CAWTHRON

# Baseline Monitoring Of Port Tarakohe, Golden Bay

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CAWTHRON

# Baseline Monitoring Of Port Tarakohe, Golden Bay

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# EXECUTIVE SUMMARY

This report provides a baseline assessment of sediment properties and benthic biological composition undertaken 7-8 April 2005 in Port Tarakohe. The objective of this investigation was to describe the status of sediment physico-chemical properties and the infauna and epibiota communities at four sites likely to be exposed to ongoing impacts due to port activities.

Sediment physical and chemical characteristics at the four sites were generally consistent with previously reported values for other near shore locations in the Golden Bay and Tasman Bay region. Sediments were largely dominated by silt/clay mixed with various amounts of sand and a minimal component of coarse gravel. Organic contents ranged from moderate to slightly elevated at the sites and followed a similar distribution to the silt/clay content.

Concentrations of sediment trace metals (cadmium, chromium, copper, lead, mercury, zinc) and the metalloid arsenic were all well below the ANZECC (2000) interim sediment quality guideline (ISQG) levels that are used to indicate potential biological effects. Nickel concentration exceeded the ISQG-low guideline level at all four sites, indicating a 'possible' biological effect from Ni. The elevated levels of Ni, however, were consistent with previously reported levels for the region, and are considered to be related to natural mineral deposits within adjacent catchments. Although no ISQG guidelines are available for tin, concentrations were below instrument detection limits and therefore considered not to be of environmental concern. All semi-volatile organic compounds were also below instrument detection limits, and not considered to be of environmental concern.

Benthic infauna characteristics were variable between replicates, suggesting a patchy distribution of species. The Main Wharf site was dominated largely by opportunistic polychaete species that are able to tolerate disturbance, indicating a moderately compromised environmental condition. The abundance of polychaetes at this site was most likely due to factors other than sediment contaminant levels (*e.g*. physical disturbance).

Qualitative assessment of epibiota indicated the presence of common hard substrate sessile invertebrates such as barnacles, oysters, blue mussels, sea-squirts, and bryozoans. The red alga *Gelidium* sp. was also conspicuous at all sites, and the invasive alga *Undaria* sp. was abundant at the Pontoon site. The invasive ascidians *Styela clava* and *Didemnum vexillum* were not identified, but recent reporting of *D. vexillum* in the Port has raised concerns about the potential for exotic species to become established, and the need to identify vectors of exotic pest translocation.

In general, no elevated levels of potential contaminants were observed in the port, but there were indications of low to moderate disturbances at the Wharf site revealed by the benthic infauna community composition.

Ongoing monitoring of sediment physico-chemical properties, and epibiota and benthic infauna are warranted given the potential for increased use of the port region. Future monitoring should be expanded to include reference sites outside the influence of Port activities, and increased sample

replicates would enable changes to be detected over time. Particular monitoring emphasis should be placed on potentially invasive species including *S. clava* and the status of *D. vexillum*.

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# 1. INTRODUCTION

In April 2005, Tasman District Council (TDC) commissioned the Cawthron Institute (Cawthron) to undertake a baseline environmental assessment of Port Tarakohe, Golden Bay. The purpose of the study was to measure a suite of components of sediment quality and collect information on plant and animal communities within the Port environs. This was intended to provide a baseline record of the environmental status prior to any further developments/port-related activities which may take place in the future, and form the basis for ongoing monitoring.

# 2. STUDY SITES

Field assessments and sampling were undertaken in Port Tarakohe on 7 and 8 April 2005. Four subtidal study sites (2-7.2 m) were established for field assessment and collection of sediment samples (Figure 1, Figure 2, Appendix 1) and epibiota were semi-quantitatively inspected on adjacent intertidal substrata. The sites were designated: Main Wharf, Boat Ramp, Pontoon Marina and Moorings. The three inner Port sites were selected in order to assess baseline conditions within regions that are likely to be most affected by future Port activities. The fourth site was established in an outer Port region that, although modified to some extent and potentially affected by mooring facilities and their future usage, will likely remain in a more natural state. No attempt was made to incorporate reference or "control" sites into the sampling design as this was beyond the scope of this study. Nevertheless the site locations will enable detection of gross changes in environmental quality that can logically be explained by activities occurring within the Port.


**Figure 1.** Location of sampling sites in Port Tarakohe, Golden Bay.

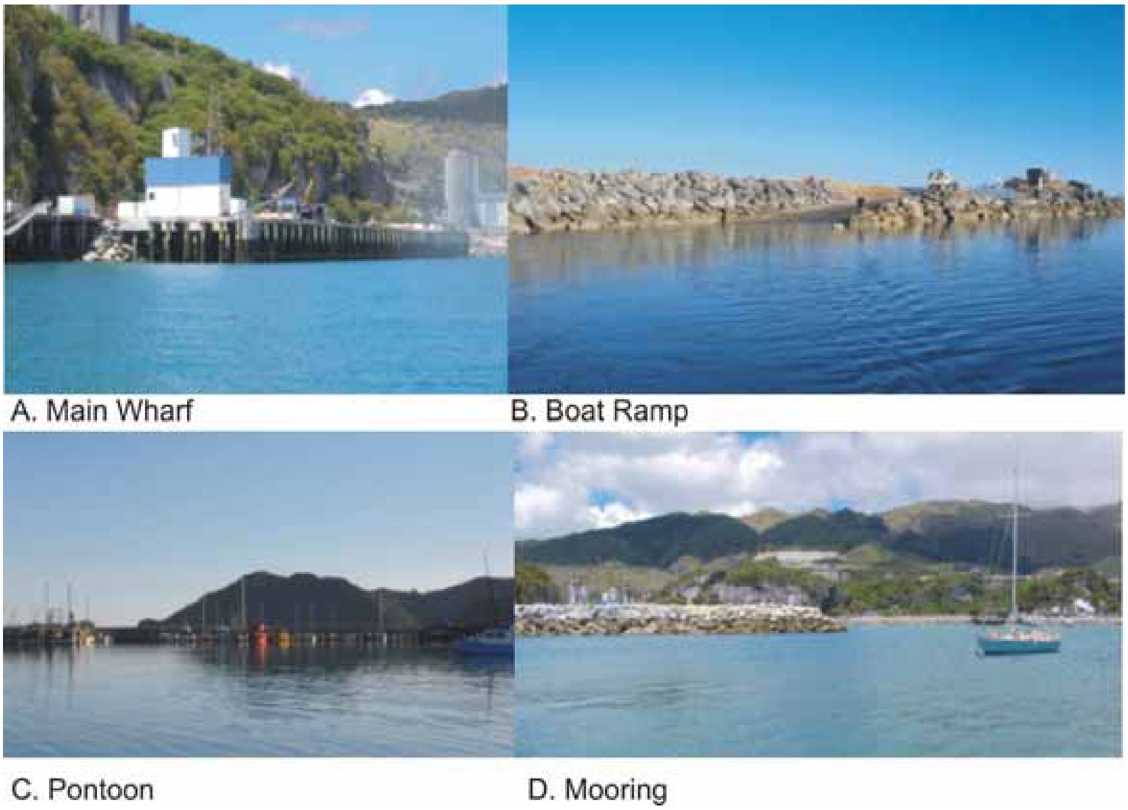


**Figure 2.** Photographs of sample sites in Port Tarakohe.

# 3. METHODS

## 3.1. Sampling and field procedures

### *3.1.1. Sediments*

Three replicate sediment cores were collected at each site for determination of physico-chemical properties. Perspex tubes (60 mm internal diameter) were manually driven into the seabed to a depth of 100-150 mm. The colour profiles of the cores and the presence/absence of anoxic patches within the sample were recorded and the depth of any obvious redox potential discontinuity (RDP) layer was measured. The cores were then photographed to provide a permanent visual record. The top 2 mm of the replicate cores were mixed thoroughly to provide one composite sample per site.

### *3.1.2. Infauna*

Benthic infauna were sampled at each site using three replicate 131 mm internal diameter PVC tubes fitted with 0.5 mm nylon mesh bags for sieving. The PVC tubes were manually driven approximately 100 mm into the sediment, removed with the core intact, and the contents gently washed through the sieve. The residual was emptied into a plastic container and preserved with 70% ethanol containing 1% glyoxal as a fixative and returned to the laboratory for processing.

### 3.1.3. *Epibiota*

Conspicuous epiflora and fauna (large-bodied, sediment surface-dwelling or sessile, hard substrata-dwelling species) were semi-quantitatively assessed on intertidal habitat near the location of each subtidal site. The general substrate features and species present were recorded. The number of individuals of the observed species were ranked (per square metre) as rare (0-2), occasional (3-5), common (6-10), or abundant (>10). Representative structures were photographed at each site to provide a permanent record for qualitative assessment.

## 3.2. Sediment physico-chemical properties

### 3.2.1. *Analyses*

Each composite sediment sample was analysed for particle size distribution, organic content (ash free dry weight), trace metals, semi volatile organic compounds (SVOCs), and total recoverable tin. Analytical methods are summarised in Table 1.

**Table 1.** Summary of analytical methods.

| Matrix | Analyte | Method Number | Description |
|---|---|---|---|
| Sediment | Particle size[1] | Cawthron SOP No. 33074 | Wet sieved through screen sizes:<br>Gravel (>2mm)<br>Sand (<2mm – >63µm)<br>Silt & Clay (<63µm) |
| Sediment | Organic Content (AFDW[2]) | APHA 20$^{th}$ Ed 2540D (modified) | Sample dried at 105°C then ashed at 550°C |
| Sediment | Trace metals (As, Cd, Cr, Cu, Ni, Pb, Zn)<br>Hg | USEPA 200.2 mod./ APHA metals by ICP-OES<br>USEPA 245.5 | Nitric/hydrochloric acid digestion. Detected by inductively coupled plasma optical emission spectroscopy (ICP-OES) |
| Sediment | SVOCs<br>Total recoverable tin | USEPA 3540, 3550, 3640 & 8270<br>USEPA 200.2 | Sonication or Accelerated Solvent Extraction (ASE). Detected by GC-MS.<br>Nitric/hydrochloric acid digestion. Detected by ICP-MS |

[1] Size classes from Udden-Wentworth scale.
[2] AFDW = ash free dry weight

### 3.2.2. *Rationale*

Sediment texture (particle size distribution) is an important variable when assessing sediment chemistry and ecology, as it can play a significant role in determining the chemical make-up of sediments (*e.g.* the capacity of the sediments for the adsorption and retention of contaminants and nutrients) and the range of organisms that may live in them. For example, muddy sediments tend to have a relatively higher organic and nutrient content, and may act as sinks for binding of trace/heavy metal contaminants. Sediment texture is also an important factor that controls the biological structure of seabed habitats, whereby the types of organisms encountered in sandy sediments are generally different to those in muddy sediments. Sediment texture is therefore a useful companion measure of the physical characteristics that can facilitate interpretation of differences between sites and over time

Sediment organic content can be used as a measure of the relative state of enrichment of benthic habitats. Considerable data describing the percentage of organic content (% AFDW) of coastal sediments in the Nelson Bays region is available for comparison.

Trace metals and semi-volatile organic compounds are often ubiquitous stormwater-related contaminants that may be derived from road transport, urban road runoff, and agricultural runoff. Sn and Cu are often associated with antifoulant usage and hull cleaning activities. The full suite of metals analysed includes arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), zinc (Zn), total recoverable tin (Sn), and the metalloid (As).

## 3.3. Infauna

### *3.3.1. Analyses*

Benthic infauna samples were sorted, identified to the lowest practicable taxonomic level and counted with the aid of a binocular microscope.

### *3.3.2. Rationale*

Sediment infauna (defined as sediment-dwelling animals retained on a 0.5 mm sieve) are frequently used in pollution monitoring in the vicinity of ports, harbours and outfalls. Various characteristics of the infauna community may provide a spatial and temporal indication of the health of the environment.

## 3.4. Epibiota

### *3.4.1. Analyses*

Epibiota analyses were carried out in the field (see Section 3.1.3).

### *3.4.2. Rationale*

Port environments are at risk for the introduction and spread of species not currently present in the Port or the region. These may be exotic species or naturally occurring species brought into the Port environment as a result of shipping activities. Such introductions may be enabled or enhanced by modification of existing habitat and/or creation of new colonisation sites (*e.g.* wharfs, moorings, seawalls *etc*.). A detailed baseline of existing epibiota is essential to detection of colonisation by potentially invasive species.

## 3.5. Data analysis

Where possible, analytical results were compared with available data previously collected for the region (various Cawthron client reports).

Observed sediment contaminant concentrations *e.g.* trace metal analyses were compared against national sediment quality criteria (ANZECC 2000). These guidelines aim to predict 'acceptable' levels of contaminants in sediment, above which adverse ecological effects may occur. The criteria are defined as Interim Sediment Quality Guideline-Low (ISQG-low) and Interim Sediment Quality Guideline-High (ISQG-high) representing two distinct threshold levels above which biological effects are predicted. The criteria are based on statistical models of toxicity data to give a level of probability of detecting adverse effects at particular contaminant levels. The lower threshold (ISQG-low) indicates a possible biological effect and acts as a trigger for further investigation, while the upper threshold (ISQG-high) indicates a probable biological effect.

The number of taxa, and their density, evenness and diversity were calculated for each site (Table 2). The maximum value for the diversity index (H) is dependent on the number of categories or species sampled for a given data set. Values typically range between 0 (indicating low community complexity) and 4 (indicating high complexity). The evenness value (E) ranges from 0 (highly irregular distribution) to 1 (regular distribution).

**Table 2.** Descriptors of macro-invertebrate community characteristics.

| Descriptor | Equation | Description |
|---|---|---|
| No. species (S) | Count (taxa) | Total number of species in a sample. |
| No. individuals (N) | Sum (n) | Total number of individual organisms in a sample. |
| Evenness (J') | $J' = H'/Log_e(S)$ | Pielou's evenness. A measure of equitability, or how evenly the individuals are distributed among the different species. Values can theoretically range from 0.00 to 1.00, where a high value indicates and even distribution and a low value indicates an uneven distribution or dominance by a few taxa. |
| Diversity (H' $log_e$) | $H' = -SUM(Pi*log_e(Pi))$ | Shannon-Wiener diversity index (log e base). A diversity index that describes, in a single number, the different types and amounts of animals present in a collection. Varies with both the number of species and the relative distribution of individual organisms among the species. The index ranges from 0 for communities containing a single species to high values for communities containing many species and each with a small number of individuals. |

The infauna assemblages recorded were then contrasted using non-metric multidimensional scaling or MDS (Kruskal & Wish. 1978) and ordination and cluster diagrams based on Bray-Curtis similarities (Clarke & Warwick. 1994)). Abundance data were square-root transformed to de-emphasise the influence of the dominant species (by abundance). The major taxa contributing to the similarities of each group (areas) were identified using analysis of similarities (SIMPER; Clarke & Warwick 1994). All multivariate analyses were performed with PRIMER v5 software.

# 4. RESULTS AND DISCUSSION

## 4.1. Sediment physical and chemical properties

### *4.1.1. Visual description of sediment cores*

The core photographs are shown in Figure 3. The sediment profiles indicated fairly uniform muddy sand textures throughout the depth of the cores. The RPD layers were indistinct with light grey surface layers of approximately 90 mm depth at the Moorings site, 25 mm at the Main Wharf site and 15-16 mm at the remaining sites, indicating relatively well oxygenated conditions with no evidence of sediment anoxia (*i.e.* black layers or mottling). The sediment cores from the Main Wharf displayed the most distinct layering of light over darker sediments.

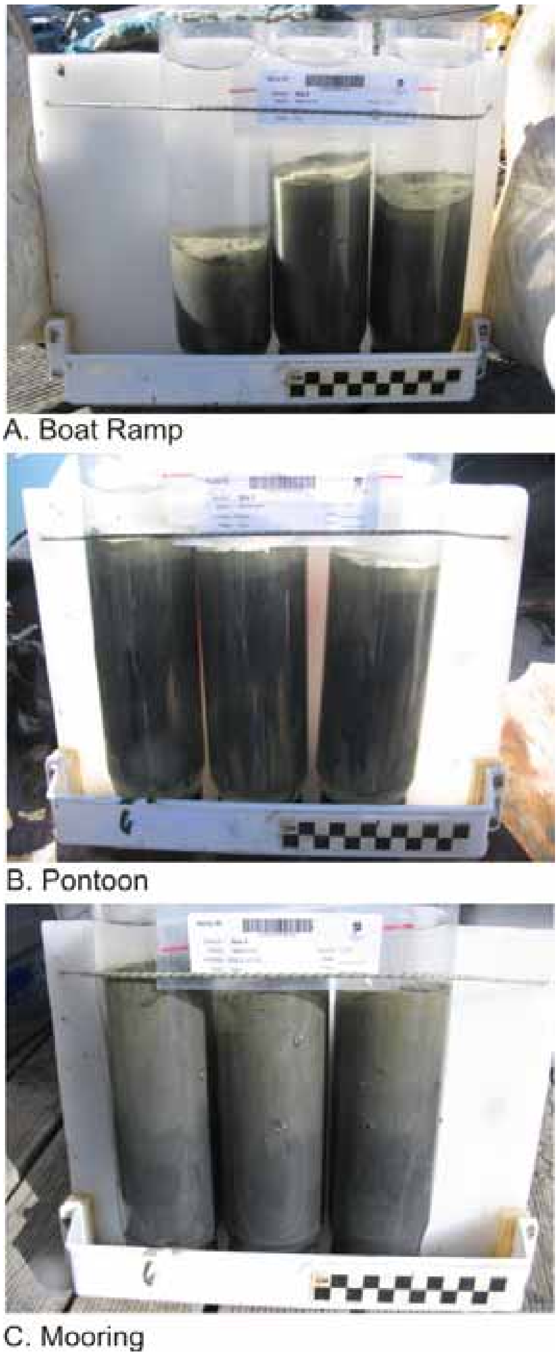


**Figure 3.** Sediment cores from Port Tarakohe. Sediment core photograph from the Main Wharf site was not available.

### *4.1.2. Particle size and chemistry*

In general, the particle size results (Figure 4) confirmed visual observations of the core profiles, that fine sand and mud were the dominant particle size classes. The Moorings, Pontoon and Main Wharf sites were mud dominated (~90 %, 59 and 73 % silt/clay respectively) while the Boat Ramp site was sand dominated (59 %).

Sediment organic contents ranged from 3.9 to 7.6 % at the four sites (Figure 5), and the distribution among sites was strongly correlated with the silt/clay content ($r^2$ = 0.96). The Moorings and Pontoon sites had the highest AFDW concentrations (7.6 and 6.8 % respectively) indicating slight to moderately rich benthic conditions, while slightly lower concentrations were observed at the Main Wharf and Boat ramp sites (4.9 and 3.9 % respectively.

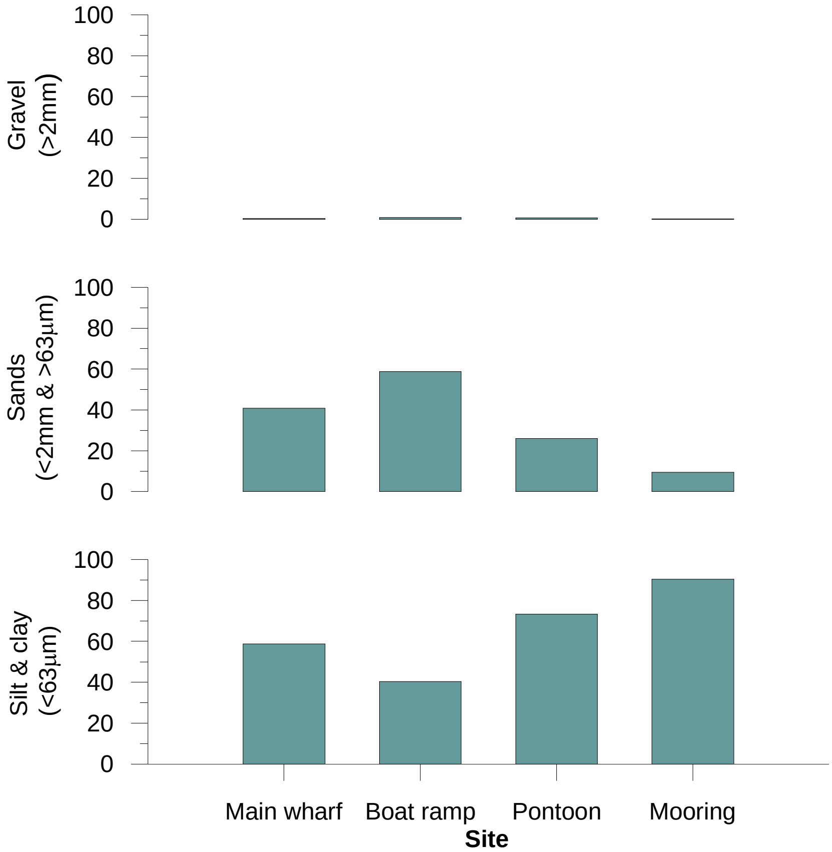


**Figure 4.** Sediment particle size distribution.

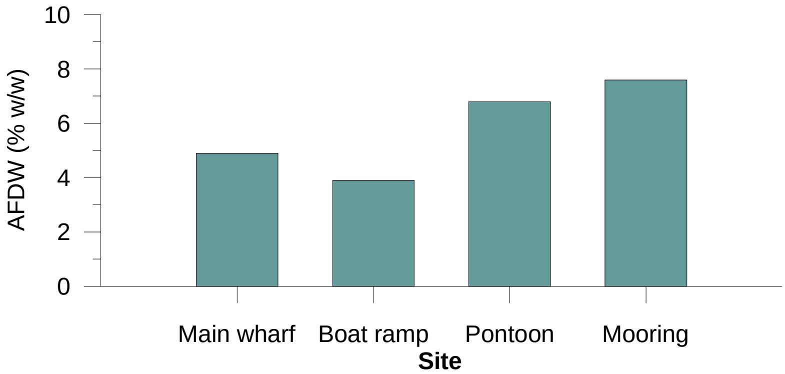


**Figure 5.** Sediment organic content (% ash free dry weight w/w).

Hg, As, Cd, Cr, Cu, Pb and Zn concentrations (Figure 6) were all below ANZECC (2000) ISQG-Low sediment quality guideline levels. Cd, Hg and total Sn were all below the analytical detection limit of the instrument. Ni concentrations exceeded ISQG-low guideline levels at all four sites. Levels were highest at the Pontoon site (36 mg/kg) and ranged from 29-32 mg/kg at the other sites. This is consistent with previous reports of elevated Ni for coastal sites in the Tasman Bay region (Forrest et al. submitted, Gillespie & Clark 2006).

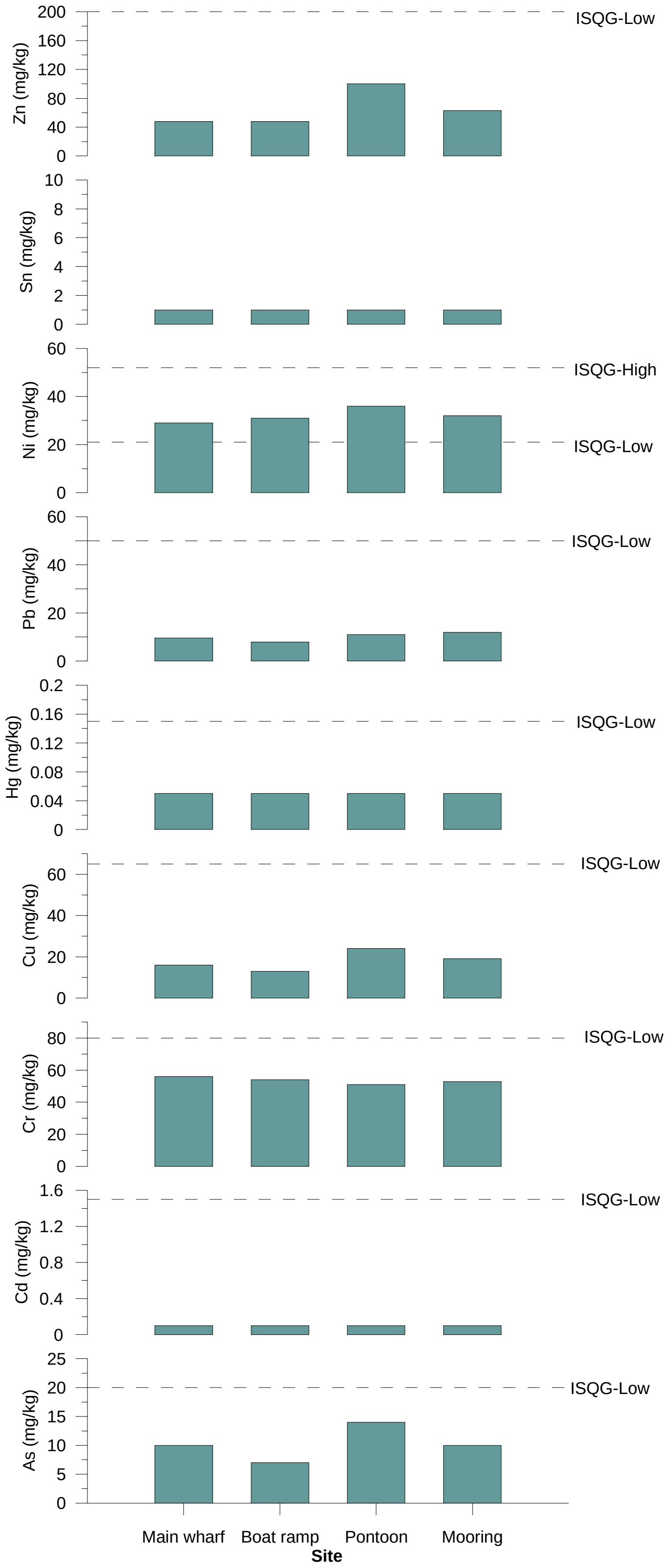


**Figure 6.** Sediment trace metal concentration (mg/kg). Dotted lines represent sediment quality guideline levels for ANZECC (2000) ISQG-Low and High criteria. Cd, Hg, and Sn concentrations were all below instrument detection. There are no ISQG guidelines for total Sn.

The full suite of SVOCs is listed in Appendix 2. The sediment levels of SVOCs at all sites were below instrument analytical detection limits, and therefore considered not to have been enriched in sediments within the Port region.

## 4.2. Biological properties

### *4.2.1. Benthic infauna*

The full set of infauna data are presented in Appendix 3. The mean density, species richness, and Shannon-Weiner diversity (H) and evenness (E) indices are presented in Figures 7 and 8. Interpretation of infauna results was somewhat compromised due to the low number of replicate samples analysed and the high variability amongst them.

Infauna density was the highest at the Main Wharf, ranging from 250-636 individuals per core and lowest at the Pontoon and Moorings sites, ranging from 104-110 and 58-111 individuals per core respectively. Infauna density was slightly elevated at the Ramp site, ranging from to 152-327 individuals per core.

Species richness was similar at the Main Wharf, Ramp and Pontoon sites, ranging from 15-26 taxa per core, with the Main Wharf having the most variation between cores (Figure 5). Species richness at the Moorings site was the lowest, ranging from 10-12 taxa per core. The higher number of taxa at the Main Wharf was due to the presence of a single individual of some taxa in one of the replicate core samples, and indicates that the distribution of these taxa is patchy and inconsistent at this site.

The Shannon-Weiner diversity index was moderate for all sites, indicating a medium level of complexity in species composition. Diversity was lowest at the Main Wharf (~1.6-1.9), and highest at the Boat Ramp site (~2.2-2.4). Evenness was the lowest at the Main Wharf (range (0.57-0.63), and highest at the Mooring site (0.83-0.86). These patterns in community composition were largely due to the dominance of several polychaete species at the Main Wharf, and the presence of other taxa, such as gastropods, bivalves and amphipods at the other sites.

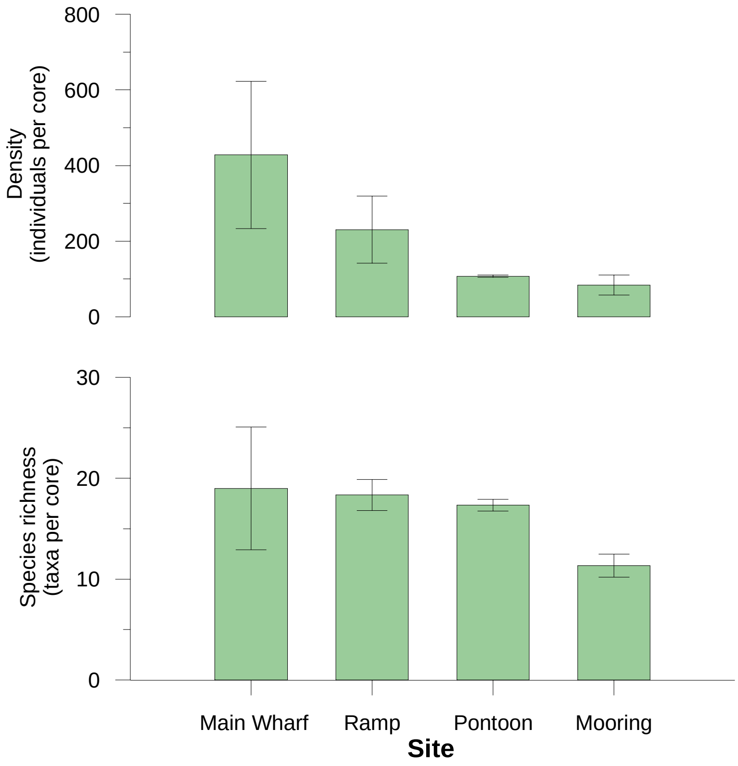


**Figure 7.** Infauna density and species richness at sites sampled in Port Tarakohe. Data are mean values (± SD).

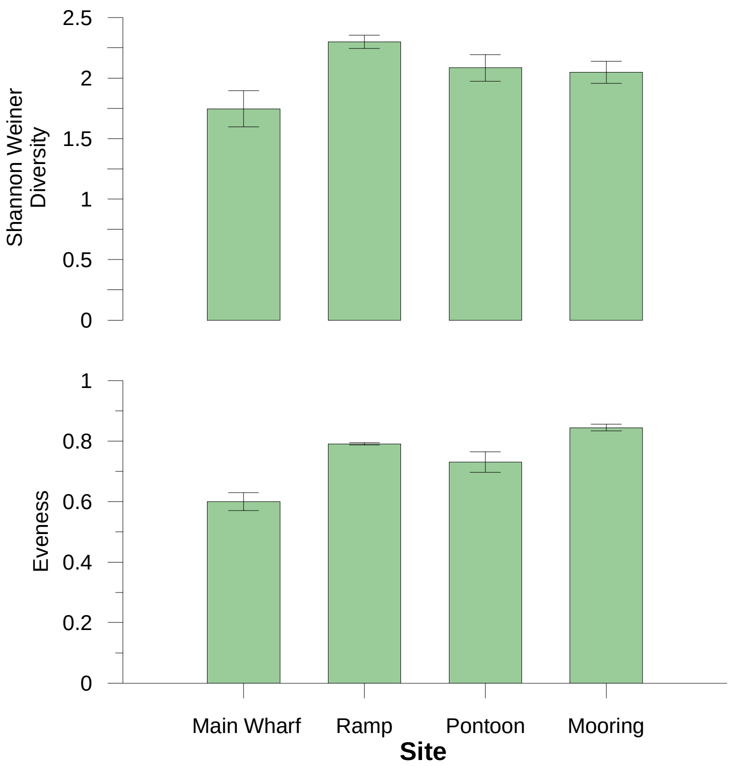


**Figure 8.** Shannon-Weiner diversity (H) and evenness (E) indices at sites sampled in Tarakohe Port. Data are mean values (± SD).

The density of several families of polychaete worms have commonly been used as an indicator of biotic 'health' of a given area (ANZECC 2000). These typically include the dominance of capitellid worms (*e.g*. *Heteromastus filiformis*) or spionid worms (*eg*. *Prionospio* sp.). For most of the sample stations in Port Tarakohe, a range of such opportunistic species of polychaetes dominated the community structure. In particular, the Main Wharf site was dominated by opportunistic polychaetes (*Prionospio* sp., *H. filiformis*) and nematodes which are characteristic of physically disturbed or organically enriched sediments. These polychaete species were also abundant at the Ramp and Pontoon sites. The deposit feeding polychaete *Cossura consimilis* was abundant at all four sites.

The dominant species contributing to the infauna composition at sample sites in Port Tarakohe are shown in Table 3. Multi-dimensional scaling based on benthic infauna communities showed distinct groupings (at the 60 % level similarity) of the Main Wharf, Ramp and Pontoon/Moorings sites (Figure 9). Similarity in species assemblages was the highest at the Ramp site (74 %), followed by the Moorings site (71 %). At the Main Wharf, the polychaetes *Prionospio* sp., *C. consimilis* and *H. filiformis*, were dominant contributors to community structure. At the Ramp site, the community structure was dominated by the bivalves *Theora lubrica* and *Nucula cf gallinacea*, and the polychaetes *Prionospio* sp. and *H. filiformis*.

Other co-dominant species included an amphipod at the Moorings site, and the bivalve *Serratina charlottae* at the Pontoon site.

**Table 3.** Average abundance and similarity of benthic infauna species within Port Tarakohe. Includes the major contributing taxa (up to 70 %) based on a square-root transformation.

| Site/Species | Av Abund | Av. Sim | Sim/SD | % Contrib | % Cum |
|---|---|---|---|---|---|
| **Main Wharf** | | | | | |
| **Average similarity: 68.13** | | | | | |
| *Prionospio* sp. | 150.67 | 18.21 | 5.86 | 26.73 | 26.73 |
| *Cossura consimilis* | 87 | 11.75 | 8.72 | 17.24 | 43.97 |
| *Heteromastus filiformis* | 67 | 10.43 | 6.91 | 15.31 | 59.28 |
| Nematoda | 66 | 7.79 | 1.6 | 11.43 | 70.72 |
| **Ramp** | | | | | |
| **Average similarity: 74.79** | | | | | |
| *Theora lubrica* | 40 | 10.49 | 4.98 | 14.02 | 14.02 |
| *Prionospio* sp. | 32.33 | 8.07 | 15.45 | 10.79 | 24.81 |
| *Heteromastus filiformis* | 26.33 | 7.54 | 19.23 | 10.08 | 34.89 |
| *Nucula cf gallinacea* | 24.67 | 7.3 | 19.74 | 9.76 | 44.65 |
| *Serratina charlottae* | 35.33 | 7.26 | 10.25 | 9.71 | 54.36 |
| Amphipoda A | 14.67 | 6.83 | 8.07 | 9.13 | 63.5 |
| *Cossura consimilis* | 18.67 | 6.18 | 3.61 | 8.26 | 71.76 |
| **Pontoon** | | | | | |
| **Average similarity: 67.86** | | | | | |
| *Theora lubrica* | 31 | 15.27 | 95.61 | 22.5 | 22.5 |
| *Heteromastus filiformis* | 26.33 | 12.17 | 9.04 | 17.93 | 40.43 |
| *Nucula cf gallinacea* | 8 | 7.51 | 8.09 | 11.07 | 51.5 |
| *Cossura consimilis* | 5 | 5.93 | 13.57 | 8.74 | 60.24 |
| *Serratina charlottae* | 8 | 5.93 | 18.05 | 8.73 | 68.97 |
| *Prionospio* sp. | 9 | 4.81 | 3.7 | 7.08 | 76.05 |
| **Moorings** | | | | | |
| **Average similarity: 71.0** | | | | | |
| Amphipoda A | 17.67 | 13.77 | 13.44 | 19.4 | 19.4 |
| *Theora lubrica* | 17 | 9.9 | 2.57 | 13.94 | 33.34 |
| *Prionospio* sp. | 9.33 | 9.74 | 13.44 | 13.72 | 47.05 |
| *Nucula cf gallinacea* | 9.67 | 9.36 | 6.71 | 13.18 | 60.24 |
| *Cossura consimilis* | 6.67 | 7.6 | 8.52 | 10.71 | 70.94 |

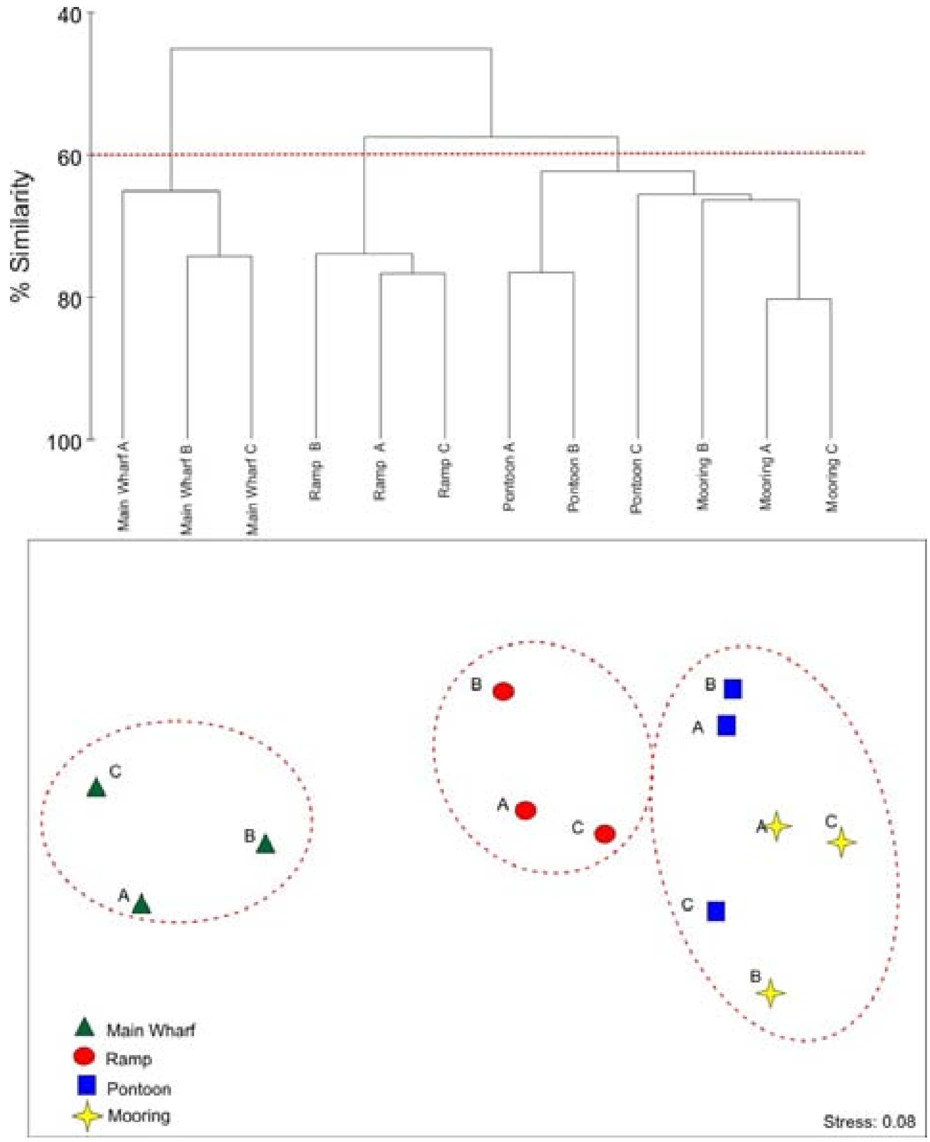


**Figure 9.** Cluster diagram and multi-dimensional scaling plot of infauna sampled at four sites in Port Tarakohe. Data were square-root transformed count data. MDS clusters are formed at 60% level similarity (Stress = 0.08).

### *4.2.2. Epibiota*

A summary of the conspicuous epibiota observed at each site is listed in Table 3. No epifaunal species of special ecological or conservational value were observed in densities above trigger values identified in the DoC (1995) guidelines. The gastropods *Notoacmea* sp. and *Turbo smaragdus* were abundant at the Mooring site, and present in lower numbers at the Pontoon and Ramp site. The Main Wharf was dominated by the presence of barnacles, and the invasive bryozoan *Watersipora subtorquata*. The pilings at the wharf were also encrusted with occasional clumps of mussels, oysters, and saddle squirts. The Pontoon site contained occasional clumps of bivalves and saddle squirts.

Several species of algae were also observed at all sites, and were largely dominated by the red algae *Gelidium* sp.

The potentially invasive sea squirt, *Didemnum vexillum*, was not observed at the study sites at the time of the survey, however we note that its presence in Port Tarakohe was recently confirmed on 9 June 2006, and an attempted eradication program established on 20 June 2006 (A. Coutts, Cawthron, pers. comm.). Although not observed during the present study, the invasive sea squirt may have been present at other locations within the Port environs. The eradication of *D. vexillum* from other regional ports has been the subject of a control programme by the New Zealand Mussel Industry since 2002. The distribution of *D. vexillum* has been reported in both Whangamata and Tauranga in the Bay of Plenty, and is reported to be widespread in Queen Charlotte Sound at the top of the South Island. The current report of *D. vexillum* in Tarakohe is of particular significance, as it is in close proximity to the established mussel farms in Wainui Bay, and is also adjacent to the coastal boundaries of the Abel Tasman National Park.

A potential invasion by the solitary ascidian *Styela clava* is an additional concern, as it has recently been reported in Port Nelson. Previous reported locations of *S. clava* in New Zealand are Hauraki Gulf, Lyttelton Harbour, and Tutuke Marina (Northland).

Vectors for transport of invasive species into Port Tarakohe are most likely to be sourced from fouling animals on hulls of vessels (commercial and recreational) moving in and out of the Port from other regional ports. Ongoing monitoring of vessel traffic, including information on origin of potentially high risk vessels may be beneficial in identifying the risk of unwanted species being introduced.

**Table 4.** Abundance of epibiota with habitats adjacent to study sites (r = rare 0-2, o = occasional 3-5, c = common 6-10, a = abundant >10).

| Taxa/species | Main wharf | Pontoon | Boat Ramp | Moorings |
|---|---|---|---|---|
| | Wharf piles and rock wall | Boulders/rocks/ cobbles/gravel | Boulder beach, fine silty muddy seabed | Cobble and boulder |
| **Molluscs** | | | | |
| **Gastropods** | | | | |
| *Notoacmea* sp. (limpet) | r | r | o | a |
| *Turbo smaragdus* (cats eye) | - | c | c | a |
| *Maoricolpus roseus* | - | - | - | o |
| **Bivalves** | | | | |
| *Crassostrea gigas* (pacific oyster) | - | r | - | - |
| *Mytilus edulis* (blue mussel) | c | o | - | - |
| *Perna canaliculus* (green mussel) | - | r | o | o |
| *Monia zelandica* (Window oyster) | a | - | - | c |
| **Chitons** | | | | |
| *Acanthochitona zelandica* | - | - | o | o |
| **Crustaceans** | | | | |
| Paguridae (hermit crab) | - | - | o | - |
| *Palaemon affinis* (shrimp) | - | o | - | o |
| Cirripedia (barnacles) | a | - | - | - |
| **Ascidians** | | | | |
| *Cnemidocarpa bicornuata* (saddle squirt, solitary ascidian) | c | o | - | o |
| *Botrylloides* sp. (colonial ascidian) | o | - | - | - |
| *Aplidium* sp. (colonial ascidian) | | o | | |
| **Bryozoans** | | | | |
| *Watersipora subtorquata* (encrusting) | a | - | - | - |
| *Bugula* sp. (arborescent) | o | o | - | - |
| **Echinoids** | | | | |
| Cushion stars - *Patiriella regularis* | - | o | c | r |
| Kina - *Evechinus chloroticus* | - | - | o | o |
| **Polychaetes** | | | | |
| *Galeolaria hystrix* | o | c | c | a |
| Spirorbidae | - | - | - | o |
| **Fish** | | | | |
| *Forsterygion* sp. (black triplefin) | o | c | c | a |
| **Algae** | | | | |
| *Colpmenia sinuosa* | r | - | - | - |
| Coralinacea (pink coralline algae) | - | - | c | a |
| *Laurencia thyrsifera* | r | - | - | - |
| *Ceramium apiculatum* | r | - | - | - |
| *Undaria* sp. | - | a | - | - |
| *Anotrichium sp. c.f Sargussum sinclairii* | - | r | - | - |
| *Carpophyllum maschalocarpum* | r | - | - | - |
| *Ulva lactuca* (sea lettuce) | r | - | - | - |
| *Polysiphonia* sp. | - | a | - | - |
| *Codium fragile* | - | o | - | - |
| *Polysiphonia* sp. (red alga) | - | a | - | - |
| *Gelidium* sp. (red alga) | a | a | a | a |
| **Number of taxa** | **14** | **16** | **11** | **15** |

# 5. SUMMARY

Sediment physical and chemical characteristics at the four sites were generally consistent with previously reported values for other near shore locations in the Golden Bay and Tasman Bay region. Sediments were largely dominated by silt/clay mixed with various amounts of sand and a minimal component of coarse gravel.

Organic contents ranged from moderate to slightly elevated at the sites and followed a similar distribution to the silt/clay content.

Concentrations of sediment trace metals (cadmium, chromium, copper, lead, mercury, zinc) and the metalloid arsenic were all well below the ANZECC (2000) interim sediment quality guideline levels that are used to indicate potential biological effects. Nickel concentration exceeded the ISQG-low guideline level at all four sites, indicating a 'possible' biological effect from Ni. The elevated levels of Ni, however, were consistent with previously reported levels for the region, and are considered to be related to natural mineral deposits within adjacent catchments. Although no ISQG guidelines are available for tin, concentrations were below instrument detection limits and therefore considered not to be of environmental concern. All semi volatile organic compounds were also below instrument detection limits, and not considered to be of environmental concern.

Benthic infauna characteristics were variable between sites, suggesting a patchy distribution of species. The Main Wharf site was dominated largely by opportunistic polychaete species that are able to tolerate disturbance, indicating a moderately compromised environmental condition. The abundance of polychaetes at this site was most likely due to factors other than sediment contaminant levels (*e.g.* physical disturbance).

Qualitative assessment of epibiota indicated the presence of common hard substrate invertebrates such as barnacles, oysters, blue mussels, sea-squirts, and bryozoans. The red alga *Gelidium* sp. was also conspicuous at all sites.

In general, no elevated levels of potential contaminants were observed in the port, but there were indications of low to moderate disturbances at the Wharf site revealed by the benthic infauna community composition.

# 6. RECOMMENDATIONS

Ongoing monitoring of sediment physico-chemical properties, and epibiota and benthic infauna are warranted given the potential for increased use of the port region. However some consideration should be given to enhancing the study design with the inclusion of comparable reference sites outside the influence of port activities and additional replicates for the various analyses. These changes would be required to enable detection of changes over time using a Before After Control Impact (BACI) design framework.

Particular monitoring emphasis should be placed on potentially invasive species including *Didemnum vexillum* and *Styela clava.* Monitoring for these potentially invasive species should include a more detailed description and quantitative assessments of epibiota on the Port structures, and assessment of vessels that may pose an increased risk of introducing these species into the Port.

# 7. ACKNOWLEDGEMENTS

Thankyou to Ashley Coutts (Cawthron) for information relating to *Didemnum vexillum* and *Styela clava*.

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# 9. APPENDICES

**Appendix 1.** Seabed sampling coordinates.

| Site | Depth | NZMG_E | NZMG_N |
|---|---|---|---|
| Main wharf | 4.8 | 2501396.181 | 6042571.056 |
| Boat Ramp | 2 | 2501084.079 | 6042542.932 |
| Pontoon marina | 7.2 | 2501307.408 | 6042739.754 |
| Mooring site | 6.3 | 2501186.643 | 6042848.446 |

**Appendix 2.** Semi-volatile organic concentrations in sediments from four areas within the Port Tarakohe study area.

| SVOC | Main wharf mg/kg dry wt | Boat ramp mg/kg dry wt | Pontoon marina mg/kg dry wt | Moorings site mg/kg dry wt |
|---|---|---|---|---|
| **Bis(2-chloroethyl)ether** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **1,3-Dichlorobenzene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **1,4-Dichlorobenzene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **1,2-Dichlorobenzene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Bis(2-chloroisopropyl)ether** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **N-nitrosodi-n-propyl amine** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Hexachloroethane** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Nitrobenzene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Isophorone** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Bis(2-chloroethoxy)methane** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **1,2,4-Trichlorobenzene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Naphthalene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Hexachlorobutadiene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **2-Methylnaphthalene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **2-Chloronaphthalene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Acenaphthylene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **2,6-Dinitrotoluene** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Acenaphthene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Dibenzofuran** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **2,4-Dinitrotoluene** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Fluorene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **4-Chlorophenylphenylether** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **N-Nitrosodiphenylamine** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Hexachlorobenzene** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Phenanthrene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Anthracene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Carbazole** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Fluoranthene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Pyrene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Benzo[a]anthracene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Chrysene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Benzo[b]fluoranthene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Benzo[k]fluoranthene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Benzo[a]pyrene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Indeno(1,2,3-c,d)pyrene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Dibenzo[a,h]anthracene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **Benzo[g,h,i]perylene** | < 0.07 | < 0.06 | < 0.08 | < 0.09 |
| **3,3'-Dichlorobenzidine** | < 0.7 | < 0.6 | < 0.8 | < 0.9 |
| **Dimethylphthalate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Diethylphthalate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Di-n-butylphthalate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Bis(2-ethylhexyl)phthalate** | < 0.7 | < 0.6 | < 0.8 | < 0.9 |
| **Di-n-octylphthalate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Butylbenzylphthalate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Di-(2-ethylhexyl)adipate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Alpha BHC** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Beta BHC** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Gamma BHC (Lindane)** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Delta BHC** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |

**Appendix 2.** continued.

| SVOC | Main wharf mg/kg dry wt | Boat ramp mg/kg dry wt | Pontoon marina mg/kg dry wt | Moorings site mg/kg dry wt |
|---|---|---|---|---|
| **Aldrin** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Heptachlor** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Heptachlor epoxide** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Endosulfan I** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **4,4'-DDE** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Dieldrin** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Endrin** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Endrin Aldehyde** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Endosulfan II** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **4,4'-DDD** | < 0.1 | < 0.1 | < 0.2 | < 0.2 |
| **Endosulfan sulphate** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **4,4'-DDT** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **Phenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2-Chlorophenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2-Methylphenol (o-cresol)** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **3 & 4-Methylphenol (m- + p-cresol)** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2-Nitrophenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2,4-Dimethylphenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2,4-Dichlorophenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **4-Chloro-3-methylphenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2,4,6-Trichlorophenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |
| **2,4,5-Trichlorophenol** | < 0.3 | < 0.2 | < 0.3 | < 0.4 |

**Appendix 3.** Macroinvertebrate (infauna) species and abundance per core (0.0135 m2) at four sites in Port Tarakohe.

| Taxa | Common Name | Feeding type | Main Wharf | | | Boat Ramp | | | Pontoon | | | Mooring ( | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | A | B | C | A | B | C | A | B | C |
| **Porifera** | Calcareous Sponges | Filter feeder | | | | | | | | | 1 | | | |
| **Cnidaria** | | | | | | | | | | | | | | |
| *Hydroida (thecate)* | | Filter feeder | | | | | | | | | 1 | | | |
| *Edwardsia sp.* | Burrowing anemone | Filter and deposit feeder | | | | | | | | 1 | | | | |
| **Nematoda** | Roundworm | | 89 | 8 | 102 | | 1 | 1 | | | | | | |
| **Mollusca** | Unidentified gastropod | | 1 | | | | | | | | | | | |
| *Cominella adspersa* | Kawari | Carnivore & scavenger | | | | 1 | | | | | | | | |
| *Neoguraleus sp.* | Snail | | | | | 1 | | | | | | | | |
| *Turbonilla sp.* | | Infaunal deposit feeder | 1 | | | | | | | | | | | |
| *Xymene ambiguus* | | | 1 | | | 1 | | | 1 | 1 | 2 | 2 | | |
| *Arthritica bifurca* | Small bivalve | Infaunal deposit feeder | | | 10 | 5 | 2 | | 3 | 4 | | 8 | | 2 |
| *Bassina yatei* | Frilled venus shell | | | | | | | | | | | | | 1 |
| *Ennucula strangei* | | | 1 | | | | | | | | | | | |
| *Leptomya retiaria retiaria* | | Infaunal deposit feeder | 2 | 1 | 1 | 15 | 20 | 6 | 1 | | | | | |
| *Macomona liliana* | Wedge shell, Hanikura | Infaunal suspension feeder | | | 1 | | | | | | | | | |
| *Nucula cf gallinacea* | | Infaunal deposit feeder | 14 | 6 | 5 | 18 | 42 | 14 | 9 | 6 | 9 | 13 | 5 | 11 |
| *Nucula hartvigiana* | Nut Shell | Infaunal deposit feeder | 4 | 1 | 2 | 5 | 6 | 2 | | | | | 1 | 1 |
| *Nucula nitidula* | Nut shell | Infaunal deposit feeder | | | | 2 | | 1 | | 4 | | | | |
| *Serratina charlottae* | | Infaunal suspension feeder | 5 | | | 15 | 76 | 15 | 15 | 5 | 4 | 11 | 1 | 5 |
| *Soletellina nitida* | Golden sunset shell | Infaunal suspension feeder | | | | | | | | | 1 | 1 | | 0 |
| *Theora lubrica* | Window shell | Infaunal deposit feeder | 29 | 23 | 9 | 25 | 49 | 46 | 30 | 35 | 28 | 28 | 4 | 19 |
| **Oligochaeta** | Oligochaete worms | Infaunal deposit feeder | 5 | | 3 | | | | | | | | | |
| **Polychaeta** | | | | | | | | | | | | | | |
| *Heteromastus filiformis* | | Infaunal deposit feeder | 103 | 31 | 67 | 19 | 42 | 15 | 23 | 16 | 40 | 6 | 15 | 3 |
| *Cossura consimilis* | | Deposit feeder | 148 | 44 | 69 | 26 | 23 | 7 | 4 | 6 | 5 | 5 | 11 | 4 |
| Maldanidae | Bamboo Worms | Infaunal deposit feeder | | | | 1 | | 1 | | | | | | |
| *Armandia maculata* | | Infaunal deposit feeder | 4 | | | | 1 | | 1 | | | | | |
| Paraonidae | | Infaunal deposit feeder | 5 | | | | | | 2 | 1 | | | | |
| Dorvilleidae | | Facultative carnivore | 5 | | | | | | | | 1 | | | |

**Appendix 3.** continued.

| Taxa | Common Name | Feeding type | Main Wharf | | | Boat Ramp | | | Pontoon | | | Mooring | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | A | B | C | A | B | C | A | B | C |
| Lumbrineridae | | Infaunal carnivore & deposit feeder | 1 | 2 | 4 | | 3 | 1 | | | | 1 | | |
| Glyceridae | Blood worm | Infaunal carnivore & deposit feeder | 2 | 1 | 1 | 1 | 1 | 1 | | | 1 | | 1 | |
| Hesionidae | | Carnivore and deposit feeder | 1 | 1 | | | | | | | | | | |
| *Aglaophamus macroura* | | Infaunal carnivore | | | | | | | | | | | | 1 |
| Sigalionidae | Scale worm | Infaunal carnivore | | | | | | | | 1 | | | | |
| *Polydora sp.* | | Surface deposit & filter feeder | | 4 | 1 | 3 | 10 | 5 | | | 1 | | | |
| *Prionospio sp.* | | Surface deposit feeder | 207 | 125 | 120 | 56 | 25 | 16 | 5 | 20 | 2 | 12 | 6 | 10 |
| Cirratulidae | | Deposit feeder | 1 | | | 1 | | | | | | | | |
| *Pectinaria australis* | Sand mason worm | Infaunal deposit feeder | | | 2 | | | | 2 | 1 | | | | |
| **Crustacea** | | | | | | | | | | | | | | |
| Mysidacea | Mysid shrimp | Filter and deposit feeder | 1 | | | | | | | | | | | |
| Cumacea | Cumaceans | Infaunal filter or deposit feeder | | | | | | 1 | | | | | | |
| Amphipoda a | Amphipods | Epifaunal scavenger | 3 | | | 12 | 16 | 16 | 1 | 1 | 10 | 21 | 12 | 20 |
| Amphipoda b | Amphipods | Epifaunal scavenger | 1 | 1 | | | | | 1 | 1 | 1 | | | |
| Amphipoda c | Amphipods | Epifaunal scavenger | 1 | | | | | | | | | | | |
| *Macrophthalmus hirtipes* | Stalk-eyed Mud Crab | Deposit feeder & scavenger | | | | | 1 | | 3 | 1 | 2 | 3 | 2 | 5 |
| Ostracoda | Ostracods | Omnivorous scavenger | | | | 4 | 5 | 4 | 1 | | | | | |
| Copepoda | Copepods | Epifaunal scavenger | 1 | | | | 4 | | 1 | 3 | | | | |
| **Bryozoa** | Encrusting bryozoan | Filter feeder | | 1 | 1 | | | | | | | | | |
| | Erect bryozoan | Filter feeder | | 1 | | | | | | | | | | |
| **Echinoidea** | | | | | | | | | | | | | | |
| *Echinocardium cordatum* | Heart Urchin | Deposit feeder | | | | 1 | | | | | | | | |
| **Ascidiacea** | | | | | | | | | | | | | | |
| *Asterocarpa cerea* | Colonial ascidian | Filter feeder | | | | | | | 1 | | | | | |
| *Diplosoma listerianum* | Colonial ascidian | | | | | | | | | | 1 | | | |
| **Total count** | | | **636** | **250** | **398** | **212** | **327** | **152** | **104** | **107** | **110** | **111** | **58** | **82** |
| **Total taxa** | | | **26** | **15** | **16** | **20** | **18** | **17** | **18** | **17** | **17** | **12** | **10** | **12** |