.07	3.38	79.92	83.37	12.41	4.14	16.55
Jul-14	81	8.48	1.84	0.18	0.10	2.94	80.92	83.96	9.63	6.23	15.86
Oct-14	82	6.75	1.74	0.06	0.11	3.19	81.33	84.63	7.35	7.96	15.31
Jan-15	83	6.76	1.49	0.00	0.25	3.43	84.53	88.21	7.00	4.79	11.79

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Apr-15	84	8.85	1.91	0.19	0.19	3.54	82.08	85.81	8.68	5.30	13.98
Jul-15	85	8.33	1.85	0.02	0.11	3.21	80.41	83.73	9.97	6.28	16.25
Oct-15	86	7.10	1.54	0.00	0.09	2.60	82.88	85.57	10.15	4.28	14.43
Jan-16	87	8.71	1.48	0.32	0.14	3.33	86.57	90.04	6.33	3.32	9.64
Apr-16	88	9.39	1.57	1.10	0.13	3.61	80.18	83.92	9.99	5.00	14.99
Jul-16	89	8.93	1.88	0.08	0.08	4.10	80.72	84.90	6.01	9.02	15.03
Oct-16	90	8.70	1.38	0.13	0.24	3.57	82.94	86.76	8.30	4.81	13.11
Jan-17	91	12.04	1.60	0.33	0.29	3.95	86.14	90.37	4.85	4.45	9.30
Apr-17	92	9.27	1.81	0.09	0.15	3.30	82.33	85.77	8.24	5.89	14.13
Jul-17	93	9.97	2.19	0.10	0.10	3.19	81.52	84.82	10.92	4.16	15.08
Oct-17	94	11.23	2.22	1.00	0.11	3.15	83.46	86.71	9.72	2.56	12.28
Jan-18	95	11.21	1.59	0.35	0.15	3.59	82.90	86.64	9.42	3.59	13.01

Te Kapa (TKmud)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	14.74	1.87	0.00	0.10	0.33	54.48	54.91	34.20	10.89	45.09
Oct-00	26	8.40	2.32	0.00	0.16	1.66	60.85	62.67	19.14	18.19	37.33
Jan-01	27	5.94	2.33	0.00	0.09	1.73	62.42	64.24	29.95	5.82	35.77
Apr-01	28	13.11	3.06	0.04	0.21	1.50	62.77	64.48	29.83	5.65	35.48
Jul-01	29	17.41*	2.90	0.00	0.34	1.38	60.87	62.59	35.93	1.49	37.42
Oct-01	30	12.63	2.58	0.00	0.00	0.88	61.61	62.49	32.13	5.38	37.51
Jan-02	31	9.15	1.84	0.00	0.00	1.28	65.13	66.41	29.48	4.11	33.59
Apr-02	32	14.32	1.40	0.25	0.07	1.11	65.59	66.77	28.75	4.23	32.98
Jul-02	33	14.16	2.46	0.00	0.04	0.61	63.87	64.52	26.90	8.59	35.49
Oct-02	34	9.91	3.41	0.16	0.16	1.69	65.82	67.67	25.73	6.43	32.16
Jan-03	35	11.38	2.59	0.40	0.17	1.34	76.72	78.23	12.82	8.55	21.37
Apr-03	36	9.11	2.31	0.29	0.08	1.29	76.09	77.46	26.15	3.85	30.00
Jul-03	37	9.65	2.18	0.07	0.07	1.45	64.66	66.18	32.11	1.63	33.74
Oct-03	38	9.06	2.46	0.03	0.09	0.77	57.06	57.92	32.54	9.52	42.06
Jan-04	39	6.07	2.54	0.00	0.15	1.78	63.57	65.50	26.93	7.57	34.50
Apr-04	40	5.96	4.66*	0.00	0.26	1.25	63.77	65.28	18.52	16.20	34.72
Jul-04	41	7.22	2.69	1.95	0.05	1.10	58.56	59.71	36.34	1.98	38.32
Oct-04	42	4.03	3.99	0.00	0.14	1.41	63.54	65.09	28.56	6.35	34.91
Jan-05	43	6.90	4.10	0.00	0.14	1.73	60.75	62.62	23.01	14.38	37.39
Apr-05	44	11.03	2.63	0.00	0.48	1.29	60.63	62.40	29.43	8.17	37.60
Jul-05	45	6.82	1.91	0.00	0.04	1.52	62.11	63.67	26.86	9.48	36.34
Oct-05	46	6.46	2.53	0.00	0.08	1.61	62.70	64.39	22.66	12.95	35.61
Jan-06	47	6.06	2.68	0.00	0.08	0.90	58.34	59.32	31.56	9.12	40.68
Apr-06	48	5.73	1.63	5.12*	0.30	1.06	77.61	78.97	10.97	4.94	15.91
Jul-06	49	8.48	2.52	0.00	0.06	1.49	62.65	64.20	27.60	8.20	35.80
Oct-06	50	10.77	2.75	0.00	0.00	1.41	64.19	65.60	24.36	10.03	34.39
Jan-07	51	11.46	2.39	0.62	0.01	1.24	63.86	65.11	27.30	6.97	34.27
Apt-07	52	12.04	2.74	0.07	0.14	1.23	60.80	62.17	24.71	13.04	37.75
Jul-07	53	11.92	2.87	0.00	0.06	1.34	61.78	63.18	29.11	7.72	36.83
Oct-07	54	11.00	2.36	0.00	0.08	1.62	71.85	73.55	19.40	7.05	26.45
Jan-08	55	9.40	2.62	0.12	0.15	1.74	70.71	72.60	21.10	6.17	27.27
Apr-08	56	10.55	2.36	0.19	0.35	2.37	70.45	73.17	17.24	9.40	26.64
Jul-08	57	12.72	2.70	0.00	0.09	1.21	65.74	67.04	25.80	7.17	32.97
Oct-08	58	8.83	2.05	0.02	0.02	0.60	41.98	42.60	36.78*	20.60*	57.38*
Jan-09	59	10.55	2.56	0.01	0.08	1.16	67.21	68.45	24.82	6.71	31.53
Apr-09	60	12.38	2.58	0.08	0.15	1.67	72.12	73.94	18.89	7.09	25.98
Jul-09	61	13.07	2.45	0.00	0.09	1.21	65.74	67.04	32.26	0.70	32.96
Oct-09	62	9.28	2.64	0.00	0.12	1.78	65.00	66.90	28.87	4.23	33.10
Jan-10	63	9.17	2.89	0.05	0.30	1.94	60.70	62.94	29.75	7.26	37.01
Apr-10	64	14.67	2.42	0.00	0.12	1.66	69.19	70.97	20.96	8.06	29.02
Jul-10	65	10.78	2.73	0.37	0.44	1.64	74.45	76.53	14.63	8.47	23.10
Oct-10	66	12.95	2.82	0.12	0.25	1.53	62.34	64.12	35.76	0.00	35.76
Jan-11	67	11.35	2.30	0.03	0.13	1.46	65.40	66.99	30.97	2.02	32.99
Apr-11	68	12.15	2.19	0.03	0.13	1.36	66.22	67.71	28.33	3.93	32.26
Jul-11	69	13.30	2.62	0.09	0.15	2.71	67.79	70.65	21.62	7.63	29.25
Oct-11	70	13.07	2.34	0.00	0.04	1.41	62.62	64.07	30.54	5.39	35.93
Jan-12	71	12.26	2.02	0.09	0.13	1.30	66.58	68.01	27.74	4.16	31.90
Apr-12	72	16.28	2.03	0.00	0.11	1.86	71.35	73.32	19.13	7.55	26.68
Jul-12	73	16.74	2.46	0.01	0.12	1.34	64.51	65.97	19.80	14.23	34.03
Oct-12	74	15.36	1.92	0.00	0.04	0.77	69.19	70.00	18.75	11.25	30.00
Jan-13	75	10.09	1.49	0.13	0.09	1.27	68.25	69.61	19.52	10.74	30.26
Apr-13	76	12.04	1.74	0.19	0.07	1.15	66.80	68.02	23.22	8.58	31.80
Jul-13	77	13.29	2.18	0.00	0.10	1.51	74.29	75.90	18.62	5.48	24.10
Oct-13	78	10.75	2.28	0.00	0.05	1.32	66.42	67.79	23.81	8.40	32.21
Jan-14	79	15.51	2.13	0.03	0.02	0.63	58.74	59.39	34.24	6.34	40.58
Apr-14	80	14.44	1.72	2.07	0.21	1.50	80.74*	82.45*	9.03	6.45	15.48
Jul-14	81	13.06	2.10	0.00	0.03	1.16	70.49	71.68	20.84	7.48	28.32
Oct-14	82	11.46	2.39	0.06	0.07	1.47	65.50	67.04	23.99	8.91	32.90
Jan-15	83	12.73	2.11	0.00	0.20	2.08	67.07	69.35	22.86	7.79	30.65

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Apr-15	84	12.99	2.19	0.00	0.10	1.30	65.02	66.42	25.68	7.90	33.58
Jul-15	85	12.74	1.91	0.04	0.13	1.49	68.57	70.18	22.18	7.60	29.78
Oct-15	86	11.09	2.04	0.05	0.08	1.42	67.22	68.72	25.59	5.64	31.23
Jan-16	87	11.56	1.96	0.04	0.26	1.94	69.69	71.88	23.58	4.49	28.08
Apr-16	88	9.17	1.62	0.08	0.09	1.82	79.96	81.87	12.53	5.51	18.05
Jul-16	89	13.29	2.80	0.00	0.07	1.49	67.10	68.66	16.30	15.05	31.34
Oct-16	90	11.22	2.61	3.05	0.61*	2.70	68.60	71.91	12.52	12.52	25.04
Jan-17	91	14.99	2.20	0.04	0.16	2.03	65.60	67.78	24.56	7.62	32.18
Apr-17	92	10.54	2.19	0.08	0.26	2.43	68.54	71.22	23.71	4.99	28.70
Jul-17	93	11.79	2.14	0.08	0.21	1.94	73.95	76.10	17.15	6.67	23.82
Oct-17	94	14.67	3.09	0.00	0.25	2.66	65.10	68.00	26.66	5.33	32.00
Jan-18	95	10.66	1.75	0.00	0.45	3.29*	72.53	76.26	17.41	6.33	23.74

Te Kapa (TKsand)

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Jul-00	25	6.35	0.90	3.72	0.29	2.24	87.48	90.01	4.27	2.00	6.27
Oct-00	26	15.39	1.57	1.79	0.23	2.83	75.16	78.22	16.76	3.22	19.98
Jan-01	27	9.62	1.49	1.60	0.07	2.05	85.81	87.93	7.93	2.55	10.48
Apr-01	28	-	11.93*	0.00	0.35	0.48	53.70	54.53	36.64*	8.83	45.47
Jul-01	29	9.99	1.59	0.06	0.09	1.83	79.95	81.87	17.02	1.06	18.08
Oct-01	30	5.22	1.20	0.68	0.07	2.17	82.89	85.13	11.83	2.35	14.18
Jan-02	31	5.23	2.53	1.58	0.14	1.65	79.31	81.10	14.72	2.61	17.33
Apr-02	32	6.30	2.22	0.32	0.09	1.42	83.94	85.45	12.41	1.82	14.23
Jul-02	33	6.14	2.13	0.00	0.09	0.20	45.41	45.70	30.34	23.95*	54.30*
Oct-02	34	6.48	4.62	0.19	0.19	2.22	82.16	84.57	11.42	3.81	15.23
Jan-03	35	7.32	1.68	0.76	0.49	1.66	79.10	81.25	7.20	10.79	17.99
Apr-03	36	7.60	1.37	0.46	0.17	0.94	77.47	78.58	26.00	4.00	30.00
Jul-03	37	6.76	1.32	0.09	0.31	2.93	82.82	86.06	9.23	4.62	13.85
Oct-03	38	5.50	2.08	0.50	0.09	1.17	77.57	78.83	11.00	9.68	20.68
Jan-04	39	17.43*	1.79	3.93	1.09*	1.67	82.64	85.40	4.57	6.09	10.66
Apr-04	40	9.85	2.53	0.35	0.19	1.32	83.56	85.07	9.72	4.86	14.58
Jul-04	41	14.10	1.85	0.34	0.41	1.67	89.73*	91.81*	4.58	3.27	7.85
Oct-04	42	7.62	2.29	0.65	0.37	1.66	88.12	90.15	4.60	4.60	9.20
Jan-05	43	9.05	1.70	6.36	0.30	1.33	85.73	87.36	1.57	4.71	6.28
Apr-05	44	7.30	1.73	0.00	0.53	1.60	85.16	87.29	6.35	6.35	12.70
Jul-05	45	13.89	1.54	1.04	0.06	1.51	87.18	88.75	6.50	3.71	10.21
Oct-05	46	9.66	1.70	21.57*	0.16	1.72	67.63	69.51	6.69	2.23	8.92
Jan-06	47	9.23	2.14	0.55	0.19	1.60	79.99	81.78	9.72	7.95	17.67
Apr-06	48	3.20	2.06	0.00	0.11	1.23	69.60	70.94	21.65	7.42	29.07
Jul-06	49	4.76	1.96	5.38	0.31	1.53	76.93	78.77	9.90	5.94	15.84
Oct-06	50	4.93	1.97	0.62	0.04	1.26	84.42	85.72	8.19	5.46	13.65
Jan-07	51	5.39	1.43	4.36	0.10	1.22	82.07	83.39	8.01	4.24	12.25
Apt-07	52	5.50	1.48	1.20	0.18	1.58	87.11	88.87	6.35	3.59	9.94
Jul-07	53	6.53	1.98	0.85	0.45	3.02	84.50	87.97	8.49	2.68	11.17
Oct-07	54	4.93	1.66	1.00	0.25	2.44	88.53	91.22	3.89	3.89	7.78
Jan-08	55	7.11	1.75	0.79	0.24	2.03	88.25	90.52	5.56	3.13	8.69
Apr-08	56	5.50	1.79	1.30	0.59	2.83	85.39	88.81	8.14	1.75	9.89
Jul-08	57	7.11	1.61	0.37	0.40	1.69	83.73	85.82	6.63	7.18	13.81
Oct-08	58	6.19	2.21	14.38	0.28	2.04	73.90	76.22	5.65	3.76	9.41
Jan-09	59	6.19	1.68	0.49	0.75	3.03	86.26	90.04	6.15	3.31	9.46
Apr-09	60	8.02	1.79	3.76	0.17	1.35	77.56	79.08	9.24	7.92	17.16
Jul-09	61	6.65	1.54	0.37	0.40	1.69	83.73	85.82	13.49	0.32	13.81
Oct-09	62	6.19	2.14	11.28	0.20	2.52	70.02	72.74	8.95	7.03	15.98
Jan-10	63	7.68	2.60	2.54	0.65	3.27	71.63	75.55	11.25	10.66	21.91
Apr-10	64	6.65	2.40	1.67	0.37	2.67	79.91	82.95	7.95	7.42	15.37
Jul-10	65	5.50	1.91	0.07	0.20	1.52	81.40	83.12	15.78	1.03	16.81
Oct-10	66	6.19	1.92	0.33	0.59	2.91	76.24	79.74	11.63	8.30	19.93
Jan-11	67	7.68	2.33	0.10	0.26	1.75	81.66	83.67	10.32	5.90	16.22
Apr-11	68	7.34	1.93	0.23	0.22	1.90	81.24	83.36	8.99	7.41	16.40
Jul-11	69	8.83	1.81	0.27	0.55	3.39*	78.40	82.34	11.25	6.14	17.39
Oct-11	70	6.65	1.92	4.58	0.53	2.42	82.51	85.46	7.03	2.93	9.96
Jan-12	71	7.91	1.58	1.05	0.22	1.81	82.10	84.13	8.30	6.52	14.82
Apr-12	72	7.33	1.25	12.00	0.32	1.65	74.67	76.64	6.12	5.24	11.36
Jul-12	73	8.37	1.66	1.19	0.49	2.23	83.80	86.52	4.99	7.30	12.29
Oct-12	74	10.09	1.13	1.54	0.35	1.28	84.38	86.01	5.06	7.39	12.45
Jan-13	75	9.17	1.19	0.99	0.35	1.87	81.70	83.92	7.07	8.02	15.09
Apr-13	76	8.48	1.43	0.65	0.26	2.13	79.51	81.90	8.72	8.72	17.44
Jul-13	77	9.17	1.63	2.03	0.57	1.95	81.96	84.48	7.83	5.66	13.49
Oct-13	78	6.93	1.66	2.03	0.34	1.85	67.71	69.90	17.21	10.87	28.08
Jan-14	79	10.53	1.43	10.08	0.15	1.77	73.88	75.80	11.54	2.58	14.12
Apr-14	80	9.38	2.03	0.04	0.03	1.10	63.32	64.45	25.90	9.61	35.51
Jul-14	81	8.12	1.46	4.92	0.52	1.57	85.57	87.66	3.49	3.93	7.42
Oct-14	82	7.67	2.28	20.36	0.17	1.53	68.05	69.75	5.18	4.71	9.89
Jan-15	83	7.34	1.37	9.97	0.44	1.44	78.63	80.51	4.76	4.76	9.52

Date	Series	CHLA	OC	G	CS	MS	FS	SAND	SILT	CLAY	MUD
Apr-15	84	9.25	1.77	0.97	0.37	1.88	84.40	86.65	5.92	6.45	12.37
Jul-15	85	8.80	1.47	2.31	0.59	2.14	81.85	84.58	7.28	5.83	13.11
Oct-15	86	8.57	1.64	2.01	0.40	1.66	83.31	85.36	8.42	4.21	12.63
Jan-16	87	6.65	2.46	2.12	0.31	1.46	82.90	84.67	7.18	6.03	13.20
Apr-16	88	7.11	1.34	0.82	0.16	1.58	86.76	88.49	5.54	5.15	10.69
Jul-16	89	7.80	1.81	0.44	0.26	1.62	85.47	87.34	5.09	7.13	12.21
Oct-16	90	8.35	2.22	17.06	0.23	1.39	69.63	71.26	6.06	5.63	11.68
Jan-17	91	9.72	1.75	12.20	0.22	1.49	74.69	76.40	5.97	5.43	11.40
Apr-17	92	7.67	1.56	5.84	0.44	1.51	79.46	81.41	7.29	5.47	12.75
Jul-17	93	7.56	2.04	17.32	0.36	1.44	69.15	70.95	6.40	5.34	11.74
Oct-17	94	8.37	2.66	20.44	0.14	1.32	65.66	67.12	7.47	4.98	12.45
Jan-18	95	7.33	1.78	2.58	0.19	1.62	84.98	86.80	4.16	6.46	10.62

Appendix C: Most abundant taxa

The three dominant taxa collected from monitored sites between July 1994 (except at DC October 2005) and January 2018. The most abundant taxon is on the left hand side of the table.

Cowans Bay

Jul 94	1	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 94	2	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 95	3	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 95	4	*Cossura consimilis*	*Arthritica bifurca*	*Linucula hartvigiana*
Jul 95	5	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Oct 95	6	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 96	7	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 96	8	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 96	9	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 96	10	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 97	11	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 97	12	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 97	13	*Cossura consimilis*	*Torridoharpinia hurleyi*	*Arthritica bifurca*
Oct 97	14	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 98	15	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 98	16	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 98	17	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 98	18	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 99	19	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 99	20	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jul 99	21	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 99	22	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 00	23	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 00	24	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 00	25	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 00	26	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 01	27	*Cossura consimilis*	*Arthritica bifurca*	*Torridoharpinia hurleyi*
Apr 01	28	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 01	29	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Oct 01	30	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 02	31	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 02	32	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 02	33	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 02	34	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 03	35	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 03	36	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 03	37	*Cossura consimilis*	*Heteromastus filiformis*	*Torridoharpinia hurleyi*

Oct 03	38	*Cossura consimilis*	*Heteromastus filiformis*	*Macomona liliana*
Jan 04	39	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Apr 04	40	*Cossura consimilis*	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Jul 04	41	*Cossura consimilis*	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Oct 04	42	*Cossura consimilis*	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Jan 05	43	*Torridoharpinia hurleyi*	*Cossura consimilis*	*Linucula hartvigiana*
Apr 05	44	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Jul 05	45	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 05	46	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Jan 06	47	*Cossura consimilis*	*Linucula hartvigiana*	*Arthritica bifurca*
Apr 06	48	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jul 06	49	*Cossura consimilis*	*Arthritica bifurca*	*Linucula hartvigiana*
Oct 06	50	*Cossura consimilis*	*Arthritica bifurca*	*Torridoharpinia hurleyi*
Jan 07	51	*Cossura consimilis*	*Torridoharpinia hurleyi*	*Arthritica bifurca*
Apr 07	52	*Cossura consimilis*	*Arthritica bifurca*	*Macomona liliana*
Jul 07	53	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Oct 07	54	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca* / Polydorids
Jan 08	55	*Cossura consimilis*	*Arthritica bifurca*	*Torridoharpinia hurleyi*
Apr 08	56	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Jul 08	57	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 08	58	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 09	59	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 09	60	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 09	61	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 09	62	*Heteromastus filiformis*	*Cossura consimilis*	*Macomona liliana*
Jan 10	63	*Cossura consimilis*	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Apr 10	64	*Heteromastus filiformis*	*Cossura consimilis*	*Arthritica bifurca*
Jul 10	65	*Heteromastus filiformis*	*Cossura consimilis*	*Arthritica bifurca*
Oct 10	66	*Heteromastus filiformis*	*Cossura consimilis*	*Arthritica bifurca*
Jan 11	67	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Apr 11	68	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jul 16	89	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Oct 16	90	*Arthritica bifurca*	*Heteromastus filiformis*	*Cossura consimilis*
Jan 17	91	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Apr 17	92	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Jul 17	93	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Oct 17	94	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Jan 18	95	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*

Dyers Creek

Oct 05	46	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Macomona liliana*
Jan 06	47	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Apr 06	48	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Jul 06	49	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Oct 06	50	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Jan 07	51	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Apr 07	52	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Jul 07	53	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Oct 07	54	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Macomona liliana*
Jan 08	55	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Notoacmea scapha*
Apr 08	56	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Jul 08	57	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Notoacmea scapha*
Oct 08	58	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Notoacmea scapha*
Jan 09	59	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Notoacmea scapha*
Apr 09	60	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Jul 09	61	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Oct 09	62	*Linucula hartvigiana*	*Austrovenus stutchburyi*	*Notoacmea scapha*
Jan 10	63	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Apr 10	64	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Macomona liliana*
July 10	65	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Macomona liliana*
Oct 10	66	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Jan 11	67	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Macomona liliana*
Apr 11	68	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Aricidea* sp.
Jul 11	69	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Aricidea* sp.
Oct 11	70	*Austrovenus stutchburyi*	*Arthritica bifurca*	*Prionospio aucklandica*
Jan 12	71	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Linucula hartvigiana*
Apr 12	72	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Jul 12	73	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Oct 12	74	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Paracalliope novizealandiae*
Jan 13	75	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Apr 13	76	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Linucula hartvigiana*
Jul 13	77	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Linucula hartvigiana*
Oct 13	78	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Prionospio aucklandica*
Jan 14	79	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Apr 14	80	*Austrovenus stutchburyi*	*Aricidea* sp.	*Arthritica bifurca*
Jul 14	81	*Austrovenus stutchburyi*	*Aricidea* sp.	*Arthritica bifurca*
Oct 14	82	*Austrovenus stutchburyi*	*Aricidea* sp.	*Paracalliope novizealandiae*
Jan 15	83	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Apr 15	84	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Jul 15	85	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Oct 15	86	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Jan 16	87	*Austrovenus stutchburyi*	*Aricidea* sp.	*Linucula hartvigiana*
Apr 16	88	*Austrovenus stutchburyi*	*Aricidea* sp.	Polydorids
Jul 16	89	*Austrovenus stutchburyi*	*Aricidea* sp.	Oligochaetes

Oct 16	90	*Austrovenus stutchburyi*	*Aricidea* sp.	Oligochaetes
Jan 17	91	*Austrovenus stutchburyi*	*Aricidea* sp.	*Arthritica bifurca*
Apr 17	92	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Jul 17	93	*Austrovenus stutchburyi*	*Aricidea* sp.	*Arthritica bifurca*
Oct 17	94	*Austrovenus stutchburyi*	*Aricidea* sp.	*Prionospio aucklandica*
Jan 18	95	*Austrovenus stutchburyi*	*Aricidea* sp.	Polydorids

Hamilton Landing

Jul 94	1	*Austrovenus stutchburyi*	Polydorids	*Cossura consimilis*
Oct 94	2	*Austrovenus stutchburyi*	Polydorids	*Cossura consimilis*
Jan 95	3	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Arthritica bifurca*/*Cossura consimilis*
Apr 95	4	*Austrovenus stutchburyi*	*Cossura consimilis*	*Arthritica bifurca*
Jul 95	5	*Austrovenus stutchburyi*	*Cossura consimilis*	Polydorids
Oct 95	6	*Austrovenus stutchburyi*	Polydorids	*Heteromastus filiformis*
Jan 96	7	*Austrovenus stutchburyi*	Polydorids	*Heteromastus filiformis*
Apr 96	8	Polydorids	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Jul 96	9	Polydorids	*Heteromastus filiformis*	*Cossura consimilis*
Oct 96	10	Polydorids	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 97	11	Polydorids	*Austrovenus stutchburyi*	*Cossura consimilis*
Apr 97	12	Polydorids	*Cossura consimilis*	*Heteromastus filiformis*
Jul 97	13	Polydorids	*Heteromastus filiformis*	*Cossura consimilis*
Oct 97	14	Polydorids	*Heteromastus filiformis*	*Cossura consimilis*
Jan 98	15	*Heteromastus filiformis*	Polydorids	*Cossura consimilis*
Apr 98	16	*Austrovenus stutchburyi*	Polydorids	*Cossura consimilis*
Jul 98	17	Polydorids	*Austrovenus stutchburyi*	*Cossura consimilis*
Oct 98	18	Polydorids	*Heteromastus filiformis*	*Cossura consimilis*
Jan 99	19	*Austrovenus stutchburyi* / *Cossura consimilis*		*Arthritica bifurca* / Polydorids
Apr 99	20	*Heteromastus filiformis*	*Cossura consimilis*	*Austrovenus stutchburyi*
Jul 99	21	Polydorids	*Heteromastus filiformis*	*Cossura consimilis*
Oct 99	22	*Heteromastus filiformis*	Polydorids	*Cossura consimilis*
Jan 00	23	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Cossura consimilis*
Apr 00	24	*Heteromastus filiformis*	*Cossura consimilis*	*Torridoharpinia hurleyi*
Jul 00	25	*Heteromastus filiformis*	*Cossura consimilis*	Oligochaetes
Oct 00	26	*Heteromastus filiformis*	*Cossura consimilis*	*Arthritica bifurca*
Jan 01	27	*Cossura consimilis*	*Heteromastus filiformis*	Nemertea
Apr 01	28	*Cossura consimilis*	*Heteromastus filiformis*	*Prionospio aucklandica*
Jul 01	29	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Oct 01	30	*Cossura consimilis*	*Heteromastus filiformis*	Nemertea
Jan 02	31	*Cossura consimilis*	*Heteromastus filiformis*	*Prionospio aucklandica*
Apr 02	32	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Jul 02	33	*Heteromastus filiformis*	*Cossura consimilis*	*Arthritica bifurca*
Oct 02	34	*Cossura consimilis*	*Heteromastus filiformis*	Hemiplax hirtipes
Jan 03	35	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*

Apr 03	36	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 03	37	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 03	38	*Heteromastus filiformis*	*Cossura consimilis*	*Prionospio aucklandica*
Jan 04	39	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 04	40	*Cossura consimilis*	*Heteromastus filiformis*	*Prionospio aucklandica*
Jul 04	41	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 04	42	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 05	43	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 05	44	*Cossura consimilis*	*Heteromastus filiformis*	Oligochaetes
Jul 05	45	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Oct 05	46	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 06	47	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 06	48	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 06	49	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Oct 06	50	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 07	51	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 07	52	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 07	53	*Cossura consimilis*	*Heteromastus filiformis*	Oligochaetes
Oct 07	54	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Jan 08	55	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 08	56	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 08	57	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 08	58	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 09	59	*Cossura consimilis*	*Heteromastus filiformis*	*Prionospio aucklandica*
Apr 09	60	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 09	61	*Cossura consimilis*	*Heteromastus filiformis*	Polydorids
Oct 09	62	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 10	63	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 10	64	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 10	65	*Cossura consimilis*	Oligochaetes	*Heteromastus filiformis*
Oct 10	66	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 11	67	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 11	68	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jul 11	69	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 11	70	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 12	71	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 12	72	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 12	73	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 12	74	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan-13	75	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr-13	76	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jul-13	77	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct-13	78	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan-14	79	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr-14	80	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jul-14	81	*Cossura consimilis*	*Aricidea* sp.	Oligochaetes

Oct-14	82	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan-15	83	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr 15	84	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jul 15	85	*Cossura consimilis*	*Aricidea* sp.	Oligochaetes
Oct 15	86	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 16	87	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr 16	88	*Cossura consimilis*	*Aricidea* sp.	*Prionospio aucklandica*
Jul 16	89	*Cossura consimilis*	*Aricidea* sp.	Oligochaetes
Oct 16	90	*Cossura consimilis*	*Aricidea* sp.	Oligochaetes
Jan 17	91	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr 17	92	*Cossura consimilis*	*Aricidea* sp.	Oligochaetes
Jul 17	93	*Cossura consimilis*	*Aricidea* sp.	*Prionospio aucklandica*
Oct 17	94	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 18	95	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*

Jamieson Bay

Jul 94	1	Polydorids	*Linucula hartvigiana*	*Macomona liliana*
Oct 94	2	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Jan 95	3	*Linucula hartvigiana*	*Macomona liliana*	*Cossura consimilis*
Apr 95	4	*Linucula hartvigiana*	Polydorids	*Torridoharpinia hurleyi*
Jul 95	5	*Linucula hartvigiana*	Polydorids	*Macomona liliana*
Oct 95	6	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Jan 96	7	*Linucula hartvigiana*	*Aonides trifida*	*Heteromastus filiformis*
Apr 96	8	Polydorids	*Linucula hartvigiana*	*Aonides trifida*
Jul 96	9	Polydorids	*Linucula hartvigiana*	*Macomona liliana*
Oct 96	10	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Jan 97	11	*Linucula hartvigiana*	Polydorids	*Cossura consimilis* / *Heteromastus filiformis*
Apr 97	12	*Linucula hartvigiana*	Polydorids	*Aonides trifida*
Jul 97	13	Polydorids	*Linucula hartvigiana*	*Torridoharpinia hurleyi*
Oct 97	14	*Aonides trifida*	*Linucula hartvigiana*	*Heteromastus filiformis*
Jan 98	15	*Linucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Apr 98	16	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Jul 98	17	*Aonides trifida*	*Linucula hartvigiana*	*Heteromastus filiformis*
Oct 98	18	*Linucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Jan 99	19	Polydorids	*Linucula hartvigiana*	*Macomona liliana*
Apr 99	20	Polydorids	*Linucula hartvigiana*	*Macomona liliana*
Jul 99	21	Polydorids	*Heteromastus filiformis*	*Linucula hartvigiana*
Oct 99	22	Polydorids	*Heteromastus filiformis*	*Aonides trifida*
Jan 00	23	*Linucula hartvigiana*	Nemertea	Polydorids
Apr 00	24	*Linucula hartvigiana*	*Aonides trifida*	Scoloplos cylindrifer
Jul 00	25	Polydorids	*Aonides trifida*	*Heteromastus filiformis*
Oct 00	26	*Linucula hartvigiana*	*Aonides trifida*	Polydorids
Jan 01	27	*Linucula hartvigiana*	Polydorids	*Aonides trifida*

Apr 01	28	*Linucula hartvigiana*	*Aonides trifida*	*Paracalliope novizealandiae*
Jul 01	29	*Linucula hartvigiana*	Polydorids	*Aonides trifida*
Oct 01	30	*Linucula hartvigiana*	*Aricidea* sp.	*Macomona liliana*
Jan 02	31	*Linucula hartvigiana*	*Cossura consimilis*	*Macomona liliana*
Apr 02	32	*Linucula hartvigiana*	*Paracalliope novizealandiae*	*Cossura consimilis*
Jul 02	33	*Linucula hartvigiana*	*Heteromastus filiformis*	Polydorids
Oct 02	34	*Linucula hartvigiana*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 03	35	*Linucula hartvigiana*	*Cossura consimilis*	*Paracalliope novizealandiae*
Apr 03	36	*Linucula hartvigiana*	*Aonides trifida*	*Aricidea* sp.
Jul 03	37	*Linucula hartvigiana*	*Heteromastus filiformis*	Oligochaetes
Oct 03	38	*Linucula hartvigiana*	*Aonides trifida*	*Heteromastus filiformis*
Jan 04	39	*Linucula hartvigiana*	*Heteromastus filiformis*	*Aonides trifida*
Apr 04	40	*Linucula hartvigiana*	Polydorids	*Aonides trifida*
Jul 04	41	*Linucula hartvigiana*	Oligochaetes	*Aonides trifida*
Oct 04	42	*Linucula hartvigiana*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 05	43	*Linucula hartvigiana*	*Torridoharpinia hurleyi*	*Paracalliope novizealandiae*
Apr 05	44	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Jul 05	45	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Oct 05	46	Polydorids	*Linucula hartvigiana*	*Paracalliope novizealandiae*
Jan 06	47	*Linucula hartvigiana*	*Aonides trifida*	Polydorids
Apr 06	48	*Linucula hartvigiana*	*Heteromastus filiformis*	*Macomona liliana*
Jul 06	49	*Linucula hartvigiana*	*Heteromastus filiformis*	Oligochaetes
Oct 06	50	*Linucula hartvigiana*	*Macomona liliana*	Polydorids
Jan 07	51	*Linucula hartvigiana*	*Torridoharpinia hurleyi*	*Macomona liliana*
Apr 07	52	*Linucula hartvigiana*	Polydorids	*Cossura consimilis* / Oligochaetes
Jul 07	53	*Linucula hartvigiana*	*Aonides trifida* / Oligochaetes	Polydorids
Oct 07	54	*Linucula hartvigiana*	*Aonides trifida*	*Heteromastus filiformis*
Jan 08	55	*Linucula hartvigiana*	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Apr08	56	*Linucula hartvigiana*	*Macomona liliana*	*Austrovenus stutchburyi*
Jul 08	57	*Linucula hartvigiana*	Polydorids	*Aonides trifida*
Oct 08	58	*Linucula hartvigiana*	Oligochaetes	*Heteromastus filiformis*
Jan 09	59	*Linucula hartvigiana*	Oligochaetes	*Aricidea* sp.
Apr 09	60	*Linucula hartvigiana*	Polydorids	Oligochaetes
Jul 09	61	*Linucula hartvigiana*	Polydorids	*Cossura consimilis* / Oligochaetes
Oct 09	62	*Linucula hartvigiana*	Polydorids	*Aonides trifida*
Jan 10	63	*Linucula hartvigiana*	Polydorids	*Torridoharpinia hurleyi*
Apr 10	64	*Linucula hartvigiana*	Polydorids	*Aonides trifida*

Jul 10	65	Polydorids	*Linucula hartvigiana*	*Paracalliope novizealandiae*
Oct 10	66	*Linucula hartvigiana*	Polydorids	*Torridoharpinia hurleyi*
Jan 11	67	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Apr 11	68	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Jul 11	69	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Oct 11	70	*Heteromastus filiformis*	Polydorids	*Linucula hartvigiana*
Jan 12	71	Polydorids	*Linucula hartvigiana*	*Heteromastus filiformis*
Apr 12	72	Polydorids	*Paracalliope novizealandiae*	*Heteromastus filiformis*
Jul 12	73	*Heteromastus filiformis*	Polydorids	*Aricidea* sp.
Oct 12	774	Polydorids	*Linucula hartvigiana*	*Arthritica bifurca*
Jan-13	475	Polydorids	*Prionospio aucklandica*	*Linucula hartvigiana*
Apr-13	76	*Prionospio aucklandica*	Polydorids	*Aricidea* sp.
Jul-13	77	*Prionospio aucklandica*	*Aricidea* sp.	*Heteromastus filiformis*
Oct-13	78	Polydorids	*Aricidea* sp.	*Heteromastus filiformis*
Jan-14	79	*Aricidea* sp.	*Prionospio aucklandica*	*Cossura consimilis*
Apr-14	80	*Aricidea* sp.	*Linucula hartvigiana*	*Heteromastus filiformis*
Jul-14	81	Polydorids	*Heteromastus filiformis*	*Aricidea* sp.
Oct-14	82	Polydorids	*Aricidea* sp.	*Heteromastus filiformis*
Jan-15	83	Polydorids	*Torridoharpinia hurleyi*	*Linucula hartvigiana*
Apr 15	84	Polydorids	*Aricidea* sp.	*Heteromastus filiformis*
Jul 15	85	Polydorids	*Heteromastus filiformis*	*Aricidea* sp.
Oct 15	86	*Aricidea* sp.	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Jan 16	87	Oligochaetes	*Aricidea* sp.	*Torridoharpinia hurleyi*
Apr 16	88	*Prionospio aucklandica*	*Aricidea* sp.	*Heteromastus filiformis*
Jul 16	89	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Prionospio aucklandica*
Oct 16	90	*Heteromastus filiformis*	*Aricidea* sp.	*Prionospio aucklandica*
Jan 17	91	*Heteromastus filiformis*	Polydorids	Oligochaetes
Apr 17	92	*Heteromastus filiformis*	*Austrovenus stutchburyi*	*Linucula hartvigiana*
Jul 17	93	*Heteromastus filiformis*	*Aricidea* sp.	*Cossura consimilis*
Oct 17	94	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 18	95	Oligochaetes	Polydorids	*Austrovenus stutchburyi*

Mid Harbour

Jul 94	1	*Heteromastus filiformis*	*Cossura consimilis*	*Linucula hartvigiana*
Oct 94	2	*Linucula hartvigiana*	*Cossura consimilis*	*Macomona liliana*
Jan 95	3	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Apr 95	4	*Linucula hartvigiana*	*Cossura consimilis*	Polydorids
Jul 95	5	*Linucula hartvigiana*	*Cossura consimilis*	*Macomona liliana*
Oct 95	6	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Jan 96	7	*Linucula hartvigiana*	*Cossura consimilis*	Polydorids
Apr 96	8	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Jul 96	9	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Oct 96	10	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*

Jan 97	11	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Apr 97	12	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Jul 97	13	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Oct 97	14	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Jan 98	15	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Apr 98	16	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Jul 98	17	*Linucula hartvigiana*	Polydorids	*Austrovenus stutchburyi*
Oct 98	18	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Jan 99	19	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Apr99	20	*Linucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Jul 99	21	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Oct 99	22	*Linucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Jan 00	23	*Linucula hartvigiana*	Polydorids	*Arthritica bifurca*
Apr 00	24	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Jul 00	25	*Linucula hartvigiana*	*Cossura consimilis*	*Heteromastus filiformis*
Oct 00	26	*Linucula hartvigiana*	Polydorids	*Arthritica bifurca*
Jan 01	27	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Apr 01	28	*Heteromastus filiformis*	*Prionospio aucklandica*	*Aricidea* sp. / Nemertea
Jul 01	29	*Heteromastus filiformis*	*Aricidea* sp.	*Arthritica bifurca*
Oct 01	30	*Linucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 02	31	*Linucula hartvigiana*	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 02	32	*Linucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jul 02	33	*Linucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Oct 02	34	*Linucula hartvigiana*	*Cossura consimilis*	*Heteromastus filiformis*
Jan 03	35	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Apr 03	36	*Linucula hartvigiana*	Polydorids	*Cossura consimilis*
Jul 03	37	*Linucula hartvigiana*	*Cossura consimilis*	*Heteromastus filiformis*
Oct 03	38	*Linucula hartvigiana*	*Heteromastus filiformis*	Polydorids
Jan 04	39	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Apr 04	40	*Linucula hartvigiana*	*Cossura consimilis*	*Heteromastus filiformis*
Jul 04	41	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Oct 04	42	*Linucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 05	43	*Linucula hartvigiana*	*Cossura consimilis*	*Macomona liliana*
Apr 05	44	*Linucula hartvigiana*	*Cossura consimilis*	*Heteromastus filiformis*
Jul 05	45	*Linucula hartvigiana*	*Heteromastus filiformis*	*Cossura consimilis*
Oct 05	46	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Jan 06	47	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Apr 06	48	*Linucula hartvigiana*	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 06	49	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*

Oct 06	50	*Linucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 07	51	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Apr 07	52	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca* / Polydorids
Jul 07	53	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Oct 07	54	*Linucula hartvigiana*	Polydorids / *Macomona liliana*	*Heteromastus filiformis*
Jan 08	55	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Apr 08	56	*Linucula hartvigiana*	*Arthritica bifurca*	*Aricidea* sp.
Jul 08	57	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Oct 08	58	*Linucula hartvigiana*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 09	59	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Apr 09	60	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Jul 09	61	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Oct 09	62	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Jan 10	63	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Apr 10	64	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Jul 10	65	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Oct 10	66	*Linucula hartvigiana*	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 11	67	*Linucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 11	68	*Linucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Jul 11	69	*Linucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Oct 11	70	*Arthritica bifurca*	*Linucula hartvigiana*	*Heteromastus filiformis*
Jan 12	71	*Arthritica bifurca*	Polydorids	*Heteromastus filiformis*
Apr 12	72	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Jul 12	73	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Oct 12	74	*Arthritica bifurca*	*Cossura consimilis*	*Arthritica bifurca*
Jan 13	75	*Arthritica bifurca*	Polydorids	*Cossura consimilis*
Apr-13	76	*Arthritica bifurca*	Polydorids	*Cossura consimilis*
Jul-13	77	*Arthritica bifurca*	Polydorids	*Cossura consimilis*
Oct-13	78	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Jan-14	79	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Apr-14	80	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Jul-14	81	*Arthritica bifurca*	*Cossura consimilis*	*Aricidea* sp.
Oct-14	82	*Arthritica bifurca*	*Cossura consimilis*	Polydorids
Jan-15	83	*Cossura consimilis*	Polydorids	*Arthritica bifurca*
Apr 15	84	Polydorids	*Arthritica bifurca*	*Cossura consimilis*
Jul 15	85	*Cossura consimilis*	Polydorids	*Arthritica bifurca*
Oct 15	86	*Cossura consimilis*	Polydorids	*Arthritica bifurca*
Jan 16	87	*Arthritica bifurca*	*Cossura consimilis*	Polydorids

Apr 16	88	Polydorids	*Cossura consimilis*	*Arthritica bifurca*
Jul 16	89	*Cossura consimilis*	Polydorids	*Arthritica bifurca*
Oct 16	90	*Arthritica bifurca*	*Cossura consimilis*	Polydorids
Jan 17	91	*Arthritica bifurca*	*Cossura consimilis*	Polydorids
Apr 17	92	*Arthritica bifurca*	*Cossura consimilis*	Polydorids
Jul 17	93	*Arthritica bifurca*	*Cossura consimilis*	Polydorids
Oct 17	94	*Arthritica bifurca*	*Cossura consimilis*	Polydorids
Jan 18	95	*Arthritica bifurca*	*Cossura consimilis*	Polydorids

Te Kapa Inlet

Jul 94	1	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 94	2	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Linucula hartvigiana*
Jan 95	3	*Heteromastus filiformis*	*Cossura consimilis*	*Linucula hartvigiana*
Apr 95	4	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Cossura consimilis*
Jul 95	5	*Austrovenus stutchburyi*	*Linucula hartvigiana*	*Heteromastus filiformis*
Oct 95	6	*Linucula hartvigiana*	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 96	7	*Heteromastus filiformis*	*Austrovenus stutchburyi*	*Linucula hartvigiana*
Apr 96	8	*Heteromastus filiformis*	*Linucula hartvigiana*	*Cossura consimilis*
Jul 96	9	*Heteromastus filiformis*	*Cossura consimilis*	*Aricidea* sp.
Oct 96	10	*Heteromastus filiformis*	*Cossura consimilis*	*Aricidea* sp.
Jan 97	11	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Heteromastus filiformis*
Apr 97	12	*Heteromastus filiformis*	*Prionospio aucklandica*	*Aricidea* sp.
Jul 97	13	*Prionospio aucklandica*	*Aricidea* sp.	*Austrovenus stutchburyi*
Oct 97	14	*Heteromastus filiformis*	*Aricidea* sp.	*Cossura consimilis*
Jan 98	15	*Aricidea* sp.	*Prionospio aucklandica*	*Cossura consimilis*
Apr 98	16	*Cossura consimilis*	*Heteromastus filiformis*	*Prionospio aucklandica*
Jul 98	17	*Heteromastus filiformis*	*Aricidea* sp.	*Prionospio aucklandica*
Oct 98	18	*Aricidea* sp.	*Heteromastus filiformis*	*Cossura consimilis*
Jan 99	19	*Austrovenus stutchburyi*	*Cossura consimilis*	*Linucula hartvigiana*
Apr99	20	*Cossura consimilis*	*Austrovenus stutchburyi*	*Prionospio aucklandica*
Jul 99	21	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 99	22	*Cossura consimilis*	*Linucula hartvigiana*	*Austrovenus stutchburyi*
Jan 00	23	*Cossura consimilis*	*Prionospio aucklandica*	*Heteromastus filiformis*
Apr 00	24	*Cossura consimilis*	*Prionospio aucklandica*	*Austrovenus stutchburyi*
Jul 00	25	*Cossura consimilis*	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Oct 00	26	*Cossura consimilis*	*Heteromastus filiformis*	*Prionospio aucklandica*
Jan 01	27	*Cossura consimilis*	*Linucula hartvigiana*	*Austrovenus stutchburyi*
Apr 01	28	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Jul 01	29	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*

Oct 01	30	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 02	31	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Apr 02	32	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 02	33	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 02	34	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 03	35	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Apr 03	36	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 03	37	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 03	38	*Cossura consimilis*	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 04	39	*Cossura consimilis*	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Apr 04	40	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Jul 04	41	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 04	42	*Cossura consimilis*	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 05	43	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Apr 05	44	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 05	45	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 05	46	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 06	47	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 06	48	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 06	49	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 06	50	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 07	51	*Cossura consimilis*	*Heteromastus filiformis*	*Linucula hartvigiana*
Apr 07	52	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 07	53	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 07	54	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp. / *Austrovenus stutchburyi*
Jan 08	55	*Cossura consimilis*	*Linucula hartvigiana*	*Aricidea* sp.
Apr 08	56	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 08	57	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 08	58	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 09	59	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 09	60	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jul 09	61	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 09	62	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 10	63	*Cossura consimilis*	*Austrovenus stutchburyi*	*Linucula hartvigiana*
Apr 10	64	*Cossura consimilis*	*Aricidea* sp.	*Prionospio aucklandica*
Jul 10	65	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 10	66	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 11	67	*Cossura consimilis*	*Aricidea* sp.	*Austrovenus stutchburyi*
Apr 11	68	*Cossura consimilis*	*Austrovenus stutchburyi*	*Aricidea* sp.

Jul 11	69	*Aricidea* sp.	*Cossura consimilis*	*Austrovenus stutchburyi*
Oct 11	70	*Cossura consimilis*	*Aricidea* sp.	*Austrovenus stutchburyi*
Jan 12	71	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 12	72	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 12	73	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 12	74	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 13	75	*Cossura consimilis*	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Apr-13	76	*Cossura consimilis*	*Prionospio aucklandica*	*Aricidea* sp.
Jul-13	77	*Cossura consimilis*	*Aricidea* sp.	*Prionospio aucklandica*
Oct-13	78	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan-14	79	*Cossura consimilis*	*Heteromastus filiformis*	*Arthritica bifurca*
Apr-14	80	*Cossura consimilis*	*Arthritica bifurca*	*Heteromastus filiformis*
Jul-14	81	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Oct-14	82	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan-15	83	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr 15	84	*Cossura consimilis*	*Aricidea* sp.	*Prionospio aucklandica*
Jul 15	85	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 15	86	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 16	87	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 16	88	*Cossura consimilis*	*Aricidea* sp.	*Arthritica bifurca*
Jul 16	89	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 16	90	*Aricidea* sp.	*Cossura consimilis*	*Austrovenus stutchburyi*
Jan 17	91	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Apr 17	92	*Cossura consimilis*	*Aricidea* sp.	*Arthritica bifurca*
Jul 17	93	*Cossura consimilis*	*Aricidea* sp.	*Prionospio aucklandica*
Oct 17	94	*Austrovenus stutchburyi*	*Cossura consimilis*	*Aricidea* sp.
Jan 18	95	*Cossura consimilis*	*Aricidea* sp.	*Austrovenus stutchburyi*

Appendix D: State of the Environment Indicators: Benthic Health Model (metals and mud), Traits Based Index (TBI) and Combined Health scores.

Benthic Health Model score for metals and mud (CAPmetals, CAPmud), TBI scores and combined health scores for all monitoring sites between October 1994 and October 2017. Health scores ("x") are translated as: x ≤ 0.2 (extremely good = blue); 0.2 <x ≤0.4 (good = green); 0.4 <x ≤0.6 (moderate = yellow); 0.6 <x ≤0.8 (poor = orange) and x> 0.8 (unhealthy with low resilience = red). TBI scores in grey do not factor into the combined health score because CAPmud is <-0.12 (Group1, blue; see Section 2.5.3). Monitoring was put on hold at site CB (October 2011-October 2015) and sampling at site DC did not commence until October 2005, both are denoted by "-".

Site	Series	Time	CAPmetals	CAPmud	TBI	Combined Health
CB	2	Oct-94	0.009	0.023	0.33	0.69
CB	6	Oct-95	0.023	0.041	0.28	0.80
CB	10	Oct-96	0.010	0.041	0.34	0.69
CB	14	Oct-97	0.004	0.031	0.38	0.69
CB	18	Oct-98	0.034	0.040	0.34	0.67
CB	22	Oct-99	0.044	0.049	0.34	0.67
CB	26	Oct-00	0.059	0.079	0.38	0.67
CB	30	Oct-01	0.022	0.051	0.32	0.69
CB	34	Oct-02	0.066	0.072	0.34	0.67
CB	38	Oct-03	0.004	0.020	0.41	0.58
CB	42	Oct-04	-0.025	-0.002	0.45	0.51
CB	46	Oct-05	-0.004	0.001	0.44	0.51
CB	50	Oct-06	0.017	0.020	0.34	0.69
CB	54	Oct-07	0.019	0.009	0.39	0.62
CB	58	Oct-08	0.050	0.043	0.42	0.33
CB	62	Oct-09	0.008	0.014	0.40	0.62
CB	66	Oct-10	0.014	0.036	0.47	0.58
CB	70	Oct-11	-	-	-	-
CB	74	Oct-12	-	-	-	-
CB	78	Oct-13	-	-	-	-
CB	82	Oct-14	-	-	-	-
CB	86	Oct-15	-	-	-	-
CB	90	Oct-16	0.011	0.071	0.32	0.69
CB	94	Oct-17	0.033	0.057	0.45	0.33

Site	Series	Time	CAPmetals	CAPmud	TBI	Combined Health
DC	2	Oct-94	-	-	-	-
DC	6	Oct-95	-	-	-	-
DC	10	Oct-96	-	-	-	-
DC	14	Oct-97	-	-	-	-
DC	18	Oct-98	-	-	-	-
DC	22	Oct-99	-	-	-	-
DC	26	Oct-00	-	-	-	-
DC	30	Oct-01	-	-	-	-
DC	34	Oct-02	-	-	-	-
DC	38	Oct-03	-	-	-	-
DC	42	Oct-04	-	-	-	-
DC	46	Oct-05	-0.084	-0.115	0.38	0.49
DC	50	Oct-06	-0.060	-0.082	0.41	0.44
DC	54	Oct-07	-0.085	-0.119	0.35	0.49
DC	58	Oct-08	-0.083	-0.111	0.51	0.38
DC	62	Oct-09	-0.076	-0.115	0.42	0.38
DC	66	Oct-10	-0.088	-0.093	0.38	0.49
DC	70	Oct-11	-0.070	-0.065	0.38	0.49
DC	74	Oct-12	-0.050	-0.074	0.45	0.44
DC	78	Oct-13	-0.060	-0.085	0.43	0.44
DC	82	Oct-14	-0.069	-0.059	0.57	0.38
DC	86	Oct-15	-0.045	-0.026	0.46	0.51
DC	90	Oct-16	-0.025	-0.026	0.40	0.51
DC	94	Oct-17	-0.037	-0.052	0.53	0.44

Site	Series	Time	CAPmetals	CAPmud	TBI	Combined Health
HL	2	Oct-94	-0.033	-0.038	0.30	0.73
HL	6	Oct-95	-0.023	-0.022	0.33	0.62
HL	10	Oct-96	-0.029	-0.010	0.33	0.62
HL	14	Oct-97	0.010	0.029	0.32	0.69
HL	18	Oct-98	-0.024	-0.003	0.26	0.73
HL	22	Oct-99	0.037	0.063	0.30	1.00
HL	26	Oct-00	0.038	0.078	0.41	0.33
HL	30	Oct-01	-0.015	0.039	0.28	0.80
HL	34	Oct-02	0.038	0.066	0.35	0.67
HL	38	Oct-03	0.004	0.054	0.29	0.80
HL	42	Oct-04	0.010	0.038	0.37	0.69
HL	46	Oct-05	0.019	0.032	0.34	0.69
HL	50	Oct-06	0.029	0.066	0.30	0.67
HL	54	Oct-07	0.047	0.078	0.29	1.00
HL	58	Oct-08	0.036	0.066	0.39	0.67
HL	62	Oct-09	0.045	0.041	0.30	1.00
HL	66	Oct-10	0.012	0.063	0.38	0.69

HL	70	Oct-11	0.006	0.053	0.41	0.58
HL	74	Oct-12	0.013	0.064	0.45	0.58
HL	78	Oct-13	0.028	0.061	0.41	0.33
HL	82	Oct-14	-0.014	0.043	0.56	0.58
HL	86	Oct-15	-0.008	0.048	0.45	0.58
HL	90	Oct-16	0.016	0.053	0.42	0.58
HL	94	Oct-17	0.039	0.059	0.39	0.67

Site	Series	Time	CAPmetals	CAPmud	TBI	Combined Health
JB	2	Oct-94	-0.100	-0.068	0.71	0.38
JB	6	Oct-95	-0.101	-0.071	0.45	0.38
JB	10	Oct-96	-0.106	-0.085	0.53	0.38
JB	14	Oct-97	-0.104	-0.091	0.59	0.38
JB	18	Oct-98	-0.123	-0.111	0.40	0.49
JB	22	Oct-99	-0.090	-0.063	0.62	0.38
JB	26	Oct-00	-0.114	-0.103	0.68	0.38
JB	30	Oct-01	-0.081	-0.086	0.53	0.38
JB	34	Oct-02	-0.052	-0.075	0.46	0.44
JB	38	Oct-03	-0.091	-0.097	0.68	0.38
JB	42	Oct-04	-0.093	-0.085	0.67	0.38
JB	46	Oct-05	-0.071	-0.043	0.68	0.44
JB	50	Oct-06	-0.079	-0.082	0.67	0.38
JB	54	Oct-07	-0.112	-0.102	0.68	0.38
JB	58	Oct-08	-0.055	-0.058	0.84	0.44
JB	62	Oct-09	-0.106	-0.116	0.70	0.38
JB	66	Oct-10	-0.058	-0.057	0.92	0.44
JB	70	Oct-11	-0.095	-0.069	0.85	0.38
JB	74	Oct-12	-0.069	-0.043	1.07	0.44
JB	78	Oct-13	-0.073	-0.058	0.83	0.38
JB	82	Oct-14	-0.068	-0.037	0.85	0.44
JB	86	Oct-15	-0.039	-0.027	0.80	0.51
JB	90	Oct-16	-0.074	-0.050	0.90	0.44
JB	94	Oct-17	-0.090	-0.058	0.89	0.38

Site	Series	Time	CAPmetals	CAPmud	TBI	Combined Health
MH	2	Oct-94	-0.023	-0.038	0.27	0.73
MH	6	Oct-95	-0.013	-0.040	0.33	0.62
MH	10	Oct-96	-0.019	-0.067	0.36	0.56
MH	14	Oct-97	-0.031	-0.072	0.32	0.56
MH	18	Oct-98	-0.003	-0.041	0.32	0.62
MH	22	Oct-99	-0.007	-0.018	0.35	0.62
MH	26	Oct-00	0.030	-0.008	0.35	0.67
MH	30	Oct-01	0.013	-0.013	0.34	0.62
MH	34	Oct-02	0.037	0.020	0.27	1.00

MH	38	Oct-03	-0.046	-0.077	0.43	0.44
MH	42	Oct-04	-0.029	-0.034	0.34	0.62
MH	46	Oct-05	-0.041	-0.079	0.42	0.44
MH	50	Oct-06	0.010	-0.031	0.44	0.51
MH	54	Oct-07	-0.020	-0.059	0.35	0.56
MH	58	Oct-08	0.009	-0.030	0.51	0.51
MH	62	Oct-09	0.029	-0.027	0.33	0.67
MH	66	Oct-10	-0.011	-0.031	0.42	0.51
MH	70	Oct-11	0.005	0.015	0.42	0.51
MH	74	Oct-12	-0.007	0.018	0.49	0.51
MH	78	Oct-13	-0.027	0.019	0.50	0.51
MH	82	Oct-14	-0.021	0.018	0.52	0.51
MH	86	Oct-15	-0.007	0.035	0.45	0.58
MH	90	Oct-16	-0.013	0.025	0.35	0.69
MH	94	Oct-17	0.015	0.022	0.45	0.58

Site	Series	Time	CAPmetals	CAPmud	TBI	Combined Health
TK	2	Oct-94	-0.084	-0.073	0.49	0.38
TK	6	Oct-95	-0.103	-0.095	0.42	0.38
TK	10	Oct-96	-0.004	-0.009	0.30	0.73
TK	14	Oct-97	-0.021	-0.010	0.46	0.51
TK	18	Oct-98	-0.022	-0.007	0.31	0.62
TK	22	Oct-99	-0.019	-0.012	0.40	0.62
TK	26	Oct-00	-0.030	-0.036	0.48	0.51
TK	30	Oct-01	-0.035	-0.013	0.38	0.62
TK	34	Oct-02	-0.032	-0.030	0.42	0.51
TK	38	Oct-03	-0.011	-0.011	0.36	0.62
TK	42	Oct-04	-0.035	-0.021	0.56	0.51
TK	46	Oct-05	-0.025	-0.013	0.46	0.51
TK	50	Oct-06	-0.006	0.007	0.52	0.51
TK	54	Oct-07	-0.050	-0.016	0.47	0.51
TK	58	Oct-08	0.004	0.028	0.48	0.58
TK	62	Oct-09	-0.026	0.009	0.44	0.51
TK	66	Oct-10	-0.022	0.002	0.45	0.51
TK	70	Oct-11	-0.033	-0.003	0.48	0.51
TK	74	Oct-12	-0.018	-0.015	0.51	0.51
TK	78	Oct-13	-0.019	0.018	0.42	0.51
TK	82	Oct-14	-0.023	-0.004	0.57	0.51
TK	86	Oct-15	-0.008	0.008	0.45	0.51
TK	90	Oct-16	-0.023	0.007	0.39	0.62
TK	94	Oct-17	-0.014	-0.010	0.51	0.51

Find out more: phone 09 301 0101, email rimu@aucklandcouncil.govt.nz or visit aucklandcouncil.govt.nz and knowledgeauckland.org.nz

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Te Kaunihera o Tāmaki Makaurau