2014 Sewage Treatment System Impact Monitoring Program

Interpretive Report

Volume 4 Ocean Sediment Program report

Foreword

This report forms Volume 4 (of four) for the 2014 Sewage Treatment System Impact Monitoring Program (STSIMP). It presents the analysis and findings from the Ocean Sediment Program. This year forms the 'assessment' year which includes the identification and counting of benthic macrofauna and the analysis of sediment quality at all sites. This report is compiled every three years.

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1 Introduction

The Ocean Sediment Program (OSP) assesses how wastewater, discharged through the deepwater ocean outfalls (of Malabar, Bondi and North Head wastewater treatment plants) perform over the longer term. This program includes monitoring the characteristics of ocean sediments and benthic macrofaunal communities. This program is conducted on a three-year cycle, the first year is an assessment year, and the second and third years are surveillance years. Under the current cycle 2013-14 is an assessment year.

In the assessment year, sediment samples are collected from nine locations and the benthic macrofauna (small animals that live on the ocean floor) are identified and counted. The sediment samples are also analysed to determine concentrations of metals, organic compounds, nutrients and sediment grain size.

This report:

- examines the ecosystem health status at locations near the deepwater ocean outfalls (supports summary in Volume 3, Section 1.4.3)
- investigates sediment quality at locations near the deepwater ocean outfalls (supports summary in Volume 3, Section 1.4.3)
- examines the degree of variation inherent in the sediment quality that is explained by one or more sediment predictor variables at locations near the deepwater ocean outfalls.

1.1 Definition of disturbance and impact

For the purpose of this report Sydney Water has adopted two specific definitions from the scientific literature. This relates to the use of the words ‘disturbance’ and ‘impact’, with the definitions derived from Underwood and Chapman (1995), Downes et al. (2002) and Morris and Therival (2009).

In relation to Sydney Water activities, a water quality disturbance occurs from discharge into receiving waters such as a creek, river, estuary and ocean. Disturbance can be shown by a recorded change in the chemistry of the receiving waters, such as an increased concentration of a nutrient.

A water quality disturbance does not always cause a change in the structure of an ecological community; the concentration of a contaminant may be below the threshold concentration required to trigger ecological change. In the ANZECC (2000) guidelines this is described under the wording ‘threshold concentrations’. Thus a water quality disturbance can occur without a measurable ecological impact.

Where concentration of a chemical in the water quality disturbance exceeds a threshold concentration, an impact in a nearby ecological community structure may become measurable when compared to (a number of) ecological communities at more distant (or upstream) reference locations.

2 Background

Approximately 80% of Sydney's sewage is treated at the North Head, Bondi and Malabar sewage treatment plants and discharged through three deepwater ocean outfalls located between 2 and 4 km off shore, in waters between 65 m and 80 m deep. As a general description, these deepwater ocean outfalls discharge wastewater through diffusers comprising multiple outlet ports spread over 500 to 750 m. This achieves rapid dilution that approximately ranges from 100:1 to 1,000:1, depending on diffuser field and oceanic conditions. The purpose of the diffusers is to release wastewater into the ocean at concentrations that are unlikely to be toxic once mixing has occurred.

Wastewater from the three deepwater ocean outfalls contains particulate matter to which contaminants may be attached. Under particular environmental conditions, negatively buoyant particles may settle and this may lead to a possible accumulation of contaminants in the sediments. Ocean currents and waves may be sufficiently large to re-suspend the sediments, thereby potentially releasing contaminants to the water column where they may be more widespread.

Once mixing has occurred, three checks are undertaken to determine that wastewater is being released at non-toxic concentrations. Firstly, the diffusers are visually inspected using a remotely operated submersible equipped with a camera; this is a check to confirm that all diffusers are working. Secondly, the wastewater is checked monthly to determine that it is not toxic at the concentrations achieved after mixing. Thirdly, the sediments are checked for chemical accumulation and potential impacts on the benthic community.

The Ocean Sediment Program is this third check and satisfies requirements under Section 4.4.5 of the Sewage Treatment System Indicators Monitoring Program (STSIMP) (Sydney Water, 2010). The STSIMP is required under condition M5 of the environment protection licences (EPL) for North Head (EPL number 378), Bondi (EPL number 1688) and Malabar (EPL number 372) wastewater treatment plants. The purpose of the Ocean Sediment Program is to quantify putative impacts on the benthic community and contaminant accumulation in sediments that may be associated with the ongoing operation of these deepwater ocean outfalls.

2.1 Previous studies

A number of sediment studies have been conducted in the Sydney region over the past 20 years. A summary of the more pertinent studies is presented here.

2.1.1 Physical processes affecting sediment movement

The settlement and resuspension of particulate matter from a buoyant jet (eg from the deepwater outfall plumes) is complex. It may be possible that such particulate matter finally settles some distance from the outfall, depending on patterns or ocean currents and waves. As a consequence, high concentrations of contaminants (attached to particulate matter) may reside at distance from, rather than close to, the ocean outfalls.

Internal waves were identified as a major physical process in the Sydney region (Middleton et al, 1997). Internal waves may interact with the sea floor, shoal and break in much the same way as surface waves on the beach. The dissipation of energy due to breaking internal waves may result in disturbance of the sediments and significant sediment movement. Quantification of sediment movement due to internal waves in the Sydney region has not been undertaken. However, sediment movement will be proportional to the power of the internal wave (a product of the wave amplitude and its period).

In waters east of Bondi Beach (water depth of 65 m), high-frequency internal waves of amplitude 10 m and period 10-30 minutes have been observed (Middleton et al, 1997). The amplitude of internal waves at tidal periods (12 hours) has been observed at 20-30 m. Such internal waves are not unique to the Sydney region.

2.1.2 Sediment chemistry

To help satisfy the operational needs of Sydney Water, Schneider et al., (1994) reported the results of a baseline survey of the contaminants in marine sediments off Sydney (survey conducted in 1990 prior to the commissioning of the deepwater outfalls). A grid-based design was used covering an area bounded by Curl Curl Beach in the north, Cape Banks in the south and seawards to approximately 7 km. The water depths from which the samples were taken ranged from 10 m to 100 m. The grid spacing in the southern part of the study area (surrounding the Malabar deepwater outfall site), was 0.5 km resulting in approximately 150 samples. Sampling was conducted on a 1 km grid in the northern part of the region (surrounding the Bondi and North Head deepwater outfall sites), resulting in approximately 80 samples. Extensive reef systems in the northern part of the system prevented a finer sampling grid. Sediment samples were collected between August 1990 and April 1991 using a modified Rossfelder vibrocorer.

As part of this study, Schneider and Wyllie (1991) tested a range of sediment samplers to assess their ability to retrieve undisturbed sediments. The retention of fine particles was used to compare a variety of grab samplers and corers. The results indicated that samples from the Van Veen grab retained the lowest percentage and greatest variability of fines, while samples from the box corer and Smith-McIntyre grab retained an intermediate percentage of fines and the piston corer and vibrocorer retained the highest percentage of fines. Samples from the vibrocorer also exhibited the least variability.

Sediment cores were logged, split and stored in Teflon bags at –25^{o}C for later analysis. Samples were analysed for physico-chemical properties (including grain size, total organic carbon and carbonates), a suite of metals (arsenic, cadmium, copper, chromium, iron, lead, nickel, manganese, mercury, selenium and zinc) and a suite of organochlorines (PCBs, HCBs, Lindane, Aldrin, Dieldrin, heptachlor, heptachlor epoxide, chlordane, DDT, DDD, and DDE). No samples were collected for analysis of the benthic community.

A comparison of seven laboratories was carried out to assess the precision and accuracy of each facility. The result indicated that none were capable of undertaking all of the analyses to the required level of precision or accuracy. All laboratories were within a factor of two in their analysis of metals, while some did not detect organochlorines samples spiked at ‘exceptionally high environmental levels’.

The main findings from this survey are summarised below.

- Elevated concentrations of metals were generally observed in a band 2-4 km offshore. In the nearshore zone, the contaminants in the sediments are in transit, being resuspended as a result of storm events. The particulate material further offshore is deposited, resulting in an accumulation of contaminants in the sediments. Beyond 4 km offshore, there is little reworking of sediments and the contaminants in sediments in this region have generally low concentrations.

- Sydney Harbour appears to be the major source of contaminants in sediments for the following substances: copper, lead, mercury, zinc, chlordane, heptachlor epoxide, Aldrin and DDD. It also appears to be a main source of PCB, Lindane and nickel contamination.
- Botany Bay appears to be the primary source of HCBs, Dieldrin and Lindane. It is noted that the sampling grid terminated near Cape Banks on the northern side of Botany Bay. The use of these data to link Botany Bay with offshore contamination may not be clearly defined.
- While the shoreline ocean outfalls were often associated with the highest concentrations of contaminants, their spatial extent was generally small (within 1 km of the outfall). Concentrations of cadmium, copper, lead, mercury, zinc, chlordane, DDT, DDD, DDE and Lindane were observed near the North Head shoreline outfall. However, this site may be confounded by dumped material. Contaminants in the sediments did not appear to be associated with the Bondi shoreline outfall. Sediments near the Malabar shoreline outfall contained elevated concentrations of chromium, chlordane, DDT, DDE, Aldrin and heptachlor epoxide.
- Groundwater was implicated as the source of contaminants (chromium, chlordane, DDT, Dieldrin, HCB and PCBs) near Maroubra Beach and as a source of selenium near Coogee Beach. However, it was recognised that confirmation studies would need to be undertaken to confirm the groundwater as a significant source of contaminants of the sediments in these regions.
- Sediment movement appears to be associated with several mechanisms. Under the dominant East Australian Current, finer particles move generally towards the south. Conversely, under storm conditions, there is likely to be increased riverine input of sediments, resuspension of previously deposited sediments and a net movement of (both fine and coarse) sediments towards the north (the predominate direction of major storms).
- In water depths of less than 30 m, sediment reworking to a depth of at least 1 m is likely. Much of this sediment movement was estimated to have occurred in the last 10 years. There is unlikely to be any sediment reworking in water depths exceeding 120 m. This is in contrast to studies by Field and Roy (1984) and Roy (1985), who suggested that the sediments in this region have remained largely undisturbed for the last 7,000 years.
- The distribution of metals was generally correlated with iron content, total organic carbon and water depth, while the distribution of organics was principally related to terrigenous gravel content of the sediment, porosity and sand particle size. Neither organic nor inorganic contaminants were strongly associated with the fine sized particles. This is in contrast to the findings of many reported studies.
- While concentrations of the contaminants were generally low, reviews of sediment toxicity data suggested that concentrations of lead, mercury, zinc, PCBs and DDT (and possibly DDD and HCBs) were capable of producing observable toxic effects in biota.

Based on the work described in Schneider et al. (1994), Schneider and Davey (1995) developed a regression model for the distribution of contaminants in the sediments off the coast of Sydney. The independent variables in the model are: iron, total organic carbon, water depth, grain size and carbonate content. For concentrations of copper and chromium, more than 60% of the variability could be explained. The conclusions reached in Schneider et al. (1994) were reiterated in this paper.

In 2000, Matthai and Birch (2000) published an article on the effects of coastal cities on surficial sediments along the central NSW coast, from the inner shelf (water depth <60 m) to the outer shelf (water depth around 200 m). The definitions of inner, middle and outer shelf were based on the sediment texture as a reflection of ambient conditions on the seafloor. The samples collected from the middle shelf, defined as a low-energy depositional environment were the most relevant to the current Sydney Water study.

Samples were collected from 309 locations, between Jervis Bay in the south and Port Stephens in the north, using a Smith-McIntyre grab similar to that used in the current study. Vibrocore samples were also collected from some locations to assess sediment quality prior to anthropogenic influences.

The Matthai and Birch (2000) study identified areas of relative enrichment of trace metals in the surficial sediments adjacent to the three major coastal cities of Wollongong, Sydney and Newcastle. The middle shelf zone, defined as the low energy depositional zone, appeared to contain the highest levels of trace metals. The levels of enrichment relative to pre-anthropogenic or minimal anthropogenic influence varied from city to city and parameter to parameter, with samples collected offshore from Newcastle generally having the highest level of enrichment. Relative to other coastal shelf environments, the levels measured on the central NSW coast were low.

Other findings and observations of the Matthai and Birch (2000) study that are relevant to the current Sydney Water study included:

- For the majority of metals, the enrichment on background levels was minimal (<1.2 times). Only copper, lead and zinc had enrichment values exceeding 1.5 times background levels
- Adjacent to Sydney, enrichment of cooper, lead and zinc in the fine fractions of sediments results mainly from the disposal of large volumes of sewage effluent. They also suggest lead in the fine fraction of these sediments may be derived from a source other than sewage alone.
- A rapid decline in the concentrations of trace metals with increasing distance from the major cities. This is directly related to the efficient dispersion of particulates along the inner shelf in the high-energy environment

2.1.3 Sediment biology

Monitoring of the marine sediments offshore of Sydney has been conducted on a regular basis since prior to the commissioning of Sydney’s deepwater ocean outfalls between 1990 and 1991. The potential impacts of the deepwater ocean outfalls included the accumulation of contaminants in the sediments and their impact on benthic faunal communities (Gibbs, 1988).

Initial sediment studies constituted part of the Sydney Deepwater Ocean Outfalls Environmental Monitoring Program (EMP). The forerunner of this program was the Pilot Study for the EMP (Gibbs, 1988). The primary objective of the pilot study was the identification of resource requirements and sampling techniques to carry out a cost effective and statistically robust sampling program.

The results of a review of sediment sampling methods (grabs, corers and dredges) were presented in Gibbs (1988). Based on this review, a Smith-McIntyre grab covering an area of 0.1 m^2 was used to obtain the sediment samples during the Pilot Study for the EMP. Murray and Murray (1987) described a sediment ‘scoop’ system that does not disturb the surface sediments and, by sealing the scoop after collection, does not lose fine materials in the retrieval process. The effectiveness of the bite profiles from different types of grabs, including the Smith-McIntyre, can be found in Riddle (1989). A subsequent review of different sampling techniques (Schneider and Wyllie, 1991) determined that vibro-coring was an efficient method of retrieving undisturbed sediment samples that retain the fine fractions of the sediments.

Three replicate sediment samples were obtained from a total of 27 sites located in nine across-shelf transects, along the 30 m, 60 m and 100 m isobaths. Inshore, three of the sites were located near the old cliff-face outfalls and the remaining six were reference sites. Similarly, along the 60 m isobath, three of the sites represented each of the deepwater ocean outfalls, the remaining six were reference sites. The nine offshore sites were reference sites. At each these, two samples were washed and preserved for infaunal identification, and a third samples was frozen and retained for chemical analysis Gibbs (1988).

The results from this pilot study indicated (Gibbs 1988):

- reliable samples were not obtained from the North Head site
- the species composition at the three depths was different
- four samples provided between 70% and 75% of species
- at least three samples should be collected from each site
- sampling should be conducted at the Bondi and Malabar deepwater outfall sites (as well as at four reference locations: two to the north of Bondi, one between Bondi and Malabar and one to the south of Malabar)
- no recommendations were made regarding the analysis of contaminants in the sediments.

2.1.4 Integrated sediment chemistry and biology

The sampling design to help assess impacts on the marine sediments of wastewater discharges from the deepwater ocean outfalls is described in EPA (1992a, 1992b). As for the pilot study, a Smith-McIntyre grab with a 0.1 m^2 surface area was used for sampling sediments.

Sampling was conducted at three reference sites and three treatment sites along the 60 m isobath. Two locations were identified at each site and three replicate grab samples were obtained from each location. Sampling was undertaken on three occasions (Winter 1989, Summer 1990 and Autumn 1990), with the first of these used to further refine the sampling techniques. The data from this survey was not used in the subsequent statistical analyses.

The results of this study indicated:

- substantial variability in the abundance of macroinvertebrates in the sediments off Sydney

- little difference observed between the outfall and control sites. However, there was substantial spatial and temporal variability among sites
- polychaetes generally dominated fauna
- due to a concern regarding statistical power, the study recommended that sampling be conducted at three locations within each site

Based on the results of the pre-commissioning studies, EPA (1992c) indicated that there would need to be a substantial change in abundance (100% or more depending on the species) to achieve power of 0.8 using three replicates.

The sampling design for examining contaminants in the sediments (EPA, 1992b) varied considerably from that for the soft sediment communities. Samples were collected using a modified Van Veen grab. Sampling was originally planned using gravity cores, but a poor retrieval rate of sediments led to abandonment of this technique. This resulted in only one complete sampling event prior to commissioning of the deepwater outfalls.

Six locations were identified: one at each of the three deepwater outfalls, near Terrigal and Turimetta Head in the north and offshore from Marley Beach in the south. Four zones were identified at each location. At the three outfall sites, one zone was located close to the diffusers, while the remaining three zones were located to the north, south and east of the outfall. Three replicate samples were obtained from each zone. Surface sediment samples were analysed for a range of physico-chemical parameters, metals and organics. Analyses were undertaken using the raw data and using data normalised according to particle size.

The results from the EPA (1992b) study indicated:

- uncertainties in the results from the Terrigal site (data from this site was not used in subsequent analyses)
- particle size has a low correlative power to metal content, with the exception of zinc and copper (there was no strong basis for normalising the data with particle size)
- concentrations of metals in the sediments of the Sydney region were comparable with background concentrations found in other regions worldwide (sediments in the Sydney coastal region are not contaminated with organochlorine compounds, but it was noted that the sensitivity of the analytical methods was relatively low)
- a high degree of within-location variability, comparable to the variability between locations
- power analyses indicated generally high power (greater than 0.8) for the metals and slightly less for the organics
- power estimates increased when the data were normalised against particle size.

As part of the post commissioning program for the EMP, sediment samples were collected (nominally) every three months using a 0.1 m^2 Smith-McIntyre grab from the above six sites (three control and three outfall sites). Six replicate samples were obtained from each site and the animals contained in each sample identified to (generally) family level. Statistical analyses of these data were undertaken to determine whether ‘observed changes in the abundances of soft-bottom organisms around the outfalls were the result of spatial and temporal variations or attributable to the deepwater outfalls.’

In the Sydney Deepwater Outfalls EMP, Final Report Series, Volume 5, *Impacts on Marine Ecosystems* there appear to be contradictory conclusions. On page 40 the authors conclude: 'The univariate statistical analysis (asymmetrical analysis of variance) detected significant sustained impacts on the soft-bottom communities surrounding the Malabar, North Head and Bondi deepwater outfalls. Increases and decreases in the abundance of soft-bottom organisms occurred at the same outfall and also varied among outfalls.' However, on page 41 the author contradicts this finding by saying; 'The asymmetrical design, as with many symmetrical designs, is not without particular problems and these were summarised in Otway et al. (1994). Specifically, the design does not permit tests for sustained impacts…' The authors go on to discuss various observations of divergence which may or may not represent impacts but follow this with; 'As no appropriate test for sustained impact is possible, the statistical significance of this result could not be examined.' 'Results of multivariate analysis echoed the spatial and temporal fluctuations detected by univariate analysis, but were unable to detect impacts at the community level.

Additional results of the EMP report are best summarised as:

- differences in 23 (North Head), 9 (Bondi) and 11 (Malabar) groups of soft-bottom organisms were detected after commissioning
- no short term impacts were detected
- the direction of change at Malabar and North Head varied among taxa (abundance of some taxa increased, others decreased), while abundance of taxa increased at the Bondi deepwater outfall
- the mud fraction of the sediments showed a significant increase at the Malabar deepwater outfall and a significant decrease at the North Head deepwater outfall (a non-significant result was returned for the Bondi deepwater outfall)

Due to the limited time frame over which the EMP study was conducted, the natural temporal variation could not be separated from putative potential impacts. Out of this work, Otway et al. (1996) noted that as the dataset grows temporally the power improves to separate, if present, a measurable impact due to a water quality press disturbance (represented by discharges from the deep ocean outfalls in the offshore ocean environment) from natural variation of the turbulent ocean environment.

The model of Pearson & Rosenberg (1978) for soft bottom sediment communities suggests that, as abundance declines close to the outfalls, we would expect the difference in mean abundance to exceed 75%. If this occurs, a-priori power analysis would indicate that there is the power to detect 'significant' changes of this magnitude with the current sampling design of the Ocean Sediment Program. Unfortunately, the time scale over which these changes may occur is not known because little is known about the natural rates of change in many biological systems (Underwood, 1992).

EPA (1996b) noted that '… the substantial variability in the structure of the soft-bottom communities has the potential to mask the effects of pollution'. Both physical and biological processes were identified as potential disrupters of the successional sequence of the integrity of the sediments.

Contaminants in the sediments were measured at six locations (three reference and three outfalls) at six-monthly intervals between July 1990 and July 1993. To help increase the statistical power of the sampling design (identified in the pre-commissioning studies as a potential problem), a fourth reference site (Jervis Bay) was added to the sampling program in January 1992. Sediment samples were collected using a Van Veen grab sampler from four zones within each site. Three replicate samples were obtained from each zone on each sampling occasion. Samples were analysed for a range of trace metals and organochlorine compounds, as well as for total organic carbon and the percentage of fines in each sample. The data were analysed using both univariate and multivariate techniques.

The results from these analyses are summarised below (EPA 1996b):

- the concentrations of trace metals were generally found to be below levels that may potentially cause biological effects. However, it is noted that the overseas guidelines against which these conclusions were assessed may not necessarily be 'applicable to Australian environmental conditions.'
- significant correlations were found between the percentage fines and chromium, manganese, selenium and zinc
- no significant correlation was found between total organic carbon and any trace metal
- no significant spatial-temporal interactions were found between outfall and control sites for cadmium, manganese, nickel, silver or zinc. However, significant interactions were found for arsenic, cobalt, copper, lead, mercury and selenium. Concentrations of arsenic, cobalt, copper and lead were generally elevated at the outfall sites compared with the control sites
- non-metric multi-dimensional scaling of the data failed to identify any discernible patterns or associations in the data
- for organochlorine analyses more than 80% of samples recorded 'below detection limits'. Only HCBs were consistently detected throughout the study. 'While not discounting the possibility for biological effects to occur due to organochlorine contamination, the study did not indicate 'an increase in HCB concentrations associated with the deepwater outfall locations.'
- pre-commissioning sampling was undertaken on only one occasion, therefore it was not possible to confidently determine the effects of the outfalls on the sediments.

An intensive sediment sampling program was conducted in 1995/96 (EPA, 1997). Sediment samples were collected using a 0.08 m^2 Smith-McIntyre grab sampler. Three sampling programs were adopted:

- small scale spatial study. Conducted in February 1995, 25 samples were obtained from each of three sites located to the south, north and east of the Malabar outfall
- small scale temporal study. Conducted monthly between July 1995 and August 1996, a total of 25 samples were collected from the southern side of the Malabar outfall on each occasion
- gradient study. Conducted in June 1996, five samples were collected from each of nine sites, increasing in distance from the Malabar outfall. The most southerly site was located 20 km south of the outfall.

Although no inter-laboratory comparisons were undertaken (as in Schneider et al, 1994), quality assurance was conducted using both blank and duplicate samples. This procedure identified a number of issues, which were resolved by using a different laboratory.

A large number of statistical analyses were undertaken. These included: bootstrapping to construct confidence intervals, maximum likelihood techniques to develop theoretical distributions of the data, univariate analyses to assess spatial and temporal differences and multivariate analyses to examine relationships among groups of samples.

Results from these analyses are summarised below (EPA 1997):

Small scale spatial study

- biological data were generally highly skewed and non-normal
- spatial differences between sites 200 m apart are statistically significant
- correlations between sediment and biological community data are statistically significant
- there is a high correlation between the percentage of fine sediments and both metals and nutrients
- grab samples obtained from sites more than 50 m apart are essentially independent.

Small scale temporal study

- although relatively small, there are temporal differences within a site
- spatial correlations between the physical and biological data were observed from month-to-month
- again, there is a high correlation between the percentage of fine sediments and both metals and nutrients
- correlations between environmental and biological variables were higher within a month than between months.

Gradient study

- the proportion of fine sediments between 2 and 4 km south of the Malabar outfall was relatively high. It was unclear whether this was due to the outfall or to natural sediment sorting
- spatial differences between sites at increasing distances from the Malabar outfall appears to be related to the proportion of fines in the sediments.

While no obvious change was observed in the benthic community examined in this study, the ‘potential for unobserved species replacement’ was noted as the benthic community was only identified to the family level.

There was no obvious accumulation of metals or nutrients in the sediments near the Malabar outfall. However, as noted above, the proportion of fines between 2 and 4 km from the Malabar outfall did increase compared to other locations. In this study (and in many other studies), an increase in the percentage of fines was linked to increased concentrations of metals and nutrients. This is in contrast to the findings of Schneider, Davey and Lock (1994) and Schneider and Davey

(1995). However, this study did recognise that the proportion of fines in the sediments only accounted for a relatively small fraction of the overall variability in the benthic community.

The role of sediment transport in changing the distribution of chemicals in the sediments was noted. Understanding of the processes for sediment movement at water depths near those of the deepwater outfalls was identified as an area needing further investigation.

2.2 The Ocean Sediment Program

The Ocean Sediment Program is the most recent sediment study. The Ocean Sediment Program constitutes a condition of the NSW EPA licence for the Malabar, Bondi and North Head wastewater systems.

The Ocean Sediment Program has been developed and conducted based on the recommendations detailed in *Study Design For Long-term Monitoring of Benthic Ecosystems Near Sydney's Deepwater Ocean Outfalls* (EPA 1998). The methods and approach adapted for the project have been agreed to through discussions between members of the OEH and Sydney Water.

Sampling is conducted annually during February and reports are prepared for each sampling event. Sampling occurs on a three year cycle, where the first year of each cycle (2002, 2005, 2008, 2011, etc) is an 'assessment' year. During these years, an extended analysis program is conducted that includes measurement of a wider range of chemical parameters (see section 4) and assessment of benthic organisms at all locations. The intermediate years (eg 2009, 2010, 2012, 2013) are 'surveillance' years.

This report presents an assessment of the data collected for the 2014 assessment year sampling program and incorporates data collected from the 2002, 2005, 2008, 2011 and 2014 assessment years to allow a prudent examination of trends over time.

2.3 Program objectives (in accordance with original licence conditions)

The long-term objective of the Ocean Sediment Program (specified in the original licence conditions derived from EPA (1998)) were to address the following questions:

1) Is there a chronic impact of effluent from Sydney's deepwater ocean outfalls?
2) Is there any spreading of a potential existing impact from effluent discharge around the Malabar outfall?

These objectives are based on issues outlined by the EPA (1998). The respective null hypotheses that the sampling design addresses are:

1) There is no chronic impact occurring
2) Any potential existing impact is not spreading

EPA (1998) notes that the two hypotheses above require different sampling strategies. Under their design the first question uses near outfall sampling points at all three outfalls, while the second question looks at a gradient study south of the Malabar outfall only (EPA (1998), page 6, Table 1).

It is recognised that achieving the long-term objectives will require a dataset that covers a substantial temporal scale. The existing dataset spans the period from 1999 to 2014. The objective of this report is to present the data in a format that describes observed conditions and any changes through time, and to investigate a range of statistical approaches to analysing the data that can ultimately be used to satisfy the program objectives.

The sampling design is detailed in EPA (1998). A summary is outlined below.

- The major strategy for this monitoring program is to compare conditions at sites near the outfalls (impact sites) with those at sites removed from the outfalls (reference or control sites). Statistically significant differences between the two types of sites would be construed as ‘impacts from the deepwater outfalls’. Ultimately, the program is required to provide Sydney Water with ‘an early warning system … that can effectively signal the need for responding to environmental degradation’. (Sites in this context are referred to as locations in the following analysis)
- To balance costs with the need for timely response to environmental degradation, a nested approach has been adopted. Every third year, detailed analyses are undertaken on the sediment chemistry and biology (‘assessment indicators’). These analyses include the identification and enumeration of benthic organisms, nutrients, trace metals and organic contaminants. During the intervening years, samples are analysed for total organic carbon and the percentage of fines in the samples (‘surveillance indicators’).

3 Sampling methods

3.1 Study area

The study area covers the mid-shelf zone from Terrigal to the Shoalhaven Bight (Figure 3-1). The northern most sites, located at Terrigal, Long Reef, North Head and Bondi, are in waters approximately 60 m deep. The remaining sites, at Malabar (0 km to 7 km), Port Hacking, Marley and Shoalhaven, are located in waters approximately 80 m deep.

3.2 Field methods

3.2.1 Locations and sites

The sampling design adopted for this study is detailed in EPA (1998) and Sydney Water (2002a). In brief, 10 randomly selected, replicate samples are obtained from each site in February of each year. Of these, five preselected samples are archived and the remaining five analysed for the required parameters. The archived samples are analysed only when 'measured declines/increases in benthic family counts are observed and/or a greater sensitivity/precision is desired'. Assessment indicators are monitored every three years, while the surveillance indicators are measured every year.

To address both of the long-term objectives of the study, the sites are grouped and classified by water depth. Sites located in waters 60 m deep form one group, while those in 80 m water depth form the second group.

Potentially impacted sites and control sites were chosen to address each question (Figure 3-1). To maximise the strength of the sampling design, two sites (one and two, the equivalent of north and south of each outfall) were sampled at each location. Details of the site groups and location names for each depth are listed below (Table 3-1).

A small change was made to the program in 2011, which saw distant reference locations of Terrigal and Shellharbour no longer sampled. This was agreed to in a variation to the program by the OEH following a review they undertook. This review concluded 'Given the lack of large changes in sediment characteristics and community composition close to Malabar outfall, it is appropriate that the Ocean Sediment Program monitoring is reviewed and (potentially) reduced in light of these findings.' Removal of the distant reference locations did not inhibit the ability to analyse data in this report, as significant differences were detected in the 2011 report and in this report between control (reference) locations. These differences indicate that the analyses have sufficient statistical power.

Figure 3-1 Ocean Sediment Program study site showing the sample locations

Table 3-1 Locations and depths of sites from 2011

Site group		
60 m depth	**80 m depth**	**Site reference**
Bondi	Malabar 0 km	1 & 2
North Head	Malabar 3 km	1 & 2
Long reef	Malabar 5 km	1 & 2
	Malabar 7 km	1 & 2
	Port Hacking	1 & 2
	Marley	1 & 2

3.2.2 Sub-site selection

This section outlines the positions of the sampling sites and the method used to determine the positions of the ten (10) random sub-sites at each sampling location. The method of sub-site selection is consistent with the method outlined in EPA (1998).

In order to select 10 random sub-sites, a 250 m x 250 m spatial grid was constructed and centred on the sampling site referred to in EPA (1998). The grid is subdivided into 50 m lengths along each axis, 50 m being equivalent to one length unit. Therefore, the grid consists of 50 m x 50 m cells and each point in the grid is allocated (x,y) co-ordinates ranging from zero to five as illustrated in Figure 3-1.

To establish the grid position of (0,0), the sample positions were converted from latitude and longitude to easting and northing in Australian Map Grid (AGD 66, AMG zone 56). Prior to this, 125 m was subtracted from both the easting and northing of the original reference positions. This allowed the grid to be centred on these positions (Figure 3-2 and Appendix A).

The co-ordinates for the 10 sub-sites were produced by randomly generating two sets of numbers (each representing either the x or y co-ordinates) ranging from 0 to 5. An example is shown in Figure 3-2 with the co-ordinates (3,1). These co-ordinates were converted to easting and northing by adding the appropriate lengths that corresponded to the (x,y) co-ordinates. Since each cell is 50 m x 50 m, each co-ordinate 'unit' corresponds to a length of 50 m. For example, for the position depicted in Figure 3-2, with the co-ordinates (3,1), 150 m (or 3 x 50 m) was added to the easting and 50 m (or 1 x 50 m) was added to the northing of the (0,0) position previously calculated.

The actual co-ordinates for each of the random sub-sites used during sampling are provided in Appendix A.

Since each sub-site provides one sediment sample, 10 samples are collected from each site. For each site, five of the samples collected are analysed ('current' samples) and five of the samples are archived for analysis if required ('archive' samples).

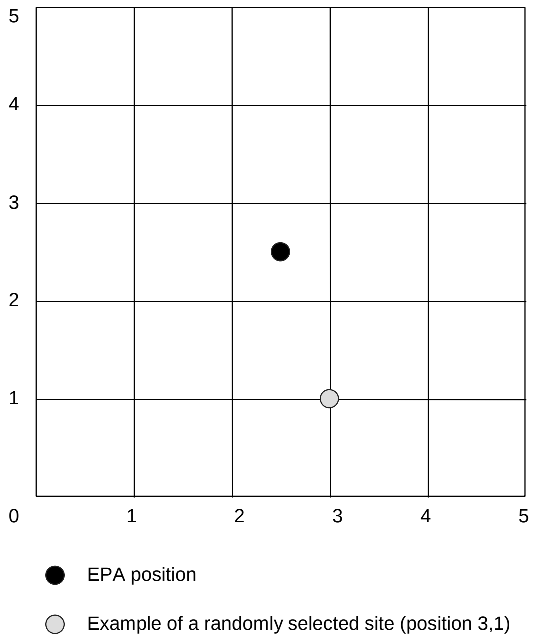


Figure 3-2 Grid used to randomly select 10 sub-sites at each of the original EPA (1998) locations

3.2.3 Sediment collection

The following section outlines the method used to collect sediment samples from the predetermined sampling locations.

The Motor Vessel (MV) Oceanographer was used as a stable platform, from which a "Smith McIntyre" grab (capacity approximately 5 L, Figure 3-3) was deployed at the randomly located sub-sites. This was achieved by manoeuvring the vessel to within approximately ±5 m of the sub-site position (this is the estimated accuracy of the Differential Global Positioning System – DGPS) before immediately deploying the grab.

Figure 3-3 Smith McIntyre grab

The MV Oceanographer held its position until the grab reached the seafloor and a sediment sample was taken. In order to ensure samples were as representative as possible, the angle and speed at which the grab was lowered to the seafloor was controlled and maintained for all the sub-sites. The grab was lowered to approximately 3 m above the seafloor and then released to collect the sample. In setting the angle and speed at which the grab was lowered, consideration was given to two things: maximising the volume of the sediment sample retrieved and minimising the bow wave generated from the grab moving through the water column. This method of controlling the grab fall rate has been shown elsewhere to reduce the loss of the fine surface material (Blomquist 1992).

3.2.4 Sediment sub-sampling and storage

The following section outlines the sediment sampling and sub-sampling methods and procedures followed for the immediate storage of the collected sediment samples. Flow diagrams of the offshore sediment program sampling overview Figure 3-4 and sediment sampling/sub-sampling procedures Figure 3-5 show a breakdown of the steps involved.

A retrieval of the grab was deemed successful if it collected a minimum sediment volume of one litre for benthic macrofauna analysis and 500 mL for chemical analyses (in 2 x 250 mL or 1 x 500 mL glass containers). 1 mL of sample volume is considered to be the approximate equivalent of 1 g wet weight for convenience. The minimum weights for sample analysis are subsequently achieved with sample to spare by assuming this weight equivalence to volume.

Separate samples were taken for physico–chemical analysis/benthic macrofauna analysis. This was done by collecting five separate samples from each site, for analysis at the conclusion of the sampling period.

Samples submitted for analysis on completion of the sampling run, had sub-samples taken for physico-chemical parameters by randomly taking single sediment sub-samples with a volume of approximately 250 mL. This was carried out twice for two separate containers, one for organic compound analyses and one for the remaining physical and chemical parameters. This was done by carefully syphoning off the overlying seawater and removing approximately 500 mL of sediment in total, using a stainless steel scoop into the 2 sample bottles.

Poor weather conditions were encountered consistently during the 2005 sampling period, and as a result, it was deemed that the use of the glass cylinder for sediment sub-sampling was deemed an unacceptable Health and Safety risk. An alternative approach was undertaken, whereby the grab sample was carefully placed in a large porcelain tray and a sub-sample was removed using a pre-washed (with acetone) stainless steel trowel. Analysis of results must be undertaken with this change of procedure in mind.

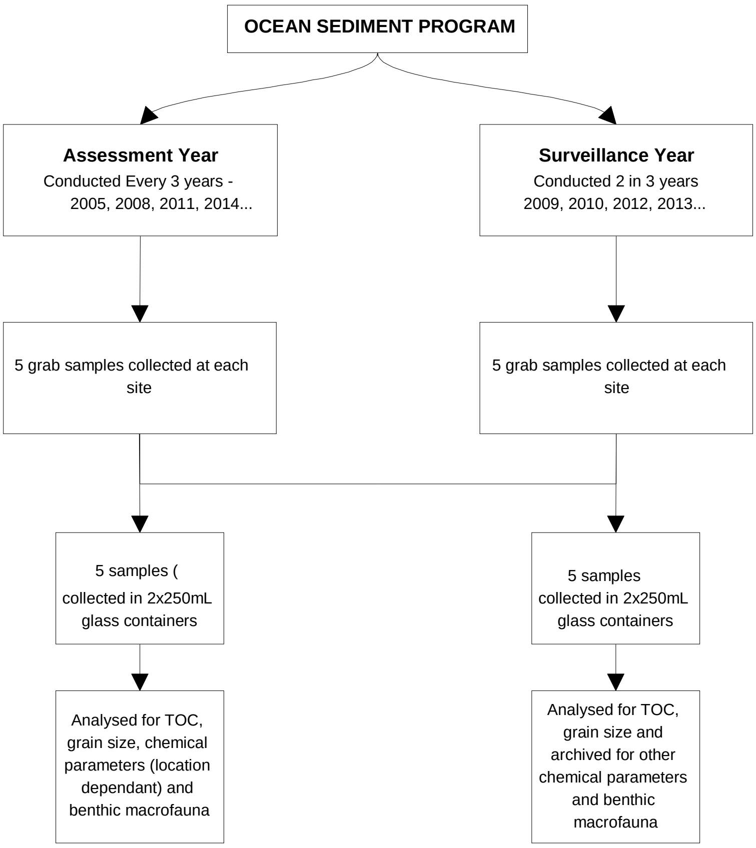


Figure 3-4 Overview of the Ocean Sediment Program sampling process

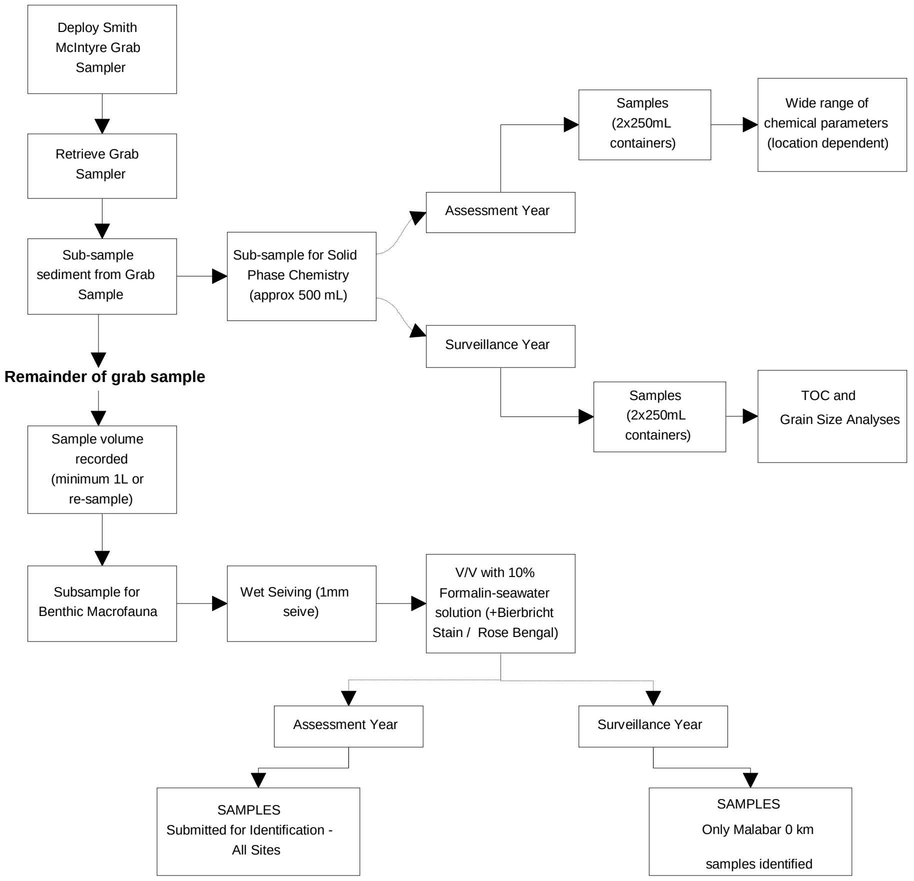


Figure 3-5 Schematic diagram of the sediment sampling procedure

Samples were placed in an appropriately labelled, pre–washed glass storage container with a Teflon-lined lid. Each sample jar was put in a zip-locked plastic bag and placed immediately in a freezer (freezer temperature approximately –20^{o}C). The samples were stored this way until analysis.

The sediment sub–sampling tools were rinsed with deionised water between sub–sites at each location, and new pre–washed sampling tools were used at each sample location.

The remaining sample was used for benthic macrofauna analysis. Remaining sediment was deposited into a container from the grab sample. The volume of the sample material in the container was recorded and then the sediment was gently rinsed through a 1 mm aperture box sieve using low pressure seawater. Care was taken not to scrape or force material through the sieve by the use of any of the tools or the hose used for rinsing. All materials ≥ 1 mm retained by the sieve were transferred to an appropriately labelled, detergent-washed glass container, and preserved in a 10% formalin and seawater solution. This mixture, which consists of 5 mL Rose Bengal in 2.5 L formalin mixed with 22.5 L seawater, was to aid in the preservation of the sample and identification of benthic invertebrates. Each of the infauna sample containers was placed in a plastic zip-lock bag and stored in a cool dry area until they were transported back to the laboratory for analysis. Benthic macrofaunal numbers were not large enough in 1999, 2005 or 2008 to warrant subsampling. As such, the whole infauna sample containers sample was processed.

In 2002, benthic macrofauna samples whose volume exceeded 1 L (after rinsing and sieving) were partially sub-sampled in the laboratory due to high numbers of benthic invertebrates collected at some locations this year. This was done by first removing all animals from the sediment and placing all worm tubes into a separate jar. The non-tube fraction of the sample was sorted and identified, separating each taxa into a separate vial. The tubeworms were then sub-sampled by weight. The tubeworm fraction was drained of alcohol until dripping stopped and was then weighed. One-eighth of the total weight was determined. Two one-eighth sub-samples of the tubeworm fraction were then removed to separate jars and labelled. One one-eighth sub-sample was sorted, identified and counted. Any animals not in the following tubeworm families were added back into the main sample, and the data sheet adjusted accordingly. The tubeworm families sub-sampled were: Maldanidae (bamboo worms); Oweniidae (polychaete worms); and Ampharetidae (polychaete worms). To identify each tubeworm, the head of the worm was located and uncovered in the tube. The worm was counted only if a head was present for consistency with all other counts and identifications. If tubeworms were sub-sampled, quality control checks for the sample included checks on the ‘remains’ of the tubeworm sub-sample (empty tubes, tubes with fragments), as is routinely done for the ‘remains’ of the main sample. If the total number of individuals in the first one-eighth tubeworm sub-sample was less than 100, the second one-eighth sub-sample was sorted and identified as above. If one one-eighth sub-sample was sorted, the counts for each of the three tubeworm families listed above were multiplied by eight to provide an estimate of those families comparable to other taxa present. If two one-eighth sub-samples were sorted, the number of worms in each of the three families was summed and multiplied by four to provide an estimate comparable to other families present in the sample. All data sheets were corrected for tubeworm sub-sampling.

Again in 2014, as seen in 2011, high numbers of benthic invertebrates were collected in some samples. In 2014 a total of 4 (out of 100) benthic macrofauna samples volume exceeded 1 L (after rinsing and sieving) required sub-sampling in the laboratory. The sub sampling method used in both 2011 and 2014 varied to that in 2002, as different taxa had high numbers. A 50% subsample was processed using a ‘Modified Marchant Sample Box’ with random selection of compartments within the box. Random selection avoided bias toward obvious larger taxa.

4 Analytical methods

The samples for physical and chemical analyses were prepared immediately after collection of the grab sample. A total of 500 mL volume of sediment was collected on each occasion from the grab sample, which was sub-sampled directly to separate containers for organic and other physico-chemical analyses. Samples were collected and stored in pre-washed and rinsed glass containers with Teflon lined lids to avoid contamination. All samples were immediately frozen after collection at approximately –20°C. The samples were stored this way until analysis.

All containers and utensils used to handle analytical samples were pre-washed and rinsed in accordance with NATA approved methods for such sample material to avoid contamination.

A summary of the sub-sampling requirements for the analyses conducted is presented in Figure 4-1. Method detection limits for all parameters are presented in Table 4-1.

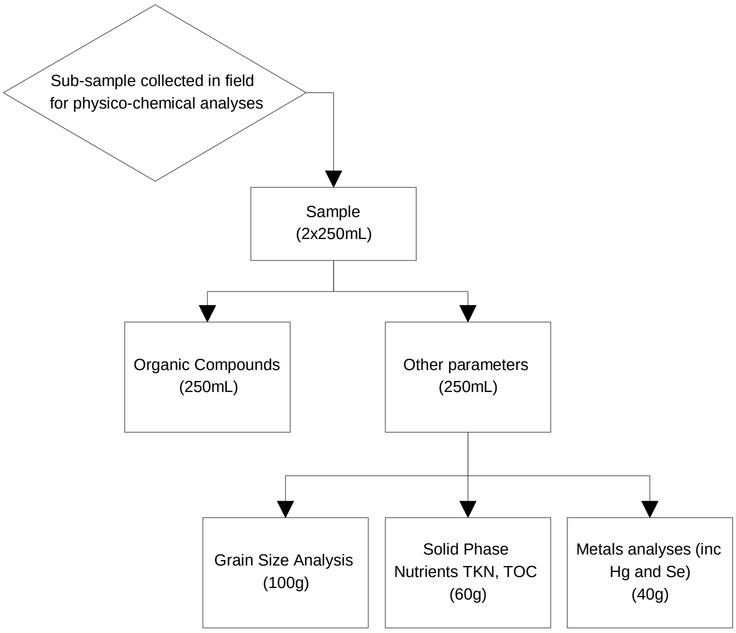


Figure 4-1 Flow chart of analytical sub-sampling requirements

Table 4-1 Approximate practical quantitation levels (PQLs)

Analyte	PQL mg/kg
TKN	20
Phosphorus	0.5
TOC	0.01%
Aluminium, Iron	0.3, 0.1
Arsenic, Chromium, Copper, Lead, Nickel, Zinc	0.01, 0.03, 0.02, 0.02, 0.01, 0.5
Cadmium	0.01
Mercury, Selenium, Silver, PCBs	0.01, 0.01, 0.01, 0.01*
Organochlorine Pesticides	0.0005*
Polyaromatic Hydrocarbons	0.01*
Cresols	0.01*

* Detection limit may not be achieved if there is high level matrix interference. From previous experience with this project, high levels of matrix interference are expected to occur infrequently.

4.1.1 Trace metals by ICP-AES, ICP-MS, CV-AAS

About 2 g of dried (at 35°C) and ground sample was weighed and transferred to a Teflon vessel, to which HNO_3 and $H2O_2$ were added. The vessel was placed in a microwave for digestion, after which the contents were diluted to 250 mL and analysed by ICP-AES, ICP-MS or Hydride generation AAS for Arsenic and Selenium or cold vapour AAS for mercury. Moisture content is determined on a separate sample portion if required (refer to APHA 3120-B 20th ed., US EPA Method 6010B (ICP-AES), 6020B (ICP-MS), Revision 2 December 1996 for further details).

For mercury analysis, some of the HNO3 / H2O2 digest is analysed by cold vapour AAS (FIMS) analysis. Hg in solution is reduced to Hg metal with SnCl2, stripped by Ar and transported to the cell where absorbance is measured (refer APHA Method 3112-B, 20th ed).

Sydney Water laboratory method numbers:

TM02MKG (As, Se analysis by Hydride generation and CV-AAS)

TM01MKG (Hg analysis by CV-AAS)

TM50MKG for ICP-AES

WTM56MKG for ICP-MS

4.1.2 Particle size analysis (wet sieve)

Approximately 50 g of wet sample was used initially. The wet sample was passed through the various sieve sizes in descending size order, with each sieve rinsed with water to ensure all possible material passed through. The material that remained in each sieve (corresponding to a particular size fraction) and the material that passed through the smallest sieve were transferred to separate pre-weighed beakers and dried at 105°C. The total weight was calculated by adding the weights of the various fractions and the weight of each fraction then used to calculate the size fraction as a percentage of the total.

Sydney Water laboratory method number: TM54WET (In-house method)

4.1.3 Total Kjeldahl Nitrogen

Samples were digested with potassium sulphate, sulphuric acid and mercuric oxide as a catalyst to convert ammonium compounds to ammonium sulphate. The resulting ammonia nitrogen was determined using the salicylate modification of the automated phenate method, adapted for the FIA. (Refer to APHA 4500-Norg D 20th ed.; and G. Rayment & F.R. Higginson, Australian handbook of soil and water chemistry methods.)

Sydney Water laboratory method number: NU72

4.1.4 Total Organic Carbon

For the TOC analysis, the sample was dried at 40oC, and homogenised using mortar and pestle. 1 g of dried sample is digested with HCl and homogenised again. Approximately 5 mg of sample is weighed for analysis. The analysis method is then based on converting all organic and inorganic substances by flash combustion. All of the resulting gases are reduced and separated by gas chromatography (GC) and detected by TCM. The sample is digested with 1N hydrochloric acid in a ratio of 1:5 sample/acid. All results are reported as % dry weight (Refer to Instruction manual NA1500, Carlo Erba and APHA 5310-C, 20th ed. for further details).

Sydney Water laboratory method numbers: WC97

4.1.5 Organochlorine Pesticides, HCB, and Polychlorinated Biphenyls

A known amount of sample was dried using sodium sulphate and extracted by ultrasonication with dichloromethane (DCM). The samples were concentrated and a clean-up procedure using alumina was employed to enable separation of polychlorinated biphenyls (PCBs) and organochlorines (OCs).

The samples were analysed by GC with an ECD using the dual column confirmation technique (in-house method – modified version of APHA6630).

Sydney Water laboratory method number: TC001OSP

4.1.6 Polyaromatic Hydrocarbons

A known amount of sample was dried using sodium sulphate and extracted by ultrasonication with DCM. The samples were concentrated and a clean-up procedure using silica gel employed.

The samples were analysed by gas chromatography/mass spectrometry (GC/MS) (in-house method – modified version of APHA 6640).

Sydney Water laboratory method number: TC004SLL

4.1.7 Cresols

A known amount of sample was extracted with an acetonitrile/water mixture using sonication. The samples are then analysed by HPLC using a fluorescence detector (in-house method).

Sydney Water laboratory method number: WTC009SD

4.1.8 Chlorophenols

A known amount of sample was acidified with concentrated sulphuric acid then dried using sodium sulphate before being extracted by ultrasonication with DCM. The samples are concentrated and derivatised with acetic anhydride then analysed by GC/MS (in-house method – modified version of APHA6420).

Sydney Water laboratory method number: WTC005SD

5 Data analysis methods

This report provides a presentation and assessment of the data collected for this program since its inception in 1999. 2014 was the sixth assessment year of the program so, for the majority of the chemical parameters and the biological component, the 2014 results are the sixth set of results. For the remaining parameters (particle size (PS), TOC and biology for Malabar 0 km), the 2014 data set is the 16th for the program.

The statistical approach adopted for 2014 follows on from the methods that were most successful in 2011. These methods include methods that have become available through the scientific literature since 2008 under the PERMANOVA+ (Anderson et al, 2008) add on module to PRIMER (Clarke and Warwick, 2001).

The biology statistical test based on the ANOSIM technique run in 2011 was not repeated in 2014. Recent evaluation of this technique and PERMANOVA technique indicated ANOSIM performed poorly in the presence of heterogeneity in multivariate dispersion while PERMANOVA performed in an acceptable manner (Anderson and Walsh, 2013). As heterogeneity in multivariate dispersion is a common feature of ecological data, balanced PERMANOVA models which include asymmetrical models, have been presented in this report to account for this advance in our understanding of multivariate analysis techniques.

Given this context, the following statistical techniques have been used to describe data in this report.

Wastewater chemistry:

- comparison of raw data against ANZECC (2000) guideline levels

Sediment chemistry:

- comparison of raw data against ANZECC (2000) guideline levels
- test data to see if assumptions of ANCOVA are met (test for common regression slopes)
- where appropriate run ANCOVA using fines as the covariate and pair-wise tests
- otherwise run spatial ANOVA comparing control and impact for north 60 m and south 80 m sites

Biology:

- benthic community analysis by multivariate analysis (MDS plots, tree diagrams (dendrograms), Asymmetrical PERMANOVA, CAP, PERMDISP, SIMPER, DISTLM)
- Univariate ANOVA of the number of taxa by higher taxonomic group
- Univariate ANOVA of abundance of each higher taxonomic group.

Unless stated otherwise, a level of significance of 0.05 was used in this report.

5.1 Sediment chemistry analysis

The sediment chemistry data available for assessment varied between years. During surveillance years, sediment analyses were limited to grain size and TOC determinations, while a wider range of analyses were conducted during assessment years; these included nutrients, metals and organic compounds. The surveillance years' data assessment was limited to a determination of whether a trigger criterion was exceeded and if further analysis work was required. The criterion defined from a previous EPA investigation (EPA, 1998), is TOC results should not exceed 1.2% (99th percentile) in more than one sediment sample from the Malabar 0 km location. This was the case in 2014 with TOC results being below 1.2% for the Malabar 0 km location.

During assessment years, in accordance with EPA licence requirements, a more expansive list of 22 organic chemicals and 19 organochlorine pesticides were tested for the North Head and Malabar 0 km locations. As these chemicals were not tested for at either control or positive-control locations statistical testing was not appropriate. Instead these sediment chemistry parameters were compared to (where set) ANZECC (2000) guidelines guideline values for sediments.

For statistical analyses, parameters that were measured at all sites (both control and deepwater outfall locations, as well as the gradient study positive-control locations – Malabar 3 km, Malabar 5 km and Malabar 7 km) were available for statistical assessment. These chemicals included 11 metals, one metalloid, and two organic chemicals. Although results were all at the laboratory detection level for the organic chemical m-cresol and most measurements of the organic chemical naphthalene were also recorded at the detection level. Due to the dominance of detection level data it was not appropriate to statistically test these two organic chemicals.

For the purposes of this report, unless stated otherwise, a disturbance is defined as a significant (at $\alpha = 0.05$) departure from concentrations of chemicals at control (reference) locations.

Prior to data analyses for the 2005 data assessment report, investigations of the data structure were carried out to determine the need for normalisation and transformation of the data. An initial assessment of the homogeneity of variance was conducted using Bartlett's Test. The test was made on the following data groupings and manipulations (Table 5-1).

Table 5-1 Data groups prepared for Bartlett's tests for homogeneity of variance

Data manipulations	Data groupings
Raw data	All locations all years All years 60 m locations All years 80 m location All locations 1999 only All locations 2002 only All locations 2005 only 60 m locations 1999 only 60 m locations 2002 only 60 m locations 2005 only 80 m locations 1999 only 80 m locations 2002 only 80 m locations 2005 only Each location (12) all years
Normalised against mud	
Normalised against TOC	
Raw data square root transform	
Raw data log10 transformed	
Raw data reciprocal transformed	
Mud normalised data square root transformed	
Mud normalised data log10 transformed	
Mud normalised data reciprocal transformed	
TOC normalised data square root transformed	
TOC normalised data log10 transformed	
TOC normalised data reciprocal transformed	

In general terms, data groupings greater than those for a single site failed the test of homogeneity of variance; and none of the transformations or normalisations tested improved this situation across the range of parameters assessed. In discussions with the OEH it was decided that, while this assumption for conducting Analysis of Variance (ANOVA) was not met, ANOVA is sufficiently robust to be an appropriate test for use as required despite the outcomes of the Bartlett's tests. Given the assessment was conducted on data collected from a period of 7 years, it was determined that the outcomes of further assessment using data collected since 2005 was unlikely to change the outcomes. Subsequently, Bartlett's test was not conducted on data collected from 2008 onwards. An advantage of performing ANOVA with PERMAONA+ software is that it potentially overcomes the limitation of lack of homogeneity, as 'p values' are calculated by permutation.

Similarly, correlations were produced for data reported in the 2005 data assessment report to assess relationships between parameters measured, particularly between fines, TOC and metals. It was found that there was no consistent relationship between either TOC or particle size and the chemical parameters measured, and that relationships between the chemical parameters and TOC or particle size were generally no stronger than between many of the chemical parameters. As with the Bartlett's test, it was determined that further correlations would not add value to the previous work and would therefore not be conducted from 2008 onwards.

The correlation findings presented in the 2005 data assessment report are in agreement with Schneider et al. (1994), who found that ‘neither metals or organochlorines had a strong association with the fine sized particles (mud) in the sediment. However, the results of this study are in accordance with previous studies in the area that have reported a poor relationship between contaminants and grain size’.

From these initial data assessments, there was little to indicate that a particular normalisation or transformation should be conducted prior to data analysis. It was decided in 2005 that ANOVA would be conducted on the raw data and Analysis of Covariance (ANCOVA) would be trialled using fine grain size as a covariate where appropriate. This was repeated in 2008, 2011 and again in 2014 with checks of both fine grain size and TOC as covariates.

5.1.1 Description of analysis of covariance

ANCOVA is a statistical technique that allows the analyst to control one variable in a data set that correlates with the variable of interest. For example, it has been widely reported that metal contamination in sediments will be predominantly associated with the amount of fine sediment. Thus, if a sample contains a large amount of mud it may also contain elevated concentrations of metals. However, if the samples were looked at as metals per gram of fine sediment they may have the same concentration. Similarly, this potential relationship with fine sediments will add to the variability of the sample and may confound differences between sites.

Consider the following hypothetical example. Using ANOVA on samples with variable fine sediment content to which metals are attached provides data that contains the natural variability of the metal, as well as the natural variability of the sediment. This produces larger variance than for each variable alone and may result in a graph such as Figure 5-1. ANOVA would not detect a difference between these sites.

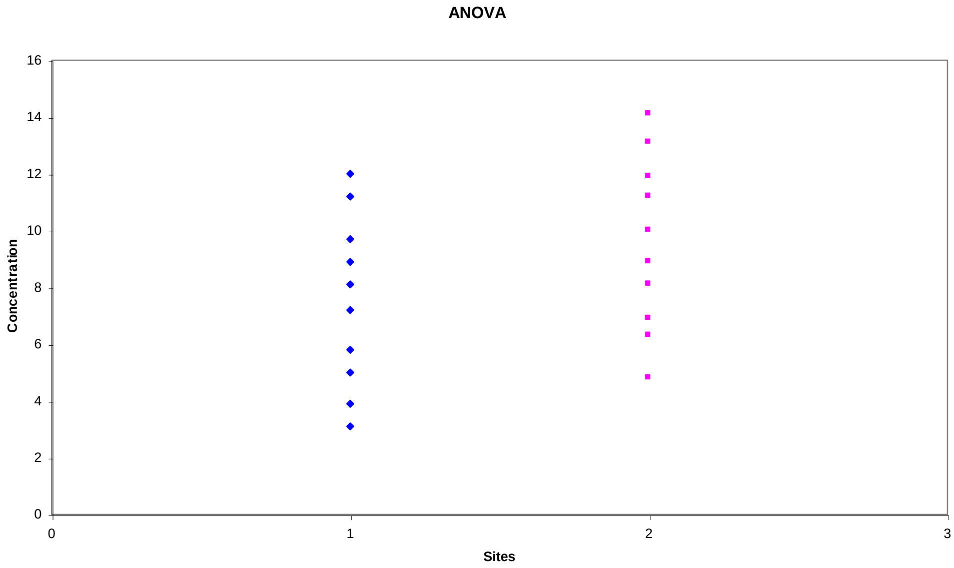


Figure 5-1 Spread of data comparing sites using ANOVA

However, the picture could be substantially different if the sediments are also plotted so that the variance associated with them can be controlled (Figure 5-2).

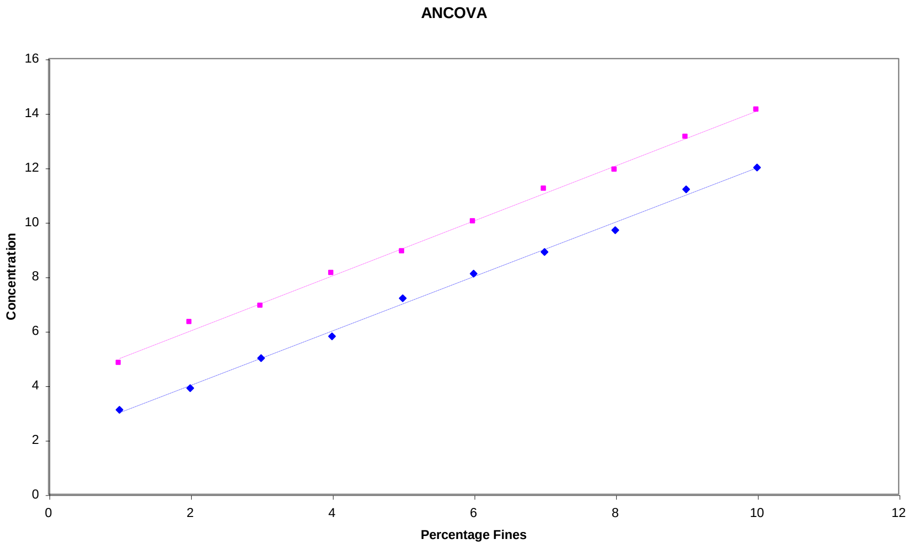


Figure 5-2 Spread of data comparing sites while controlling for the variation associated with fine sediments, as would be done for ANCOVA

ANCOVA allows the experimenter to address the question of whether the difference between the lines (sites) is significant. The underlying assumption, however, is that the slope of the lines are similar.

Prior to running ANCOVA, this assumption regarding the slope of the lines must be tested. If the slopes are similar, as in Figure 5-2, the Null Hypothesis that there is no difference between the slopes will be supported and the ANCOVA can proceed. If the slopes of the lines are not the same (example provided in Figure 5-3), the Null Hypothesis will be rejected and ANCOVA would not be used.

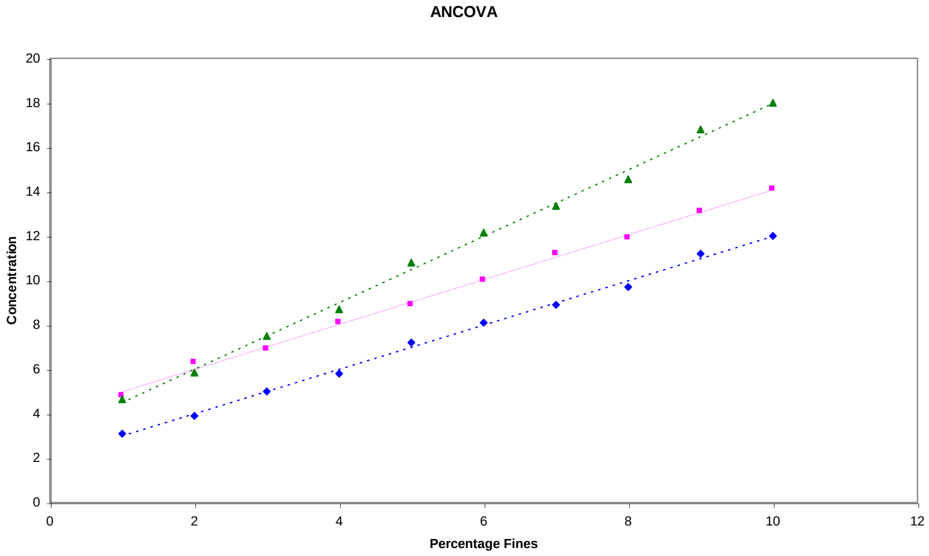


Figure 5-3 The slope of these lines would be significantly different and thus the assumptions of ANCOVA would not be met

The basic process of ANCOVA is relatively simple. Initially, all data is pooled and a regression line for all the data is calculated. Using an Analysis of Variance style of procedure, the individual regression lines can then be compared with the pooled regression line. If the individual lines are significantly different from the pooled line, the intercept of the lines with the y-axis can then be compared. This allows an assessment of the extent of contamination for each site, now that the variance associated with different mud (fine sediment) content is controlled.

ANCOVA and ANOVA were run using the PERMANOVA+ for Primer package. Under this package, the regression line comparison (to see if they have the same slope) is made via the interaction term of a two way ANOVA. This is followed by a Pair-wise comparison of Euclidian distance, where the variate and co-variate are both taken into account.

5.1.2 Comparison with ANZECC (2000) guidelines

The data ranges have been tabulated and the upper measurements compared to the lower and upper ANZECC guideline value for sediments. These tables are presented in the results section.

5.1.3 Control vs. outfall assessment

To assess whether the deep ocean outfalls were resulting in any measurable disturbance in sediment quality, an analysis was made comparing control or reference locations (sites not expected to be influenced by the outfalls) with outfall sites (sites proximate to and potentially disturbed by the outfalls). Since locations were sampled in two depth regimes (60 m and 80 m), the data was separated prior to any statistical analyses (Table 5-2).

Table 5-2 Locations groupings for data analyses

60 m depth		**80 m depth**		**80 m depth**	
Site	Type	Site	Type	Site	Type
Long Reef	control	Malabar 0 km	outfall	Malabar 0 km	gradient study
North Head	outfall	Port Hacking	control	Malabar 3 km	gradient study
Bondi	outfall	Marley Beach	control	Malabar 5 km	gradient study
				Malabar 7 km	gradient study

The 60 m and 80 m depth data were analysed separately using a hierarchy of analytical techniques. Initially, ANCOVA was run using the fine sediment fraction as the co-variate. If the assumption of this ANCOVA was met (that is the interaction term was not significant) and the Locations factor was significant, a pair-wise comparison was run between all combinations of sites. If the assumption was not met an ANCOVA using TOC as the covariate would be run. As previously this was followed by a pair-wise comparison if it was valid to do so.

If both ANCOVA’s were not valid then ANOVA would be run on unadjusted data followed by pair-wise comparisons provided the Locations factor was significant.

5.1.4 Malabar gradient study

Data collected adjacent to Malabar outfall and locations 3 km, 5 km and 7 km south of the outfall were investigated to determine if a spatial gradient, in terms of level of sediment contamination relative to the outfall location, could be found in the area to the south. This was conducted under the premise that the wastewater plume from the outfall dispersed in a generally southerly direction, based on previous investigations conducted by the NSW EPA (now OEH).

The 80 m depth samples from Malabar outfall through to Malabar 7 km and on to Marley Beach were run together using ANCOVA then ANOVA, as described above.

5.2 Sediment biology

In order to assess any putative impacts from the operation of deepwater ocean outfalls, spatial and temporal comparisons of the benthic faunal communities and their dominant taxa were conducted. Spatial comparisons of benthos at impact (outfall) locations and those of control (natural reference) locations were undertaken. The communities of 60 m and 80 m depth were investigated together and then separately to avoid potential variation arising by mixing data of two depths. A study along a distance (gradient) south of the Malabar outfall was also explored, as the sites were at 0 km, 3 km, 5 km and 7 km from the outfall. 80 m control (natural reference) locations were also further south at 10 km and 17 km.

Analyses of these data explored graphical/distributional, univariate and multivariate methods, as used in the analysis of marine benthos (Clarke and Warwick 2001; Pohle and Thomas 2001; Anderson et al, 2008).

Data analysis included the following approaches to community data:

- univariate methods – ANOVA of population (taxon) parameters were conducted on individual variables, such as taxon number and number of individuals within taxa at the Phyla level
- multivariate methods – Classification (dendrograms), Ordination (MDS plots), SIMPER, Asymmetrical PERMANOVA, PERMDISP, CAP, DISTLM and dbRDA ordination plots.

Multivariate data analyses were performed using the PRIMER Version 6.1.16 software package (Clarke and Warwick 2001) and the PERMANOVA+ Version 1.0.6 (Anderson et al, 2008) add on module to PRIMER. Analysis techniques included:

- Classification
- MDS ordination
- CAP
- SIMPER
- PERMANOA
- PERMDISP
- DISTLM and dbRDA.

These analysis techniques complement univariate analyses by exploring patterns of invertebrate community structure. Prior to analysis, the data from the field survey were either square root or quadratic root-transformed and rare taxa observed in only one sample were removed.

Similarities (distances) between the fauna of each pair of sites were calculated using the Bray-Curtis measure, which is not sensitive to rough approximations in the estimation of taxa abundances (Faith et al., 1987). The Bray-Curtis resemblance measure is focused on compositional changes in taxa identities (Anderson and Walsh 2013) and incorporates a measure of abundance. A compositional focus seemed prudent in light of a nine year post-commissioning study of a 60 m deepwater ocean outfall off Victoria, British Columbia. That study detected a localised measurable impact in benthic communities within 100 m of the outfall diffuser array with reduced taxonomic richness (a change in composition) and higher abundance of those taxa (Taylor et al. 1998). Other measureable impacts in benthic communities that have been studied in near shore waters where reductions in species (compositional change) in the immediate vicinity of the outfall together with increases in abundance of a few species were recorded (Gibbs, 1988).

The group average classification technique was used to place the sampling sites into groups, each of which had a characteristic invertebrate community based on relative similarity of their attributes. The group average classification technique initially forms pairs of samples from the most similar taxa and gradually fuses the pairs into larger and larger groups (clusters) with increasing internal variability.

Classification techniques will form groups even if the data set actually forms a continuum. In order to determine whether the groups were 'real' the samples were ordinated using the non-metric multidimensional scaling (MDS) technique. Ordination produces a plot of sites on two or three axes, such that sites with similar taxa lie close together and sites with a differing taxon composition lie farther apart. Output from classification analysis was checked against sample groupings on the ordination plot to see if site before-after (a-priori) groups of samples occurred, which would indicate a response from operation of the deepwater diffusers.

A constrained ordination procedure, such as MDS, inevitably introduces distortion when trying to simultaneously represent the similarities between large numbers of samples in only two or three dimensions. The success of the procedure is measured by a stress value, which indicates the degree of distortion imposed. A stress value of below 0.2 in the PRIMER software package indicates an acceptable representation of the original data, although lower values are desirable.

To achieve suitable multivariate representations of data in 2 or 3 dimensions, an analysis strategy to minimise stress (and achieve a better measure of fit) is to pool up invertebrate data by averaging or summing at the site or sub-site level. Although, summing should only be performed if the same number of replicates is available for each site sampled.

The CAP routine is design to look for axes in multivariate space that best separate groups (Anderson et al, 2008). An unconstrained ordination, such as MDS, attempts to display the greatest total variation across the multivariate data cloud, while CAP is able to search out groups that may be in a different direction to the primary direction of greatest variation.

The SIMPER routine was used to explore which taxa were principally responsible for differences between sets of samples defined a-priori. This routine employs Bray Curtis similarities to examine the contribution of individual taxa to the average similarity between groups and within groups.

Anderson et al (2008) states '…increases or decreases in the multivariate dispersion of ecological data has been identified as a potentially important indicator of stress in marine communities (Warwick and Clarke 1993, Chapman et al., 1995)'. To statistically test this aspect of the data the PERMDISP routine of PERMANOVA+ was run on factors as outlined below.

As heterogeneity in multivariate dispersion is a common feature of ecological data balanced PERMANOVA models, which include asymmetrical models have been presented in this report to account for recent advances in our understanding our multivariate analysis techniques after evaluation of PERMANOVA in the presence of heterogeneity in multivariate dispersion by Anderson and Walsh (2013).

Asymmetrical permutational analysis of variance (PERMANOVA) model were based upon the Bray-Curtis dissimilarity matrix being constructed from square root transformed data. A total of 9999 ‘permutations were run with the ‘reduced model’ option selected. Anderson et al (2008) recommends this option is run in conjunction with conservative Type III sums of squares to base hypothesis decisions upon. Although for the below listed asymmetrical PERMANOVA models, which are balanced, they produce the same result when Type I sums of squares were selected.

The ‘Distance-based linear models’ (DISTLM) routine based on spatial geographic (distance between location samples) and chemistry (various metals) sets of predictor variables were used to explore taxonomic turnover between the spatially set Malabar gradient locations. Anderson et al. (2008) states ‘By analysing the data in sets, one can explicitly examine the proportion of variation in the species data that is explained by the environmental variables over and above the amount explained by the spatial variables alone.’

Modelled output of DISTLM was displayed in a constrained dbRDA ordination plot. To assess the adequacy of the plot, both fitted variation and total variation were inspected. If fitted variation exceeds 70% then the plot is likely to capture most of the salient pattern in the fitted DISTLM model (Anderson et al., 2008). The amount of total variation is also important to consider. If the total variation is very small, then the dbRDA axis maybe of little overall relevance in the multivariate system as a whole (Anderson et al., 2008).

6 Results

6.1 Contributing factors

6.1.1 Oceanography

Wastewater from the three deepwater ocean outfalls contains particulate matter to which contaminants may be attached. Under particular environmental conditions, negatively buoyant particles may settle, leading to a possible accumulation of contaminants in the sediments. Sufficiently large ocean currents and waves will re-suspend the sediments thereby potentially releasing contaminants to the water column and their distribution may become more widespread.

The work described in this section assesses the plume characteristics and examines the likelihood of sediment re-suspension in the two-month period leading up to, and during, the February 2014 ocean sediment sampling period. An assessment is also made of the wave data between 2000 and 2014 to determine whether the conditions during 2014 were fundamentally different from those in the previous decade. Unless explicitly noted, analyses were undertaken using data averaged into daily bins.

Inevitably, there are some gaps in the data. Gaps were filled using spectral techniques. Data on either side of the gap were subject to a Fourier analysis and the corresponding spectral bands were averaged. The result was subjected to an inverse Fourier transform and used to patch across the data gap. While this is a relatively simple method of data patching, it does provide a data patch with spectral characteristics similar to those of the data near the gap. Patching of the data was undertaken on less than 5% of the total length of the record and is unlikely to result in substantial errors in the analyses undertaken here.

Plots of the daily maximum wave height (Hmax), daily average significant wave height (Hsig) and corresponding significant wave period (Tsig) from the beginning of 2000 until the end of February 2014 are presented in Figure 6-1. Superimposed on these plots are the times during which the sediment sampling was undertaken (i.e. February of each year).

Daily maximum wave heights are generally in the range 2-6 metres, although wave heights in excess of 10 m can be observed in some years. Significant wave height is generally less than 2 m, although it exceeds 4 m at some times in some years. Significant wave period is generally in the range 7-10 sec, with excursions as great as 15 sec observed in some years.

Wave data from May 2006 onwards was obtained from the Long Reef waverider buoy, located further offshore and to the north of the ORS. This is the likely reason for the extreme wave heights appearing larger prior to 2006 than after 2006.

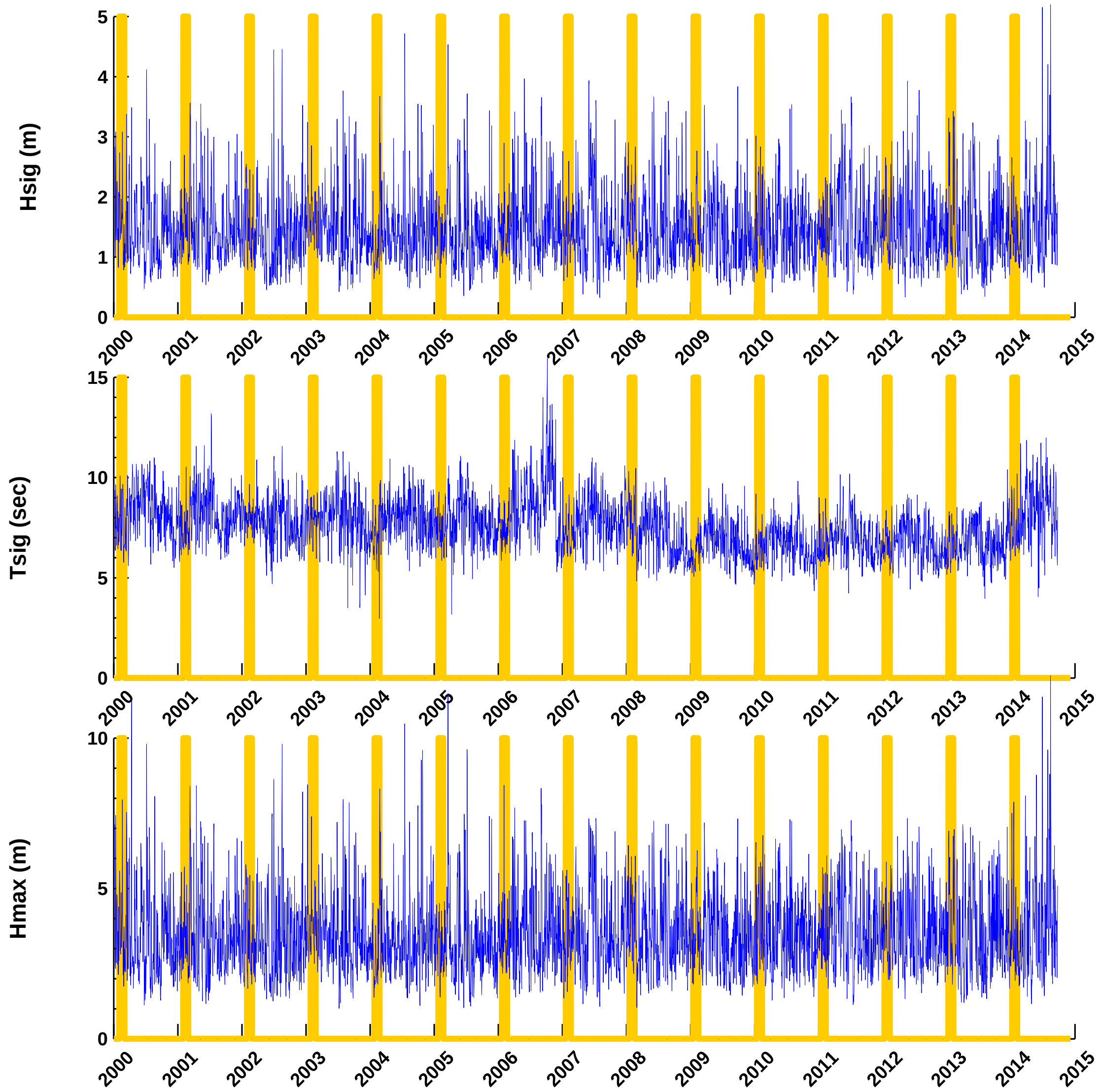


Figure 6-1 Daily maximum wave height, significant wave height and significant wave period from 1 January 2000 to 31 December 2013. Data obtained from the Ocean Reference Station. The vertical lines indicate February of each year – the month during which sediment sampling was undertaken

6.1.2 Interannular variability

An analysis of variance (ANOVA) was undertaken to compare wave data collected during the December-January-February period of each year. To apply ANOVA, three conditions should be met: data are independent, data exhibit homogeneity of variance and data are from a normal distribution (eg Sahai and Ageel, 2000). ANOVA is a fairly robust technique and is able to cope with departures from the last two conditions (Sahai and Ageel, 2000).

Independence: Independence of the data is a critical condition for the application of ANOVA. A lagged correlation assessment was undertaken to check that the data used in the analysis are not linearly correlated. The first “turning point” in the correlation versus lag plot indicates that the data are uncorrelated. This occurs at a lag of less than seven days for the wave heights. Based on this lack of correlation, wave data more than one week apart are regarded as independent. Commencing on the 1st January of each year, wave data from every seventh day were selected for the ANOVA. (Data commencing on other days were similarly selected with no substantial difference in the results).

Homogeneity of variance: Bartlett’s test was used to validate the assumption that the wave data from each year originates from populations of equal variances. At the 5 % level of significance, most of the calculated chi-squared value was slightly greater than the critical chi-squared value, suggesting that the data variances were “almost” homogeneous. ANOVA is robust to departures from homogeneity of variance and based on the closeness of the calculated and critical statistics, it is concluded that the data variances originate from populations of almost equal variances and the analysis is continued.

Normally distributed: Two tests were used to determine whether the data were normally distributed – D’Agostino’s test and the Jarque-Bera test. Both tests produced essentially the same results. The tests generally indicated that the wave heights and periods were normally distributed at the 5 % level of significance. On the basis that ANOVA is fairly robust to departures from normality and that the distributions look almost normal, this condition is relaxed and the ANOVA proceeds.

Results from the ANOVA are presented in Table 6-1 for significant wave height, Table 6-2 for maximum wave height and in Table 6-3 for significant wave period commencing from day 1. (It is noted that commencing from any other day produces essentially the same results). A bar under the mean values indicates no statistically significant difference among those years. For both the maximum and significant wave height, the results indicate no statistically significant difference (at the 5% level) among the different years. However, it should be noted that the statistical power for the wave heights is low (less than about 0.3). The statistical power for the significant wave period is between 0.7 and 0.9 (depending on the start day).

Table 6-1 ANOVA results for the significant wave height

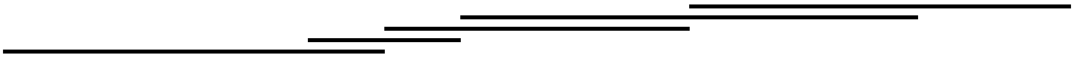
Year	2005	2003	2002	2010	2013	2001	2000	2007	2009	2012	2004	2011	2008	2014	2006
Mean (m)	1.33	1.37	1.38	1.40	1.42	1.46	1.47	1.47	1.47	1.49	1.50	1.55	1.59	1.61	1.64

Table 6-2 ANOVA results for the maximum wave height

Year	2005	2001	2002	2003	2010	2013	2004	2007	2000	2012	2009	2011	2008	2006	2014
Mean (m)	3.08	3.28	3.29	3.35	3.37	3.41	3.48	3.50	3.53	3.57	3.57	3.61	3.72	3.72	3.79

Table 6-3 ANOVA results for the significant wave period

Year	2010	2009	2012	2013	2011	2008	2003	2007	2002	2005	2004	2014	2000	2001	2006
Mean (s)	6.54	6.76	6.83	6.86	7.03	7.37	7.57	7.68	7.91	7.94	8.03	8.10	8.21	8.24	8.85



6.1.3 Sediment movement

Soulsby (1997) suggested that if: h < 0.1 g T2 or h < 10 Hsig where: h is the water depth, g is the gravitational acceleration, T is the wave period and Hsig is the significant wave height, then wave driven oscillatory flow at the sea bed may be important to sediment mobility. Based on these formulae, if the water depth is 65 m, wave action may be important for sediment mobility when the wave period exceeds 8.1 sec or the significant wave height exceeds 6.5 m. At 80 m water depth, these values are 9.0 sec and 8.0 m respectively. From Figure 6-1, it appears unlikely that wave height alone is sufficient to induce substantial sediment mobility. However, the wave period occasionally exceeds 10 sec indicating that the relatively long wave periods observed at the ORS site may induce sediment mobility at both the 65 m and 80 m sites. Shear stress at the sea bed is usually used to determine whether currents (including those induced by waves) are of sufficient strength to initiate sediment movement. There are many different ways for determining the critical shear stress to initiate sediment movement and a review by Rowinski et al. (2005) assesses a number of different methods for determining bed shear stress. One such method was the use of the Shields parameter. Both Blake et al. (2004) and Camenen and Lason (2005) use various forms of the 'Shields parameter approach' to estimate sediment movement. The former approach is used here.

From Blake et al. (2004), the shear stress, τ, (related to the Shield's parameter) from flow due to currents can be expressed as:

$$\tau = \rho \frac{k^2}{\left[\ln\left(\frac{h}{2z_0}\right)\right]^2} u^2$$

where; ρ is the density of the sea water, k (=0.42) is von Karman's constant, z0 is the effective bottom roughness (approximated by the median grain size diameter), h is the water depth and u is the average current speed.

The shear stress due to waves can be estimated by:

$$\tau = \frac{\rho}{2} \exp\left[5.213 \left(\frac{2500 \ d_0}{H}\right)^{0.194} - 5.9777\right] u^2$$

where: d0 is the median grain size, H is the wave height and u is the orbital current speed from the (deepwater) wave-induced motion, which is given by:

$$\text{speed (u)} = 3.14 \frac{H}{T} \exp\left(\frac{2.01 \ z}{T^2}\right)$$

where: H is the wave height, T is the wave period and z is the water depth (assumed negative).

Knowing the median grain size, the bed shear stress from both wave-induced currents and the bulk water currents can be estimated.

The critical shear stress to initiate sediment motion is a complex, non-linear function. From Blake et al (2004), for particles larger than 0.2 mm, the critical shear stress, τ (N/m2), to initiate sediment movement is given by:

$$\begin{aligned}
\tau &= 0.024\,\frac{(\rho_s - 1)\,g\,d}{d*} && \text{for } 1 < d* \le 4\\
\tau &= 0.014\,\frac{(\rho_s - 1)\,g\,d}{d*^{0.64}} && \text{for } 4 < d* \le 10\\
\tau &= 0.004\,\frac{(\rho_s - 1)\,g\,d}{d*^{0.1}} && \text{for } 10 < d* \le 20\\
\tau &= 0.0013\ d*^{0.29}(\rho_s - 1)\,g\,d && \text{for } 20 < d* \le 150\\
\tau &= 0.0055\ (\rho_s - 1)\,g\,d && \text{for } d* > 150
\end{aligned}$$

where ρs is the specific density of the particles, g = 9.81 m/s2, d is the median particle diameter and d* is given by:

$$d* = d\left[(\rho_s - 1)\,\frac{g}{\upsilon^2}\right]^{1/3}$$

and υ is the kinematic viscosity of the water.

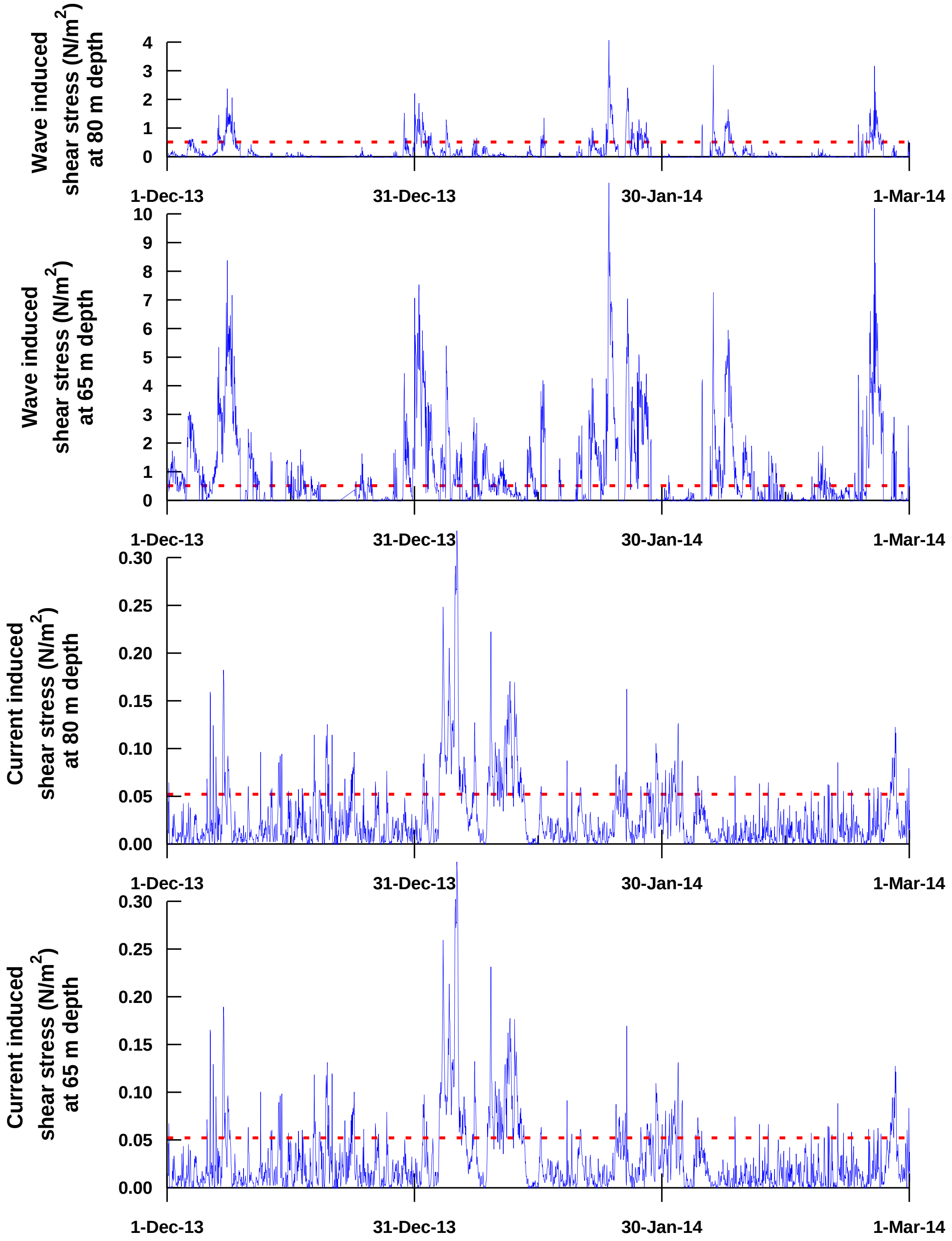


Figure 6-2 Wave and current induced shear stress at 65 m and 80 m water depth. The horizontal dashed line is the critical shear stress to initiate sediment movement

Comparing the critical shear stress required to initiate sediment movement with the current / wave induced shear stress, provides estimates of when sediment movement is likely to occur. Based on this model, sediment movement resulting from the bulk currents occurs relatively often during this time (particularly from mid-January 2014 onwards) (Figure 6-2). The wave environment during late 2013 and early 2014 appears larger than in previous years and wave induced shear stress is relatively large compared with previous years. In waters of depth 80 m, wave induced sediment movement is likely to occur in early-to-mid December 2013, early and late January 2014 and mid and late February 2014. At 65 m depth, sediment movement is likely to occur for much of the 1 December 2013 to 28 February 2014 time period.

Therefore, in the two months preceding the 2014 sediment-sampling period, substantial sediment movement is likely to have occurred as a result of either waves or currents. Such an active seabed environment will mask any potential accumulation of contaminants in the sediments, making it difficult to interpret results obtained from such studies.

6.1.4 Plume distribution

The near-field plume model described in Tate and Middleton (2000, 2004) is used in conjunction with data from the North Head, Bondi and Malabar wastewater treatment plants and oceanographic data from the Ocean Reference Station to estimate the position and dilution of the plumes from each of the three deepwater ocean outfalls. The period covered is from 1 December 2013 to 28 February 2014. These results are presented in Figure 6-3, Figure 6-4 and Figure 6-5 for the North Head, Bondi and Malabar outfalls, respectively.

In general, the information contained in these figures suggests the height of plume rise lies in the range 10-30 m. Plume dilutions during this period are highly variable, lying between (approximately) 100:1 and 1000:1 but may be as large as several thousands. Dilutions are greatest for the Bondi outfall, thence for the North Head outfall and least for the Malabar outfall.

Negatively buoyant particles originally within the wastewater plume will likely fall out of suspension and reside in or on the sediments that form the sea floor. Using the wastewater characterisation data outlined in Baker et al (1995) and assuming that the current speed and direction data at the Ocean Reference Station are representative of the region, the model proposed by Cheng (quoted in Blake et al, 2004) can be used to estimate the intersection of such negatively buoyant particles with the seabed. A fundamental assumption is that all particles remain within the effluent plume until the plume has reached its level of neutral buoyancy (or the sea surface).

Estimates of the location at which negatively buoyant particles reach the sea floor are presented in Figure 6-3, Figure 6-4 and Figure 6-5 for the North Head, Bondi and Malabar outfalls respectively, for the period 1 December 2013 to 28 February 2014. Using Cheng's model, heavy particulate matter discharged from the deepwater outfalls reaches the seabed within approximately 10 km of the outfall. The spatial distribution of such negatively buoyant particles around each outfall is approximately aligned with the bottom bathymetry.

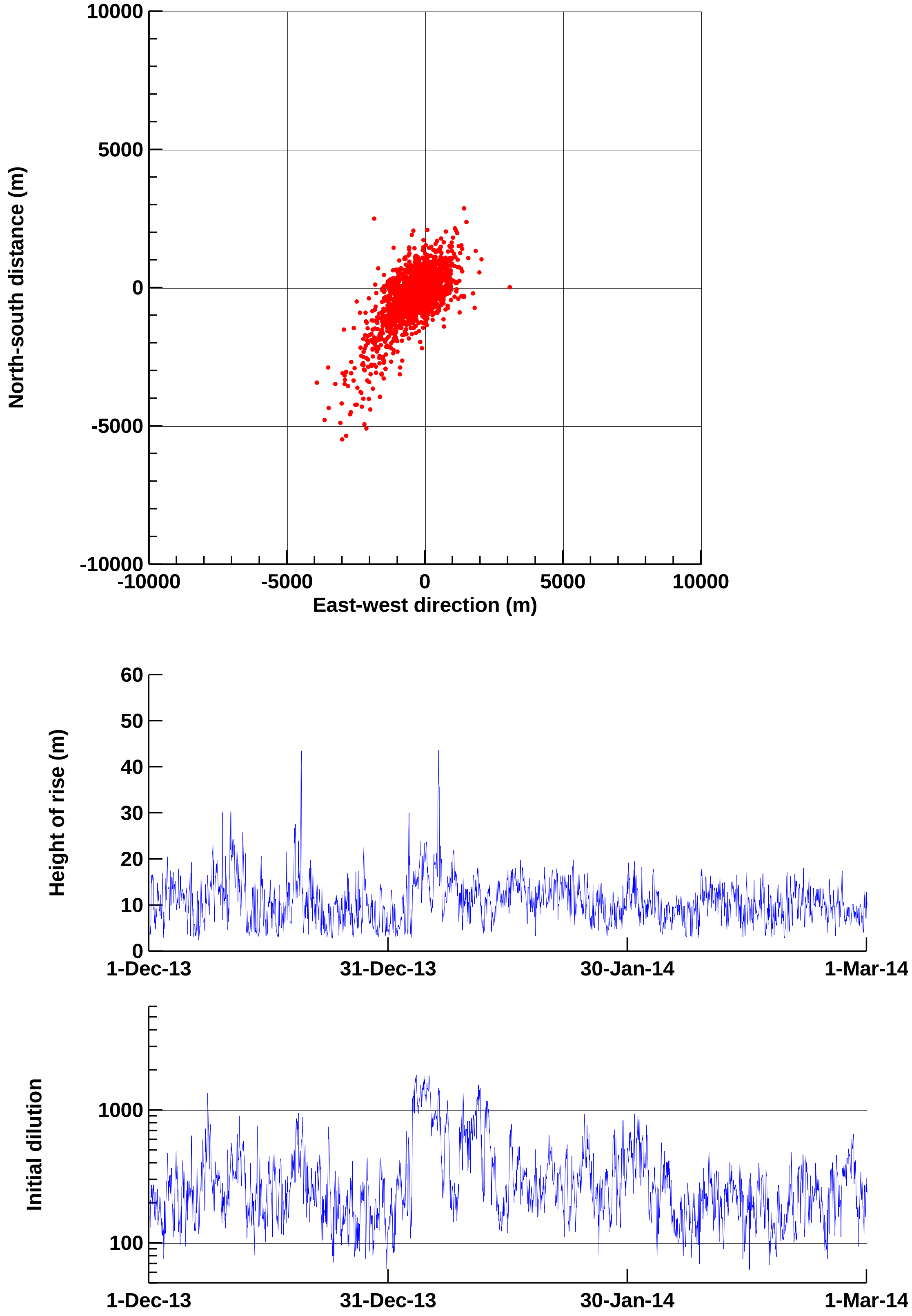


Figure 6-3 North Head outfall. Top: Estimates of the fall-out location of heavy particles from the plume for February 2014. Lower two plots: Height of plume rise and initial dilution between 1st December 2013 and 28th February 2014

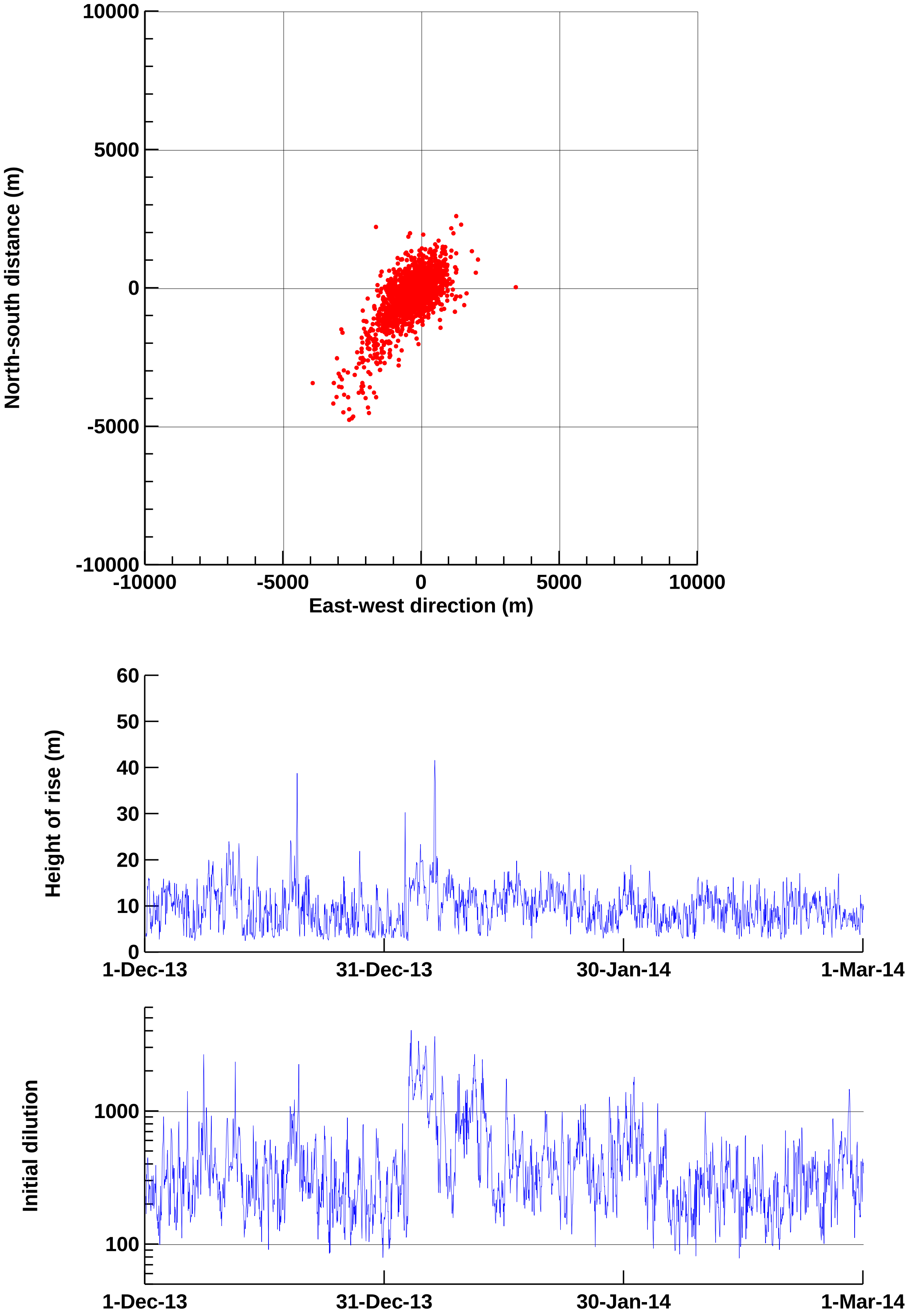


Figure 6-4 Bondi outfall. Top: Estimates of the fall-out location of heavy particles from the plume for February 2014. Lower two plots: Height of plume rise and initial dilution between 1st December 2013 and 28th February 2014

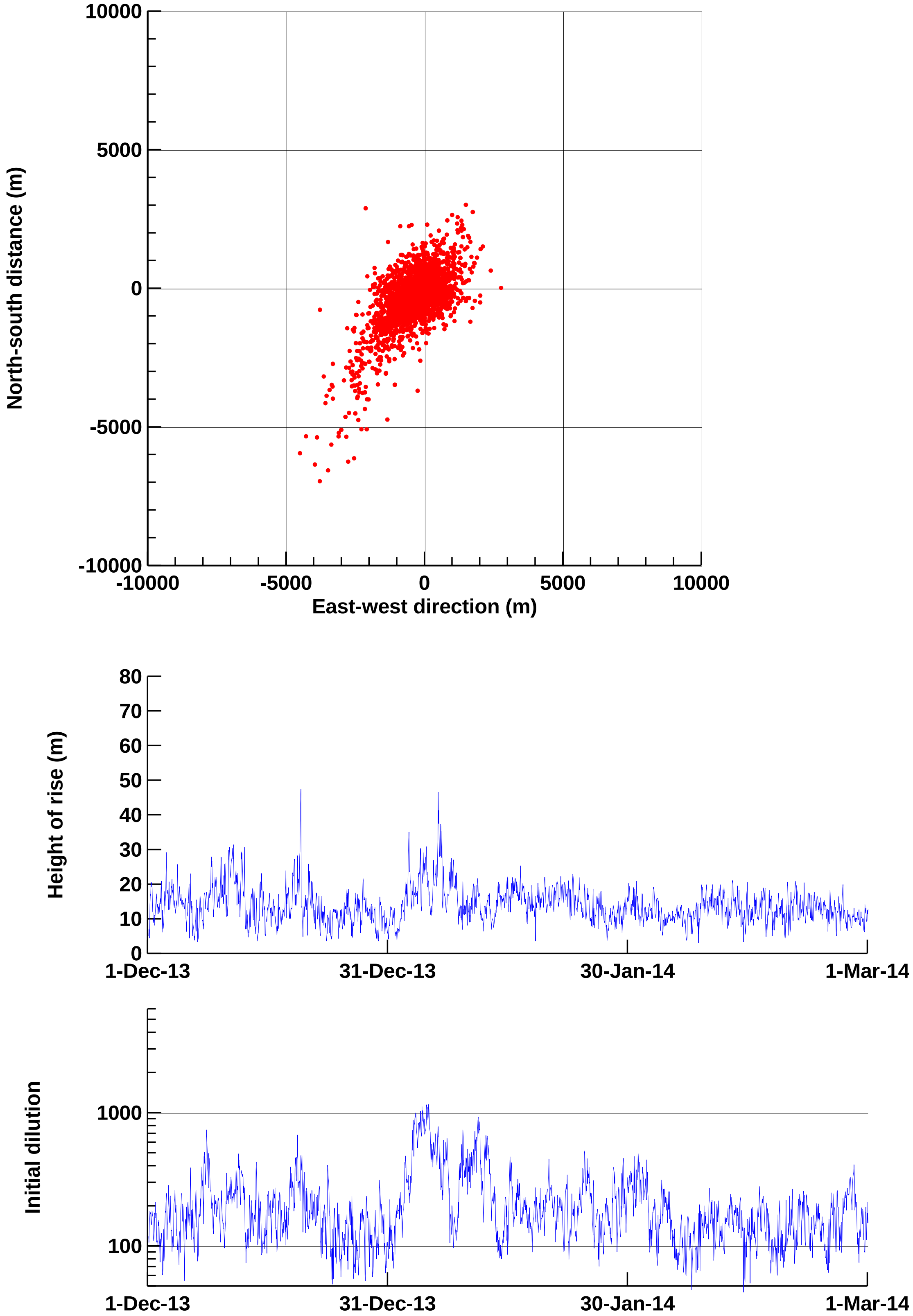


Figure 6-5 Malabar outfall. Top: Estimates of the fall-out location of heavy particles from the plume for February 2014. Lower two plots: Height of plume rise and initial dilution between 1st December 2013 and 28th February 2014

6.1.5 Wastewater quality comparison with ANZECC (2000) guideline values

Dilution factors derived from the above models were used to assess wastewater data against ANZECC (2000) guidelines for protection of 95% of marine species.

Out of the suite of parameters measured at each plant, eight chemicals had ANZECC (2000) guideline values assigned. For the other chemical parameters monitored under EPA pollution monitoring licences no set values had been assigned by ANZECC (2000) to allow this comparison.

Based modelled dilution values that were exceeded 98% of the time of these eight chemicals, only the modelled concentrations for copper were near, equalled or just exceeded the guideline value (Table 6-4, Table 6-5 and Table 6-6).

Table 6-4 Comparison of modelled chemical concentrations near the deepwater ocean outfalls for STSIMP (financial years) to ANZECC (2000) guideline values for North Head

North Head		**Chemical concentration (µg/L)**							
		cadmium	**chromium**	**copper**	**mercury**	**lead**	**zinc**	**endosulphan**	**chlorpyrifos**
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2013-14 undiluted wastewater average value		0.2	3.8	104	0.2	2.6	109	<0.01	<0.05
Dilution exceeded 98% of time	72:1	0.003	0.05	1.4	0.003	0.04	1.5	0.0001	0.0007
Dilution exceeded 10% of time	690:1	0.0003	0.01	0.2	0.0004	0.004	0.16	0.00001	0.00007
2012-13 undiluted wastewater average value		0.2	6.3	101	0.08	3.7	115	<0.01	<0.05
Dilution exceeded 98% of time	84:1	0.002	0.08	1.2	0.001	0.04	1.4	0.0001	0.0006
Dilution exceeded 10% of time	713:1	0.0004	0.01	0.1	0.0001	0.005	0.2	0.00001	0.0001
2011-12 undiluted wastewater average value		0.4	4.1	79	0.09	3.6	109	<0.01	<0.05
Dilution exceeded 98% of time	81:1	0.005	0.05	1.0	0.001	0.04	1.3	0.0001	0.0006
Dilution exceeded 10% of time	818:1	0.0005	0.005	0.1	0.0001	0.004	0.1	0.00001	0.00006
2010-11 undiluted wastewater average value		0.4	5.3	96	0.2	3.6	130	<0.01	<0.05
Dilution exceeded 98% of time	73:1	0.006	0.07	1.3	0.003	0.05	1.8	0.0001	0.0007
Dilution exceeded 10% of time	595:1	0.0006	0.009	0.2	0.0003	0.006	0.2	0.00002	0.00008
2009-10 undiluted wastewater average value		0.4	6.2	99	0.2	4.6	122	<0.01	<0.05
Dilution exceeded 98% of time	68:1	0.006	0.09	1.4	0.003	0.07	1.8	0.0001	0.0007
Dilution exceeded 10% of time	798:1	0.0005	0.008	0.1	0.0003	0.006	0.2	0.00001	0.00006
2008-09 undiluted wastewater average value		0.4	5.8	96	0.1	4.9	121	<0.01	<0.05
Dilution exceeded 98% of time	82:1	0.005	0.07	1.2	0.001	0.06	1.5	0.0001	0.0006
Dilution exceeded 10% of time	774:1	0.0005	0.007	0.1	0.0001	0.006	0.2	0.00001	0.00006

Table 6-5 Comparison of modelled chemical concentrations near the deepwater ocean outfalls for STSIMP (financial years) to ANZECC (2000) guideline values for Bondi

Bondi		**Chemical concentration (µg/L)**							
		cadmium	**chromium**	**copper**	**mercury**	**lead**	**zinc**	**endosulphan**	**chlorpyrifos**
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2013-14 undiluted wastewater average value		0.1	1.1	120	0.07	3.6	106	<0.01	<0.05
Dilution exceeded 98% of time	89:1	0.001	0.01	1.3	0.001	0.04	1.2	0.0001	0.0006
Dilution exceeded 10% of time	943:1	0.0001	0.001	0.1	0.0001	0.004	0.1	0.00001	0.00005
2012-13 undiluted wastewater average value		0.3	2.3	125	0.09	5.4	123	<0.01	<0.05
Dilution exceeded 98% of time	102:1	0.003	0.02	1.2	0.001	0.05	1.2	0.0001	0.0005
Dilution exceeded 10% of time	1033:1	0.0003	0.002	0.1	0.0001	0.005	0.1	0.00001	0.0001
2011-12 undiluted wastewater average value		0.2	1.6	110	0.06	5.1	102	<0.01	<0.05
Dilution exceeded 98% of time	104:1	0.002	0.02	1.1	0.001	0.05	1.0	0.0001	0.0005
Dilution exceeded 10% of time	1353:1	0.0001	0.001	0.08	0.00004	0.004	0.08	0.00001	0.00004
2010-11 undiluted wastewater average value		0.1	1.8	113	<0.1	3.5	104	<0.01	<0.05
Dilution exceeded 98% of time	93:1	0.001	0.02	1.2	0.001	0.04	1.1	0.0001	0.0005
Dilution exceeded 10% of time	917:1	0.0001	0.002	0.1	0.0001	0.004	0.1	0.00001	0.00005
2009-10 undiluted wastewater average value		0.2	1.8	110	<0.1	4.4	102	<0.01	<0.05
Dilution exceeded 98% of time	86:1	0.002	0.02	1.3	0.001	0.05	1.2	0.0001	0.0006
Dilution exceeded 10% of time	1233:1	0.0002	0.001	0.1	0.00008	0.004	0.08	0.000008	0.00004
2008-09 undiluted wastewater average value		0.1	2.3	118	<0.1	4.7	106	<0.01	<0.05
Dilution exceeded 98% of time	108:1	0.001	0.02	1.1	0.001	0.04	1.0	0.0001	0.0005
Dilution exceeded 10% of time	1271:1	0.00008	0.002	0.09	0.00008	0.004	0.08	0.000008	0.00004

Table 6-6 Comparison of modelled chemical concentrations near the deepwater ocean outfalls for STSIMP (financial years) to ANZECC (2000) guideline values for Malabar

Malabar		Chemical concentration (µg/L)							
		cadmium	**chromium**	**copper**	**mercury**	**lead**	**zinc**	**endosulphan**	**chlorpyrifos**
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2013-14 undiluted wastewater average value		0.2	9.3	80	0.05	3.3	102	<0.01	<0.05
Dilution exceeded 98% of time	56:1	0.004	0.17	1.4	0.001	0.06	1.8	0.0002	0.0009
Dilution exceeded 10% of time	478:1	0.0004	0.02	0.2	0.0001	0.01	0.2	0.00002	0.0001
2012-13 undiluted wastewater average value		0.2	6.0	74	0.07	4.3	97	<0.01	<0.05
Dilution exceeded 98% of time	65:1	0.003	0.09	1.1	0.001	0.07	1.5	0.0002	0.0008
Dilution exceeded 10% of time	507:1	0.0003	0.01	0.1	0.0001	0.01	0.2	0.00002	0.0001
2011-12 undiluted wastewater average value		0.2	7.8	74	0.06	4.2	107	<0.01	<0.05
Dilution exceeded 98% of time	68:1	0.003	0.11	1.1	0.001	0.06	1.6	0.0001	0.0007
Dilution exceeded 10% of time	578:1	0.0003	0.01	0.1	0.0001	0.007	0.2	0.00002	0.00009
2010-11 undiluted wastewater average value		0.1	7.8	59	<0.1	2.7	86	<0.01	<0.05
Dilution exceeded 98% of time	55:1	0.002	0.14	1.1	0.002	0.05	1.6	0.0002	0.0009
Dilution exceeded 10% of time	448:1	0.0002	0.02	0.1	0.0002	0.006	0.2	0.00002	0.0001
2009-10 undiluted wastewater average value		0.3	10.2	67	<0.1	13.3	86	<0.01	<0.05
Dilution exceeded 98% of time	55:1	0.005	0.19	1.2	0.002	0.24	1.6	0.0002	0.0009
Dilution exceeded 10% of time	551:1	0.0005	0.02	0.1	0.0002	0.02	0.2	0.00002	0.00009
2008-09 undiluted wastewater average value		0.2	7.0	68	<0.1	4.1	90	<0.01	<0.05
Dilution exceeded 98% of time	67:1	0.003	0.10	1.0	0.001	0.06	1.3	0.0001	0.0007
Dilution exceeded 10% of time	550:1	0.0004	0.01	0.1	0.0002	0.007	0.2	0.00002	0.00009

6.1.6 Rainfall

Sampling during 2014 followed a period of about average costal precipitation but lower than average inland precipitation, more like the 2005 and 2011 assessment years. As such contributions of contaminants from adjacent catchments were less likely than in wetter periods, when the sediment contribution from Sydney catchments was likely to be greater.

Rainfall data were sourced from a range of pluviometers across the Sydney area and are presented in Table 6-7 and Table 6-8. They include stations in Port Jackson and Georges River catchments from near the coast to near the top of the catchment. The values provided are the total rainfalls for each 12 month period up to the 1st of February for each year. In general, the highest rainfalls were recorded prior to sampling in 1999 and relatively low rainfalls were recorded in the 12 months leading up to February in 2003, 2007 and 2009 years.

Table 6-7 Rainfall totals for the 12 months prior to February sampling each year 1999 to 2008

Rainfall Station*	Total annual rainfall to February (mm)										
	1999	2000	2001	**2002**	2003	2004	**2005**	2006	2007	**2008**	Annual Average#
Liverpool	1,027	824	694	765	494	702	725	618	472	1,018	866
Glenfield	973	724	666	721	490	716	529	591	448	1,060	785
Pennant Hills	1,690	972	897	1,023	771	1,144	869	nd	nd	nd	1,068
Parramatta	1,210	818	571	842	570	809	661	658	614	1,248	921
Blacktown	951	496	684	597	495	640	643	566	468	768	923
Prospect	1,036	842	614	806	531	744	680	576	455	1,035	872
Paddington	1,820	1,279	801	1,168	919	1,263	1,058	849	1,028	1,475	1,216

Table 6-8 Rainfall totals for the 12 months prior to February sampling each year 2009 to 2014

Rainfall Station*	Total annual rainfall to February (mm)						
	2009	2010	**2011**	2012	2013	**2014**	Annual Average#
Liverpool	517	703	861	804	857	666	866
Glenfield	453	702	899	886	950	738	785
Prospect	469	630	815	876	860	689	872
Paddington	814	1043	1327	1493	1312	1247	1,216

* Sydney Water pluviometers 566049, 567078, 567083 and 566032

Taken from Bureau of meteorology (www.bom.gov.au) for period of record for nearest station with 30 plus years of data (Liverpool station 67035, Glenfield station 68043, Prospect station 67019 and Paddington station 66062)

nd = No data collected, none collected at Parramatta and Blacktown in the last three years

Assessment years indicated in bold highlight

6.2 Sediment chemistry

6.2.1 Total organic Carbon and percentage of fine sediment particle size

The total organic carbon (TOC) content was less than 1% at all locations in 2014. Therefore, sediment chemistry results can be compared directly with ANZECC (2000) low level guideline values. If TOC is much greater than 1% then additional carbon binding sites will reduce the contaminant bioavailability. In that case ANZECC (2000) recommends a less stringent application of sediment guidelines. This was not the case in 2014, and as such a direct comparison was made with the guideline values.

Median TOC levels recorded at sites in 2014 fell within the range previously recorded at locations over the 2001 to 2011 period (Figure 6-6). Median levels at all locations over this time period generally fluctuated within a 0.4% range. TOC was not measured at all locations in 2012 and 2013 under the NSW EPA modified study design. At northern locations (Long Reef, North Head and Bondi) median TOC levels were about half of that recorded at southern locations from Malabar 3 km to Marley Beach (Figure 6-6). Median TOC levels at northern outfall sites were similar to the northern control sites of the Long Reef location. Median TOC levels at the Malabar 0 km location had levels marginally above those recorded at the northern locations (Figure 6-6). Low levels of TOC at the outfall locations suggest particulate matter starts to fall out of suspension away from the outfalls (Figure 6-6).

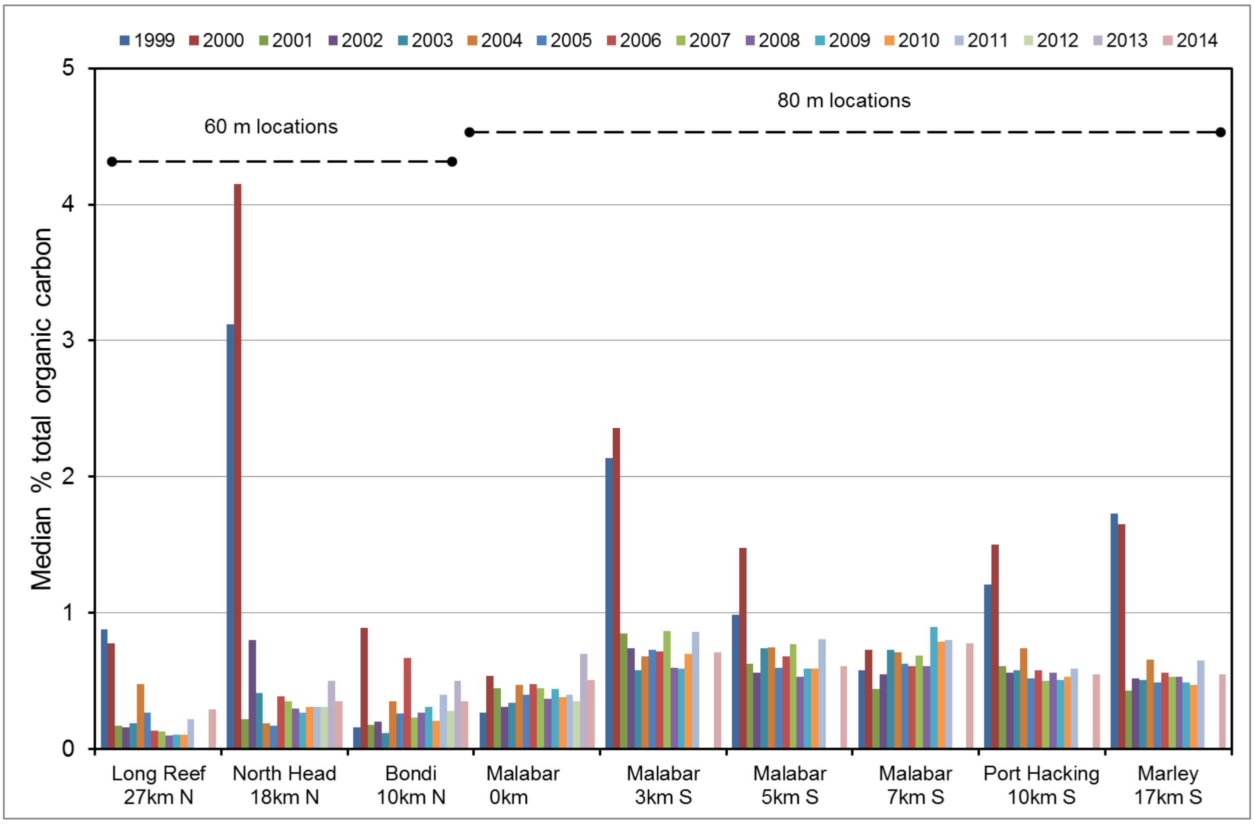


Figure 6-6 Median % total organic carbon (TOC) for each location

Overall patterns in the median percentages of fine sediment particles were similar to those of observed for TOC. The median percentage of fine sediment particles was lower around the northern locations, intermediate around the Malabar 0 km outfall location and higher for the southern locations (Figure 6-7). While there was some variation in median percentage of fine sediment particles between years at each location, levels were relatively stable at each location with the exception of the Malabar 7 km location that displayed an overall increasing trend (Figure 6-7).

The sedimentation model results of 2014 suggested negatively buoyant particles settling out generally within about 5 km of each outfall. This model also suggests particulate matter settles to both the north and south of the outfalls (depending on the current direction) with a preference to settling on the south side (Figure 6-3, Figure 6-4 and Figure 6-5). Plume modelling from other interpretive years had a similar pattern although distances varied to be generally within about 5 to 10 km of the outfalls.

Hence particle settling to the south of the Malabar outfall may explain the higher percentages recorded from the Malabar 3 km south location. Although a build-up through time was not apparent with the exception of the Malabar 7 km location.

If negatively buoyant particles were settling at about this distance over time then perhaps a pattern of build up at the Bondi location could be expected as it is about 8 km south of the North Head deepwater ocean outfall. In contrast to this possible pattern there was no apparent build-up of fine sediment around the Bondi deepwater ocean outfall (Figure 6-7). Although without a gradient study around this outfall it is difficult to draw a definitive conclusion from these results.

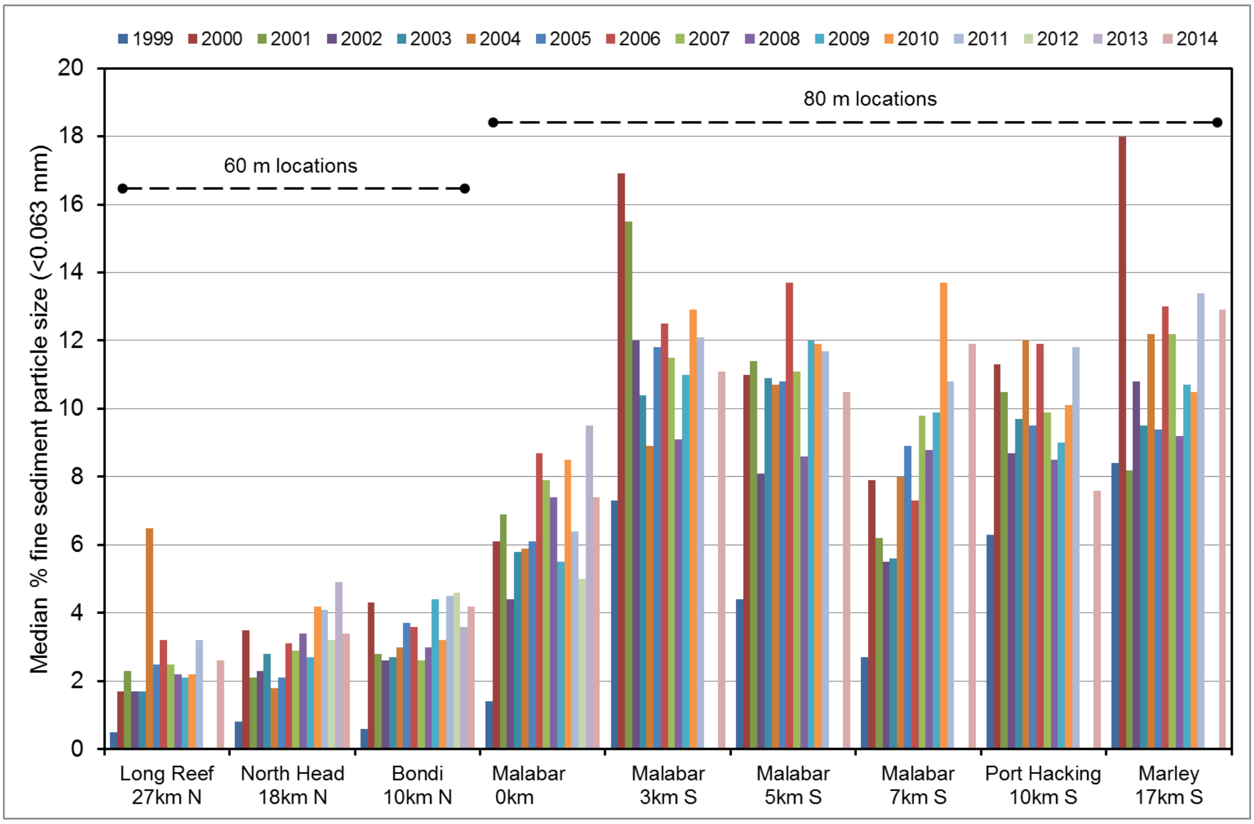


Figure 6-7 Median % fine sediment particles <0.063 mm for each location

With generally stable levels of the percentages of fine particles at locations the build-up of chemical concentrations in the sediments was the unlikely. As such an increased disturbance to benthic communities over background sediment conditions was in turn unlikely. Benthic community patterns are presented in Section 6.3 Sediment Biology.

6.2.2 Sediment chemistry comparison with ANZECC (2000) guidelines

Sediment chemistry was tested for a range of metals, a metalloid and the two organic compounds Naphthalene and m-cresol at all nine locations (Table 6-9). Additional organic compounds were tested for at the North Head and Malabar 0 km locations (Table 6-9). The organometallic tributyltin listed in the ANZECC (2000) sediment chemistry guidelines was not tested, as this chemical was previously used in the now banned boat antifouling paints, and as such is not a sewer derived source. Birch et al (2013) indicated ecological recovery within the Sydney estuary had occurred for this chemical prior to 2006.

ANZECC (2000) places two notes of caution about uncertainties with the sediment guidelines. As values have been derived from a few species rather than a range of species this raises a question of ecological relevance. The second uncertainty note indicates the guideline values do not take into account antagonism or synergism between chemicals. Hence if guideline values are exceeded a measurable ecological impact should not be automatically assumed.

The comparison of sediment chemistry results with ANZECC (2000) low level guidelines shows that, for the great majority of samples taken, guideline levels have not been exceeded. There were some exceptions that are highlighted in Table 6-9. Most of these exceptions occurred in samples collected in 1999 and 2002 for a number of organic compounds such as polyaromatic hydrocarbons (PAHs) and organochlorine pesticides, the metal mercury, and the metalloid arsenic at a number of control and outfall locations. With the exception of the North Head location these exceedances lay below the higher ANZECC (2000) interim sediment quality guideline trigger level and by 2005, many of these exceedances lay below the lower guideline level (Table 6-9). For metals and organic chemicals that had ANZECC (2000) interim sediment quality guideline trigger values were plotted with trigger levels annotated. Eight plots were raised for metals and 12 plots were raised for organic chemicals. These plots are presented in Appendix B. In addition to the above trends these plots allowed a view of the data to look for any increasing trends over time. An increase over time was not evident. Rather fluctuation thorough time was evident.

In 2014, mercury was detected above the low level guideline value (0.15 mg/kg) and below the higher guideline value (1 mg/kg). This occurred for mercury in two samples at Long Reef (0.17 and 0.41 mg/kg) and in one sample from the Malabar 3 km (0.18 mg/kg) location (Table 6-9). While at North Head a mercury reading of 3.65 mg/kg was recorded in one sample while the other nine samples had levels below the ANZECC (2000) low level guideline of 0.15 mg/kg. This single North Head reading suggested a localised hot spot rather than a broad build-up of this chemical (Appendix B).

In about half of the samples collected at the North Head location in 2014, the metalloid arsenic also exceeded the low level interim sediment quality guideline trigger value (20 mg/kg). The exceeded values were below the upper guideline trigger value (70 mg/kg) outlined by ANZECC (2000). In past assessment years, with the exception of the 2008, a similar number of samples fell between the low level guideline value and the upper guideline value for arsenic at the North Head location (Appendix B).

ANZECC (2000) indicates the source of toxicity in sediment chemistry is most often ammonia or common pesticides. While we have not tested sediment toxicity we have tested the sediments for the presence of organochlorine pesticides at North Head and Malabar locations, which were recorded at laboratory chemical detection levels in each assessment year since 2002. At these levels they are an unlikely source of disturbance to the benthic communities.

Table 6-9 Comparison of ocean sediment program sediment quality data with ANZECC (2000) guideline levels – ISQG-low (Trigger value) N/A = no level set to date

Variable	Units	Range (minimum and maximum) of results for each location												
		Long Reef						North Head						ANZECC (2000) ISQG low-high
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
TOC	%	0.15-4.93	0.08-4.41	0.09-1.92	0.07-0.36	0.1-0.52	0.11-0.6	1.10-4.92	0.20-1.88	0.1-0.39	0.19-0.59	0.11-3.49	0.23-0.59	N/A
metals														
aluminium	mg/kg	1912-4463	1660-3450	2270-5290	865-1770	1320-3750	1150-2280	2085-8475	2750-5150	2010-4430	1800-3320	2480-3690	2280-3710	N/A
cadmium	mg/kg	0.04-0.22	0.04-0.20	0.03-0.19	0.03-0.08	0.03-0.12	0.02-0.05	0.08-0.14	0.10-0.19	0.05-0.11	0.08-0.13	0.07-0.15	0.08-0.13	1.5-10
chromium	mg/kg	13.3-24.7	7.34-18.0	12.2-22.2	9.71-17.1	11.9-17.2	8.89-14.2	20.2-45.8	15.2-33.2	16.7-28.6	13.2-22.7	17.5-34.5	14.7-29.3	80-370
copper	mg/kg	1.63-2.67	1.10-3.92	1.6-4.8	0.81-3.09	1.28-4.47	1.24-3.27	3.12-16.4	2.89-4.64	2.43-5.59	2.63-5.69	2.93-6.90	2.81-7.07	65-270
iron	mg/kg	6132-12150	4330-13100	7000-12200	5020-9060	6720-11000	5010-8520	9095-19200	10400-23700	10500-18900	10100-17300	10800-20200	10400-22600	N/A
lead	mg/kg	5.90-9.80	3.60-9.96	4.97-11.5	2.53-7.62	5.19-11.3	3.34-9.5	10.4-32.8	11.6-22.3	8.09-24.3	8.06-13.3	9.33-17.3	9.52-18.8	50-220
mercury	mg/kg	0.02-0.06	0.03-0.18	0.04-0.11	0.02-0.09	0.02-0.13	0.03-0.41	0.02-0.35	0.07-0.93	0.03-0.21	0.05-0.24	0.05-0.17	0.08-3.65	0.15-1.0
nickel	mg/kg	5.55-12.3	2.59-6.04	3.88-5.75	2.27-4.26	2.83-5.34	2.12-5.35	6.73-18.5	5.92-9.73	3.83-8.04	3.34-6.50	4.56-8.01	4.28-7.81	21-52
selenium	mg/kg	0.08-0.43	0.01-0.11	0.07-0.18	0.03-0.07	0.08-0.18	0.06-0.13	0.13-0.89	0.03-0.06	0.27-0.53	0.06-0.15	0.13-0.27	0.11-0.24	N/A
silver	mg/kg	0.01-0.08	0.02-0.06	0.01-0.07	0.01-0.03	0.02-0.05	0.01-0.02	0.04-0.30	0.03-0.09	0.02-0.07	0.02-0.08	0.03-0.07	0.02-0.05	1-3.7
zinc	mg/kg	8.02-18.7	8.4-20.0	9.9-21.3	6.40-16.4	11.4-22.0	8.7-18.6	15.9-50.4	15.5-25.4	14.5-50.5	15.3-26.0	18.6-28.7	17.4-28.8	200-410
metalloid														
arsenic	mg/kg	6.97-29.9	5.74-22.7	5.06-27.6	4.22-17.3	4.91-16.5	4.06-7.49	10.4-33.1	10.0-57.4	12.8-32.9	5.87-32.2	6.47-38.7	10.6-43.2	20-70
organics														
total PAHs	µg/kg	.	.	.	.	.	.	852-15300	101-28000	231-2740	389-2680	75-2290	944-2490	4000-45000

Variable	Units	Range (minimum and maximum) of results for each location												ANZECC (2000) ISQG low-high
		Long Reef						North Head						
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
acenapthene	µg/kg	.	.	.	.	.	.	<10-34	<10-115	<10	<10-10	<10	<10	16-500
acenaphthylene	µg/kg	.	.	.	.	.	.	<10-142	<10-200	<10	<10-41	<10-31	<10-87	N/A
anthracene	µg/kg	.	.	.	.	.	.	<10-266	<10-1000	<10-23	<10-79	<10-37	<10-50	85-1100
benzo(a)anthracene	µg/kg	.	.	.	.	.	.	67-1220	13-2360	23-323	39-304	13-156	132-258	261-1600
benzo(a)pyrene	µg/kg	.	.	.	.	.	.	75-1530	14-2380	<10-293	58-343	13-226	111-291	430-1600
benzo(b)fluoranthene	µg/kg	.	.	.	.	.	.	53-1090	10-1880	18-187	38-196	14-218	120-321	N/A
benzo(e)pyrene	µg/kg	.	.	.	.	.	.	74-813	<10-1230	23-153	<10-200	<10-109	46-145	N/A
benzo(ghi)perylene	µg/kg	.	.	.	.	.	.	59-819	<10-656	<10-58	29-172	<10-227	32-111	N/A
benzo(k)fluoranthene	µg/kg	.	.	.	.	.	.	56-961	10-1710	15-203	23-116	<10-99	28-89	N/A
chrysene	µg/kg	.	.	.	.	.	.	62-1090	13-2190	24-329	<10-307	<10-155	46-127	384-2800
dibenzo(a,h)anthracene	µg/kg	.	.	.	.	.	.	<10-270	<10-463	<10-28	<10-51	<10-12	<10-33	63-260
fluoranthene	µg/kg	.	.	.	.	.	.	122-1980	19-4280	43-367	55-444	18-273	131-301	600-5100
fluorene	µg/kg	.	.	.	.	.	.	<10-97	<10-176	<10	<10-24	<10-15	<10-14	19-540
indeno-123-CD-pyrene	µg/kg	.	.	.	.	.	.	68-918	<10-2140	13-136	27-166	<10-263	92-236	N/A
naphthalene	µg/kg	<10-30	<10-25	<10-24	<10	<10-66	<5	<10-105	<10-19	<10-17	<10-17	<10-23	<10-30	160-2100
perylene	µg/kg	.	.	.	.	.	.	15-348	<10-510	<10-48	14-79	<10-69	18-52	N/A
phenanthrene	µg/kg	.	.	.	.	.	.	50-850	<10-2650	20-122	18-219	<10-136	23-135	240-1500
pyrene	µg/kg	.	.	.	.	.	.	114-1890	22-4280	41-564	88-479	17-260	126-303	665-2600
coronene	µg/kg	.	.	.	.	.	.	<100-874	<10	<10	<10-29	<10-73	39-140	N/A
M-cresol	µg/kg	<3-25	<10	<10	<10	<10-20	<10	5-42	<10	<10	<10	<10-10	<10	N/A

Variable	Units	Range (minimum and maximum) of results for each location												
		Long Reef						North Head						ANZECC (2000) ISQG
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	low-high
O-cresol	µg/kg	<3	.	.	.	.	.	<3	<10	<10	<10	<10	<10	N/A
2-Chlorophenol	µg/kg	<2	.	.	.	.	.	<2	<10	<10	<10	<10	<10	N/A
total PCBs	µg/kg	<10	.	.	.		.	<10	<10	<25	<25	<25	<25	23- -
Organochlorine Pesticides	µg/kg	<0.5-3 (DDT)	.	.	.	.	.	<0.5	All <0.5	All <0.5	All <0.5	All <0.5	All <0.5	0.02-46
others														
mud	%	1.37-3.08	0.86-2.93	1.8-5.8	1.42-3.13	1.86 – 4.92	1.61-4.58	2.24-10.9	1.09-3.19	1.4-3	1.71-9.60	1.91 – 6.67	2.27-4.67	N/A
sand	%	85.5-97.4	58.2-98.5	89.9-98.2	66.6-97.2	76.0 – 96.8	82.2-98	79.6-96.9	74.3-96.4	54.8-98.3	75.2-95.8	81.9 – 96.3	79.3-97.5	N/A
gravel	%	0.00-13.1	0.00-41.0	<0.1-7.1	0.71-27.9	0.00 – 19.8	0.15-14.7	0.00-18.2	1.48-24.1	<0.1-43	0.48-15.2	0.62 – 13.2	0.21-17.6	N/A
TKN	mg/kg	130-259	.	.	.	.	.	149-1030	292-556	251-429	312-650	279-524	298-527	N/A
phosphorus	mg/kg	339-774	.	.	.	.	.	458-763	617-1200	492-1110	432-785	523-945	468-1070	N/A

		Range (minimum and maximum) of results for each location						
		Bondi						ANZECC (2000) ISQC low-high
Variable	Units	1999	2002	2005	2008	2011	2014	
TOC	%	.	0.07-0.50	0.10-0.46	0.09-0.91	0.18-0.56	0.3-0.46	N/A
metals								
aluminium	mg/kg	.	2300-6460	826-5070	803-2480	1400-3140	1770-2690	N/A
cadmium	mg/kg	.	0.07-0.11	0.01-0.05	0.03-0.06	0.03-0.07	0.04-0.07	1.5-10
chromium	mg/kg	.	8.61-15.8	5.82-17.8	5.95-14.1	8.33-17.2	10.6-13.7	80-370
copper	mg/kg	.	2.39-5.13	1.26-7.25	1.55-4.91	2.96-6.59	3.13-5.1	65-270
iron	mg/kg	.	5060-10500	3150-8900	3970-7020	6170-9480	6090-9470	N/A
lead	mg/kg	.	6.05-14.3	4.9-12.9	4.21-9.27	5.99-12.8	6.53-14.5	50-220
mercury	mg/kg	.	0.07-1.2	0.03-0.15	0.03-0.10	0.06-0.16	0.06-0.11	0.15-1.0
nickel	mg/kg	.	4.13-7.63	1.08-5.44	1.17-4.14	1.88-5.11	2.62-4.26	21-52
selenium	mg/kg	.	0.02-0.06	0.11-0.31	0.05-0.10	0.11-0.21	0.09-0.17	N/A
silver	mg/kg	.	0.03-0.14	0.02-0.11	0.02-0.05	0.04-0.09	0.03-0.05	1-3.7
zinc	mg/kg	.	11.4-23.4	7.7-24.4	8.20-19.8	10.4-28.8	16.3-22.8	200-410
metalloid								
arsenic	mg/kg	.	4.26-7.40	3.19-6.81	4.53-6.30	3.52-6.29	5.18-10.8	20-70
organics								
total PAHs	µg/kg	.	.	.	.	.	.	4000-45000
acenapathene	µg/kg	.	.	.	.	.	.	16-500
acenaphthylene	µg/kg	.	.	.	.	.	.	N/A
anthracene	µg/kg	.	.	.	.	.	.	85-1100
benzo(a)anthracene	µg/kg	.	.	.	.	.	.	261-1600

Variable	Units	Range (minimum and maximum) of results for each location						
		Bondi						ANZECC (2000) ISQC low-high
		1999	2002	2005	2008	2011	2014	
benzo(a)pyrene	µg/kg	.	.	.	.	.	.	430-1600
benzo(b)fluoranthene	µg/kg	.	.	.	.	.	.	N/A
benzo(e)pyrene	µg/kg	.	.	.	.	.	.	N/A
benzo(ghi)perylene	µg/kg	.	.	.	.	.	.	N/A
benzo(k)fluoranthene	µg/kg	.	.	.	.	.	.	N/A
chrysene	µg/kg	.	.	.	.	.	.	384-2800
dibenzo(a,h)anthracene	µg/kg	.	.	.	.	.	.	63-260
fluoranthene	µg/kg	.	.	.	.	.	.	600-5100
fluorene	µg/kg	.	.	.	.	.	.	19-540
indeno-123-CD-pyrene	µg/kg	.	.	.	.	.	.	N/A
naphthalene	µg/kg	.	<10-15	<10-63	<10	<10-20	<5	160-2100
perylene	µg/kg	.	.	.	.	.	.	N/A
phenanthrene	µg/kg	.	.	.	.	.	.	240-1500
pyrene	µg/kg	.	.	.	.	.	.	665-2600
coronene	µg/kg	.	.	.	.	.	.	N/A
M-cresol	µg/kg	.	<10	<10	<10	<10-10	<10	N/A
O-cresol	µg/kg	.	.	.	.	.	.	N/A
2-Chlorophenol	µg/kg	.	.	.	.	.	.	N/A
total PCBs	µg/kg	.	.	.	.	.	.	23- -
Organochlorine Pesticides	µg/kg	.	.	.	.	.	.	0.02-46

Variable	Units	Range (minimum and maximum) of results for each location						
		Bondi						ANZECC (2000) ISQC
		1999	2002	2005	2008	2011	2014	low-high
others								
mud	%	.	1.97-4.28	1.4-4.4	1.65-5.34	3.03–5.59	2.46-8.04	N/A
sand	%	.	84.2-97.7	92.2-98.6	87.6-97.9	80.0–96.4	89-97.3	N/A
gravel	%	.	0.00-13.1	<0.1-4.3	<0.1-10.7	0.13–16.97	<0.1-2.94	N/A
TKN	mg/kg	.	.	.	.	.	.	N/A
phosphorus	mg/kg	.	.	.	.	.	.	N/A

		Range (minimum and maximum) of results for each location												
		Malabar 0 km						Malabar 3 km						ANZECC (2000) ISQC low-high
Variable	Units	1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
TOC	%	0.18-0.81	0.08-0.58	0.21-0.6	0.30-0.60	0.21-0.64	0.33-0.66	2.03-2.47	0.61-0.80	0.37-0.87	0.36-1.00	0.93-0.93	0.64-0.76	N/A
metals														
aluminium	mg/kg	1839-6696	1850-6240	2770-6600	2250-4240	1570-4850	1740-4480	5264-12290	5400-7580	4050-8170	1340-3430	4680-5740	3800-5810	N/A
cadmium	mg/kg	0.04-0.08	0.02-0.13	<0.01-0.07	0.06-0.10	0.05-0.07	0.03-0.07	0.10-0.16	0.09-0.12	0.03-0.1	0.05-0.17	0.09-0.11	0.08-0.11	1.5-10
chromium	mg/kg	12.0-24.1	8.01-15.2	12.3-22.4	9.77-18.8	8.64-19.2	9.8-17.5	33.3-38.6	18.3-21.6	15.3-24.8	9.9-23.0	18.9-21.4	18.2-21.9	80-370
copper	mg/kg	2.17-5.83	1.05-5.62	2.91-7.39	2.97-7.36	2.65-6.75	2.73-7.46	11.5-15.0	6.28-9.54	5.2-8.82	3.11-9.02	7.48-8.45	6.75-8.41	65-270
iron	mg/kg	4723-8427	5080-8940	6120-8850	5520-8170	4850-10500	5440-8580	9566-12910	9040-10300	7300-10300	4530-9160	9760-10900	8990-10800	N/A
lead	mg/kg	4.54-42.3	4.84-10.6	4.9-9.6	4.43-9.14	4.20-9.67	4.12-8.15	15.8-23.9	11.7-13.6	7.85-12.5	5.27-10.8	9.68-10.7	8.78-11.6	50-220
mercury	mg/kg	0.04-0.08	0.03-0.14	0.04-0.12	0.05-0.11	0.05-0.12	0.04-0.13	0.09-0.19	0.11-0.18	0.06-0.13	0.11-0.17	0.14-0.17	0.14-0.18	0.15-1.0
nickel	mg/kg	4.63-9.93	2.07-7.02	3.74-7.26	3.18-6.80	2.88-7.27	2.81-6.5	12.6-14.7	7.43-10.3	5.42-9.25	3.05-8.15	7.63-8.72	6.87-8.56	21-52
selenium	mg/kg	0.12-0.65	0.02-0.08	0.1-0.27	0.12-0.20	0.13-0.24	0.11-0.33	0.23-0.99	0.08-0.14	0.22-0.36	0.09-0.33	0.27-0.33	0.23-0.36	N/A
silver	mg/kg	0.01-0.08	0.02-0.13	0.05-0.14	0.04-0.11	0.03-0.08	0.03-0.09	0.21-0.28	0.12-0.20	0.06-0.18	0.05-0.14	0.10-0.12	0.07-0.11	1-3.7
zinc	mg/kg	13.1-31.9	9.0-23.2	15.6-28.7	15.5-28.8	14.4-28.0	12.8-27.9	35.6-49.5	25.7-36.7	22.1-32.5	12.7-33.0.	31.1-34.5	28.5-35.5	200-410
metalloid														
arsenic	mg/kg	2.87-6.71	4.23-6.09	4.4-5.32	3.16-4.62	3.07-5.41	4-5.25	5.27-7.35	5.75-6.84	4.42-5.89	2.57-3.46	3.30-5.62	4.91-6.4	20-70
organics														
total PAHs	µg/kg	<10-79	<10-269	60-260	31-297	<10-353	97-871	278-731	.	.	.	.	.	4000-45000
acenapthene	µg/kg	<10	<10	<10	<10	<10	<10	<10	.	.	.	.	.	16-500

Variable	Units	Range (minimum and maximum) of results for each location												
		Malabar 0 km						Malabar 3 km						ANZECC (2000) ISQC low-high
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
acenaphthylene	µg/kg	<10	<10	<10	<10	<10	<10-14	<10	.	.	.	.	.	N/A
anthracene	µg/kg	<10	<10	<10	<10	<10	<10-15	<10-12	.	.	.	.	.	85-1100
benzo(a)anthracene	µg/kg	<10-14	<10-21	<10-24	<10-30	<10-31	18-107	21-59	.	.	.	.	.	261-1600
benzo(a)pyrene	µg/kg	<10	<10-22	<10-22	<10-29	<10-35	14-89	15-53	.	.	.	.	.	430-1600
benzo(b)fluoranthene	µg/kg	<10	<10-20	<10-21	<10-25	<10-40	14-104	13-51	.	.	.	.	.	N/A
benzo(e)pyrene	µg/kg	<10	<10-15	<10-17	<10-20	<10-19	<10-38	20-42	.	.	.	.	.	N/A
benzo(ghi)perylene	µg/kg	<10	<10-15	<10	<10-17	<10-19	<10-34	<10-38	.	.	..	..	.	N/A
benzo(k)fluoranthene	µg/kg	<10	<10-19	<10-14	<10-12	<10-20	<10-25	21-46	.	.	.	.	.	N/A
chrysene	µg/kg	<10	<10-21	<10-25	<10-18	<10-24	<10-36	<10-78	.	.	.	.	.	384-2800
dibenzo(a,h)anthracene	µg/kg	<10	<10	<10	<10	<10	<10	<10	.	.	.	.	.	63-260
fluoranthene	µg/kg	<10-36	<10-44	<10-38	16-59	<10-52	14-116	49-145	.	.	.	.	.	600-5100
fluorene	µg/kg	<10	<10-14	<10	<10	<10	<10	<10	.	.	.	.	.	19-540
indeno-123-CD-pyrene	µg/kg	<10	<10-14	<10-17	<10-17	<10-27	12-87	<10-44	.	.	.	.	.	N/A
naphthalene	µg/kg	<10	<10-15	22-64	<10-27	<10-26	10-38	13-24	<10-20	15-36	11-33	18-38	<5	160-2100
perylene	µg/kg	<10	<10	<10	<10	<10	<10-15	<10	.	.	.	.	.	N/A
phenanthrene	µg/kg	<10	<10-24	11-35	<10-31	<10-26	10-52	21-66	.	.	.	.	.	240-1500
pyrene	µg/kg	<10-29	<10-39	<10-42	15-48	<10-44	15-102	42-108	.	.	.	.	.	665-2600
coronene	µg/kg	<100	<10	<10	<10	<10	<10-41	<100	.	.	.	.	.	N/A
M-cresol	µg/kg	4-30	<10	<10	<10	<10	<10	46-124	<10	<1.0	<10	<10	<10	N/A
O-cresol	µg/kg	<3	<10	<10	<10	<10	<10	<3	.	.	.	.	.	N/A

Variable	Units	Range (minimum and maximum) of results for each location												
		Malabar 0 km						Malabar 3 km						ANZECC (2000) ISQC low-high
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
2-Chlorophenol	µg/kg	<2	<10	<10	<10	<10	<10	<2	.	.	.	.	.	N/A
total PCBs	µg/kg	<10	<10	<25	<25	<25	<25	<10	.	.	.	.	.	23- -
Organochlorine Pesticides	µg/kg	<0.5	All <0.5	All <0.5	All <0.5	All <0.05	All <0.5	<0.5-32.1 (DDT)	.	.	.	.	.	0.02-46
others														
mud	%	2.7-8.7	1.83-10.1	3.5-10.6	2.02-12.6	2.97-9.96	3.4-12.3	16.5-20.5	10.4-13.6	5.5-14.3	4.14-11.8	10.8-13.8	8.41-14.2	N/A
sand	%	90.4-96.6	89.9-98.2	89.4-96.5	87.4-98.0	89.9-96.2	87.2-95.4	79.5-83.5	86.4-89.6	85.7-64.5	88.2-95.9	85.3-88.9	85.4-91.4	N/A
gravel	%	0-1.39	0	<0.1	<0.1	0.15-1.63	0.48-1.68	0	0	<0.1-1.2	<0.1	<0.1-1.27	<0.1-0.58	N/A
TKN	mg/kg	194-539	168-622	337-756	393-782	283-696	277-1010	905-1060	.	.	.	.	.	N/A
phosphorus	mg/kg	231-365	262-474	260-365	263-355	231-475	269-368	441-531	.	.	.	.	.	N/A

Variable	Units	Range (minimum and maximum) of results for each location												
		Malabar 5 km						Malabar 7 km						ANZECC (2000) ISQC low-high
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
TOC	%	0.77-1.26	0.39-0.71	0.09-0.95	0.36-0.70	0.70-0.92	0.52-0.67	0.35-2.93	0.42-0.63	0.17-0.89	0.39-0.79	0.70-1.11	0.66-0.88	N/A
metals														
aluminium	mg/kg	2657-8972	4170-7620	1620-7890	1710-2680	4200-4680	2840-5830	2438-28170	3280-6700	3090-6990	1550-4580	2760-5120	3020-5970	N/A
cadmium	mg/kg	0.05-0.09	0.06-0.12	0.02-0.09	0.05-0.09	0.06-0.07	0.05-0.07	<0.01-0.10	0.06-0.10	0.03-0.09	0.01-0.01	0.05-0.08	0.05-0.07	1.5-10
chromium	mg/kg	18.5-31.3	14.3-18.4	5.33-22.5	11.5-18.7	16.8-18.2	13.5-18.9	7.35-35.6	8.81-12.7	9.42-18.3	5.73-17.8	10.6-18.0	11.7-19.6	80-370

Variable	Units	Range (minimum and maximum) of results for each location												
		Malabar 5 km						Malabar 7 km						ANZECC (2000) ISQC low-high
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
copper	mg/kg	6.06-9.46	4.82-6.11	1.32-7.36	4.12-7.08	6.22-7.19	4.86-6.49	2.42-8.34	2.93-4.80	2.32-5.63	2.27-6.90	4.19-7.68	5.52-7.74	65-270
iron	mg/kg	6571-8768	6670-8290	2960-9490	4490-7080	8980-9860	6780-9860	3009-16440	3880-7360	5650-8870	3090-9340	6090-9180	6240-8660	N/A
lead	mg/kg	10.1-14.3	8.81-11.6	3.36-10.6	6.47-9.03	8.52-9.56	6.47-9.5	4.16-15.9	6.02-10.0	6.4-10.9	3.55-8.36	6.56-10.0	6.54-9.84	50-220
mercury	mg/kg	0.06-0.14	0.08-0.15	0.03-0.1	0.06-0.13	0.11-0.14	0.11-0.13	<0.01-0.06	0.06-0.09	0.04-0.10	0.04-0.11	0.07-0.12	0.08-0.13	0.15-1.0
nickel	mg/kg	7.57-14.6	5.95-8.53	1.37-10.8	3.80-6.60	6.60-7.27	4.92-7.29	3.81-15.2	4.86-7.63	3.53-6.87	1.96-8.94	4.41-7.44	4.69-7.9	21-52
selenium	mg/kg	0.16-0.49	0.06-0.09	0.07-0.29	0.10-0.24	0.24-0.30	0.17-0.28	0.13-0.94	0.05-0.13	0.11-0.22	0.09-0.19	0.18-0.30	0.19-0.31	N/A
silver	mg/kg	0.08-0.19	0.09-0.13	0.02-0.14	0.07-0.11	0.07-0.09	0.06-0.08	0.02-0.08	0.04-0.09	0.03-0.13	0.02-0.12	0.05-0.08	0.04-0.07	1-3.7
zinc	mg/kg	23.5-35.3	22.2-27.7	6-28.5	17.0-26.3	25.7-34.4	21.8-28.3	11.5-30.4	12.8-20.1	10.6-21.2	8.20-26.6	19.6-27.5	18.5-27.7	200-410
metalloid														
arsenic	mg/kg	4.68-6.30	4.26-7.43	3.19-5.58	2.15-3.41	3.70-4.31	3.89-6.33	2.60-19.6	2.45-4.42	5.11-7.16	2.27-5.27	2.05-4.74	4.15-5.87	20-70
organics														
total PAHs	µg/kg	280-5350	.	.	.	.	.	40-1310	.	.	.	.	.	4000-45000
acenapthene	µg/kg	<10-11	.	.	.	.	.	<10	.	.	.	.	.	16-500
acenaphthylene	µg/kg	<10-70	.	.	.	.	.	<10-16	.	.	.	.	.	N/A
anthracene	µg/kg	<10-127	.	.	.	.	.	<10-33	.	.	.	.	.	85-1100
benzo(a)anthracene	µg/kg	20-392	.	.	.	.	.	<10-93	.	.	.	.	.	261-1600
benzo(a)pyrene	µg/kg	20-353	.	.	.	.	.	<10-82	.	.	.	.	.	430-1600
benzo(b)fluoranthene	µg/kg	20-303	.	.	.	.	.	<10-89	.	.	.	.	.	N/A
benzo(e)pyrene	µg/kg	<10-316	.	.	.	.	.	<10-93	.	.	.	.	.	N/A
benzo(ghi)perylene	µg/kg	<10-260	.	.	.	..	.	<10-72	.	.	.	.	.	N/A

		Range (minimum and maximum) of results for each location												
		Malabar 5 km						Malabar 7 km						ANZECC (2000) ISQC
Variable	Units	1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	low-high
benzo(k)fluoranthene	µg/kg	16-238	.	.	.	.	.	<10-62	.	.	.	.	.	N/A
chrysene	µg/kg	20-343	.	.	.	.	.	<10-88	.	.	.	.	.	384-2800
dibenzo(a,h)anthracene	µg/kg	<10	.	.	.	.	.	<10	.	.	.	.	.	63-260
fluoranthene	µg/kg	47-978	.	.	.	.	.	12-217	.	.	.	.	.	600-5100
fluorene	µg/kg	<10-63	.	.	.	.	.	<10-16	.	.	.	.	.	19-540
indeno-123-CD-pyrene	µg/kg	15-302	.	.	.	.	.	<10-84	.	.	.	.	.	N/A
naphthalene	µg/kg	18-167	19-78	<10-127	<10-38	25-35	<5	<10-66	44-101	<10-100	<10-33	19-47	<5	160-2100
perylene	µg/kg	<10-101	.	.	.	.	.	<10-24	.	.	.	.	.	N/A
phenanthrene	µg/kg	21-530	.	.	.	.	.	<10-120	.	.	.	.	.	240-1500
pyrene	µg/kg	38-725	.	.	.	.	.	<10-156	.	.	.	.	.	665-2600
coronene	µg/kg	<100	.	.	.	.	.	<100	.	.	.	.	.	N/A
M-cresol	µg/kg	20-194	<10	<10	<10	<10-160	<10	5-103	<10	<10	<10	<10	<10	N/A
O-cresol	µg/kg	<3	.	.	.	.	.	<3	.	.	.	.	.	N/A
2-Chlorophenol	µg/kg	<2	.	.	.	.	.	<2	.	.	.	.	.	N/A
total PCBs	µg/kg	<10	.	.	.	.	.	<10	.	.	.	.	.	23- -
Organochlorine Pesticides	µg/kg	<0.5	.	.	.	.	.	<0.5	.	.	.	.	.	0.02-46
others														
mud	%	8.38-14.0	6.20-11.6	1.6-11.7	6.79-11.3	10-12.3	7.97-11.8	2.93-21.7	4.20-7.04	3.2-15.2	5.36-14.6	8.06-14.4	7.87-15.6	N/A
sand	%	86.0-91.6	88.1-93.8	88.3-96.5	88.7-93.2	85.6-89.8	88-91.8	76.2-96.6	88.5-95.8	84.8-95.7	85.4-94.6	85.6-91.4	84.1-91.7	N/A
gravel	%	0.00-0.42	0.00-1.20	<0.1-1.9	<0.1	2.04-0.17	0.12-0.57	0.00-2.05	0.00-4.92	<0.1-1.1	<0.1	<0.1-0.52	<0.1-3.38	N/A

		Range (minimum and maximum) of results for each location												
		Malabar 5 km						Malabar 7 km						ANZECC (2000) ISQC low-high
Variable	Units	1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
TKN	mg/kg	574-738	.	.	.	.	.	258-1050	.	.	.	.	.	N/A
phosphorus	mg/kg	341-408	.	.	.	.	.	152-279	.	.	.	.	.	N/A

		Range (minimum and maximum) of results for each location												
		Port Hacking						Marley Beach						ANZECC (2000) ISQC low-high
Variable	Units	1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
TOC	%	0.84-1.65	0.44-0.70	0.41-0.66	0.47-0.64	0.48-0.76	0.41-0.64	1.45-2.14	0.43-0.58	0.39-0.55	0.48-0.65	0.58-0.85	0.43-0.58	N/A
metals														
aluminium	mg/kg	3371-8368	4070-7060	4310-7050	2400-3280	3080-5050	3400-4650	3055-12320	4220-7250	5000-10100	541-3060	4010-5890	3700-6780	N/A
cadmium	mg/kg	0.06-0.11	0.05-0.11	0.05-0.07	0.01-0.07	0.05-0.1	0.05-0.09	0.07-0.12	0.06-0.15	0.04-0.06	0.01-0.01	0.06-0.08	0.06-0.09	1.5-10
chromium	mg/kg	20.9-27.1	11.2-15.9	15.8-19.7	13.0-15.4	13.2-19.0	14-19.8	18.9-35.8	12.9-18.6	15.0-19.9	7.09-14.0	14.5-19.3	14.9-18.2	80-370
copper	mg/kg	6.56-9.28	3.84-5.61	4.75-5.69	3.67-5.00	4.0-5.94	4.39-6	6.36-9.22	3.90-5.27	4.14-5.36	0.38-4.56	4.21-7.15	4.22-6.38	65-270
iron	mg/kg	7556-9518	6650-9590	7070-9990	7360-9030	6960-10100	7360-10400	4822-11150	7360-9240	7730-10200	4570-7780	8590-11000	7590-10700	N/A
lead	mg/kg	7.75-11.1	6.33-9.52	7.27-11.7	5.60-7.10	6.03-8.72	6.32-8.96	8.77-16.3	6.84-9.73	6.75-8.94	1.45-6.65	6.32-10.3	6.25-8.68	50-220
mercury	mg/kg	<0.01-0.08	0.06-0.15	0.05-0.09	0.07-0.09	0.06-0.12	0.06-0.11	0.01-0.08	0.05-0.08	0.05-0.08	0.01-0.06	0.06-0.10	0.05-0.08	0.15-1.0
nickel	mg/kg	9.21-11.8	5.79-8.35	6.03-7.75	4.98-5.91	5.12-7.51	5.58-8.32	10.2-14.9	5.61-9.21	6.07-7.85	0.89-5.95	6.30-8.80	6.25-8.15	21-52
selenium	mg/kg	0.51-0.91	0.06-0.11	0.18-0.32	0.13-0.17	0.14-0.29	0.18-0.24	0.20-0.90	0.04-0.09	0.20-0.34	0.05-0.15	0.18-0.32	0.21-0.28	N/A
silver	mg/kg	0.07-0.11	0.06-0.09	0.05-0.07	0.04-0.08	0.03-0.07	0.04-0.05	0.05-0.10	0.04-0.06	0.04-0.06	0.01-0.05	0.02-0.05	0.02-0.04	1-3.7

		Range (minimum and maximum) of results for each location												
		Port Hacking						Marley Beach						ANZECC (2000) ISQC
Variable	Units	1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	low-high
zinc	mg/kg	28.3-36.7	22.5-31.0	19.7-26.0	18.3-22.0	18.8-27.9	21.5-29.4	30.9-44.7	20.7-26.3	19.8-25.3	2.90-22.2	21.0-31.9	22-31.1	200-410
metalloid														
arsenic	mg/kg	4.37-6.80	4.58-5.52	3.74-5.80	2.56-4.09	3.74-5.39	4.3-5.27	4.23-7.33	4.25-5.70	4.29-5.00	2.75-4.88	2.48-3.83	4.51-5.62	20-70
organics														
total PAHs	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	4000-45000
acenapthene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	16-500
acenaphthylene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A
anthracene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	85-1100
benzo(a)anthracene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	261-1600
benzo(a)pyrene	µg/kg	.	.	.	.	.	.	.	.	.		.	.	430-1600
benzo(b)fluoranthene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A
benzo(e)pyrene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A
benzo(ghi)perylene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A
benzo(k)fluoranthene	µg/kg	.	.	.	.	.	.	.	.	.		.	.	N/A
chrysene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	384-2800
dibenzo(a,h)anthracene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	63-260
fluoranthene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	600-5100
fluorene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	19-540
indeno-123-CD-pyrene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A
naphthalene	µg/kg	209-320	25-107	59-100	15-129	21-43	<5	20-400	44-75	61-295	23-43	16-52	<5	160-2100
perylene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A

Variable	Units	Range (minimum and maximum) of results for each location												ANZECC (2000) ISQC low-high
		Port Hacking						Marley Beach						
		1999	2002	2005	2008	2011	2014	1999	2002	2005	2008	2011	2014	
phenanthrene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	240-1500
pyrene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	665-2600
coronene	µg/kg	.	.	.	.	.	.	.	.	.	.	.	.	N/A
M-cresol	µg/kg	118-300	<10	<10	<10	<10	<10	<3-5	<10	<10	<10	<10	<10	N/A
O-cresol	µg/kg	<3	.	.	.	.	.	<3	.	.	.	.	.	N/A
2-Chlorophenol	µg/kg	<2-2	.	.	.	.	.	<2	.	.	.	.	.	N/A
total PCBs	µg/kg	<10	.	.	.	.	.	<10	.	.	.	.	.	23- -
Organochlorine Pesticides	µg/kg	<0.5-0.9 (Aldrin)	.	.	.	.	.	<0.5-23.5 (DDD,DDT)	.	.	.	.	.	0.02-46
others														
mud	%	10.1-13.9	5.91-11.0	6.7-10.8	5.94-11.5	9.4-14.1	6.08-10.6	7.10-17.2	2.95-15.0	8.1-12.3	8.57-13.0	11.1-19.7	10.8-15.6	N/A
sand	%	86.1-89.9	89.0-94.1	88.7-92..4	88.5-94.1	85.6-90.5	89.2-93.6	82.9-92.9	88.2-97.0	87.7-91.9	87.0-91.4	79.5-87.8	62-88.8	N/A
gravel	%	0.00	0.00	<0.1-1.6	<0.1	<0.1-0.72	<0.1-0.75	0.00-0.40	0.00-0.54	<0.1-1.3	<0.1	0.37-1.27	0.24-0.63	N/A
TKN	mg/kg	619-700	.	.	.	.	.	593-859	.	.	.	.	.	N/A
phosphorus	mg/kg	339-383	.	.	.	.	.	237-439	.	.	.	.	.	N/A

Results that exceed ANZECC (2000) low level thresholds but below upper level thresholds are shaded grey

Results that exceed ANZECC (2000) upper level thresholds are shaded blue

6.2.3 Statistical testing of sediment chemistry

A summary of ANCOVA statistical analyses conducted on the chemical data collected during 2014 is presented in Table 6-10 for 60 m depth sites, Table 6-11 for 80 m depth sites and Table 6-12 for the spatial gradient data of Malabar.

More detailed output of these statistical tests is presented in Appendices C, D and E.

6.2.4 60 m depth locations (Long Reef, North Head, Bondi)

ANCOVA testing identified silver, zinc and copper to represent a pattern that may indicate a disturbance in the sediment chemistry for the 60 m sites with Bondi and North Head being equivalent and significantly different to Long Reef (B = NH ≠ LR) (Table 6-10).

Table 6-10 Summary comments on statistical analysis of physico-chemical data

60 m depth sites (Long Reef, North Head, Bondi)	
SILVER - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - B = NH ≠ LR	LEAD - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - NH ≠ LR ≠ B
CADMIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH	ALUMINIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH
CHROMIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH	IRON - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH
NICKEL - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH	ZINC - Significant difference between locations, ANCOVA with Fines - Pair-wise summary - NH = B ≠ LR
COPPER - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - NH = B ≠ LR	MERCURY - No significant difference between locations, ANCOVA with Fines - Pair-wise Summary - Not valid to run
ARSENIC - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH	SELENIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - LR = B ≠ NH

6.2.5 80 m depth locations (Malabar 0 km, Port Hacking, Marley Beach)

Only copper fell into a pattern that may indicate a disturbance for the 80 m sites with Malabar being significantly different to Port Hacking and Marley Beach (M0 ≠ MB = PH) (Table 6-11).

Table 6-11 Summary comments on statistical analysis of physico-chemical data collected in 2011 at 80 m depth sites

80 m depth sites (Malabar, Port Hacking, Marley Beach)	
SILVER - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 ≠ PH ≠ MB	LEAD - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = MB ≠ PH
CADMIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = MB = PH	ALUMINIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = MB = PH
CHROMIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = PH = MB	IRON - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = PH = MB
NICKEL - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - MB = PH ≠ M0	ZINC - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = PH = MB
COPPER - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 ≠ MB = PH	MERCURY - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M0 = PH ≠ MB
ARSENIC - No significant difference between locations, ANCOVA with Fines - Pair-wise Summary - Not valid to run	SELENIUM - No significant difference between locations, ANCOVA with Fines - Pair-wise Summary - Not valid to run

6.2.6 Malabar 0 km to 7 km data for assessment of spatial gradient

Looking at Malabar 0 km to 7 km locations no spatial pattern of contamination was observed that would be regarded as consistent with an outfall where concentrations decrease with distance away from the outfall location as the most likely pattern is M0 ≠ M3 ≠ M5 ≠ M7 (Table 6-12).

The recorded pattern was also not consistent with a more even spread of contamination nearer the outfall.

Table 6-12 Summary comments on statistical analysis of physico-chemical data collected in 20011 at Malabar 0 km to 7 km for spatial gradient investigation

Malabar 0 km to 7 km	
SILVER - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M7 = M5	LEAD - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M5 = M7
CADMIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M5 = M7	ALUMINIUM - No significant difference between locations, ANCOVA with Fines - Pair-wise Summary - Not valid to run
CHROMIUM - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M7 = M5	IRON - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M7 = M5
NICKEL - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M5 = M7	ZINC - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M7 = M5
COPPER - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M5 = M7	MERCURY - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M7 = M5
ARSENIC - Significant difference between locations, ANCOVA with Fines - Pair-wise Summary - M3 ≠ M0 = M7 = M5	SELENIUM - No significant difference between locations, ANCOVA with Fines - Pair-wise Summary - Not valid to run

6.3 Sediment biology

6.3.1 Control (reference) versus impact (outfall) comparisons

Benthic macrofauna were analysed with statistical methods outlined in Section 5.2. Analysis of combined locations from both depths (60 m and 80 m) for five years (2002, 2005, 2008, 2011 and 2014) was initially conducted.

6.3.2 60 m and 80 m locations and years 2002, 2005, 2008, 2011 and 2014

A temporal and spatial view of the data was undertaken in this section. Data collected from the assessment years of 2002, 2005 2008, 2011 and 2014, was combined for the outfall (North Head, Bondi and Malabar 0 km) and control (reference) locations (Long Reef, Port Hacking and Marley). This combined analysis ignored the previous precautionary separation of locations by 60 m and 80 m depths, despite pre-commissioning studies listed above that suggested community structure did vary with depth. This combined analysis was presented in the last interpretive report (Sydney Water 2011) where significant differences in community structure were identified between years for both 60 m and 80 m control locations. While these previous findings suggest data should not be combined, as a prudent interrogation of the data the following testing was undertaken.

A MDS ordination with all replicates of the control locations (Long Reef, Port Hacking and Marley) and outfall (potentially impacted) locations (North Head, Bondi and Malabar 0 km) was run with a square root transformation. This yielded an acceptable stress value of 0.2 for a two dimension plot (Figure 6-8). Not apparent in this plot was a pattern attributable to depth. There was also no clear separation between outfall and control (reference) location samples (Figure 6-8). Rather, a north to south separation occurred in one direction of the plot, while in the opposite direction in this plot temporal variation was apparent in the colour coding Figure 6-9. This spatial and temporal variation was also more easily seen in Figure 6-10 that was based upon replicate samples averaged by site.

Classification analysis displayed a north to south split of samples as the first division of the tree diagram separated Long Reef, North Head Bondi and Malabar average-site samples from those to the south of Port Hacking and Marley (Figure 6-11). If an impact existed the first or a very high up division in the classification would be expected separating outfall average-site samples from control average-site samples. This was not the case. The first north-south division occurred at a similarity of 46% with subsequent similarity in taxonomic composition in average-site groups ranging from 49% up to 82%, which was relatively high.

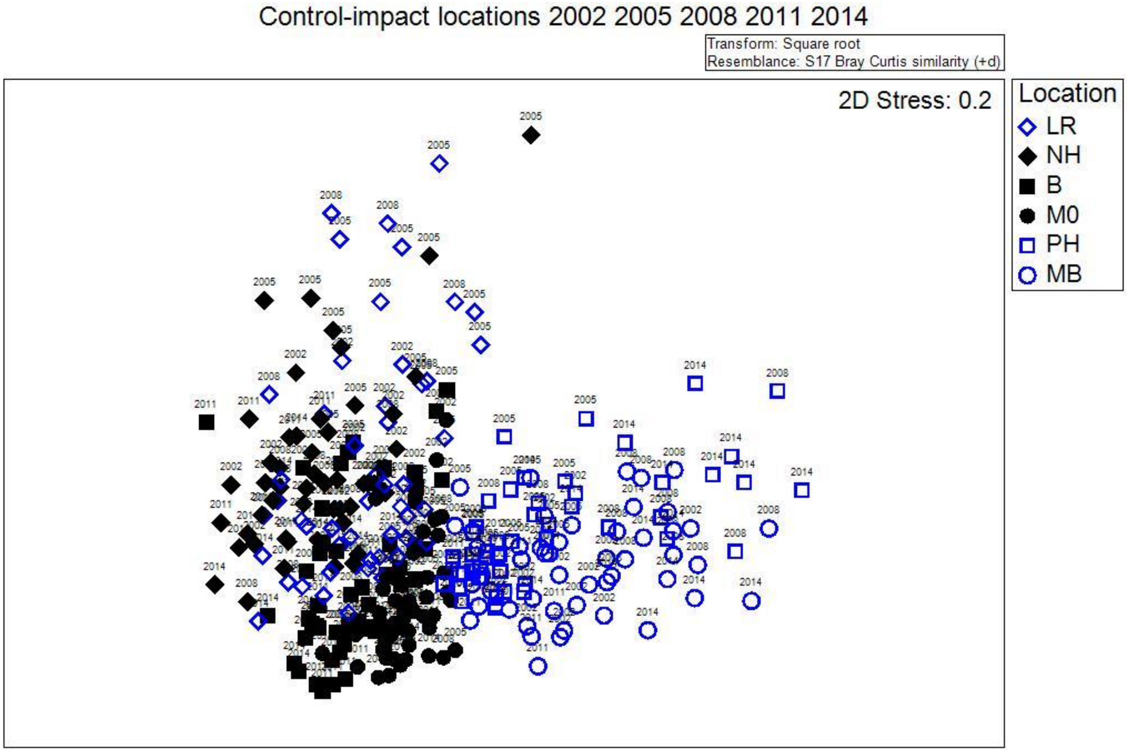


Figure 6-8 MDS ordination plot of 60 m and 80 m locations based on family level for years 2002 2005 2008 2011 and 2014

NB Symbols of outfall locations coloured black and symbols of control locations coloured blue.

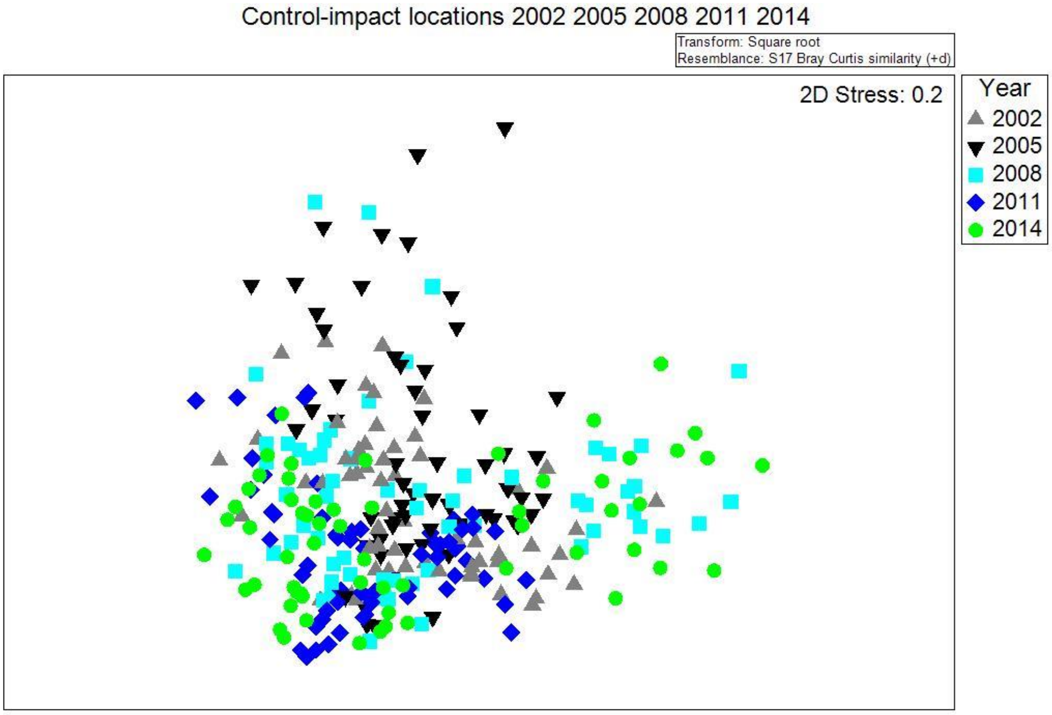


Figure 6-9 MDS ordination plot of 60 m and 80 m locations based on family level for years 2002 2005 2008 2011 and 2014 colour coded by year

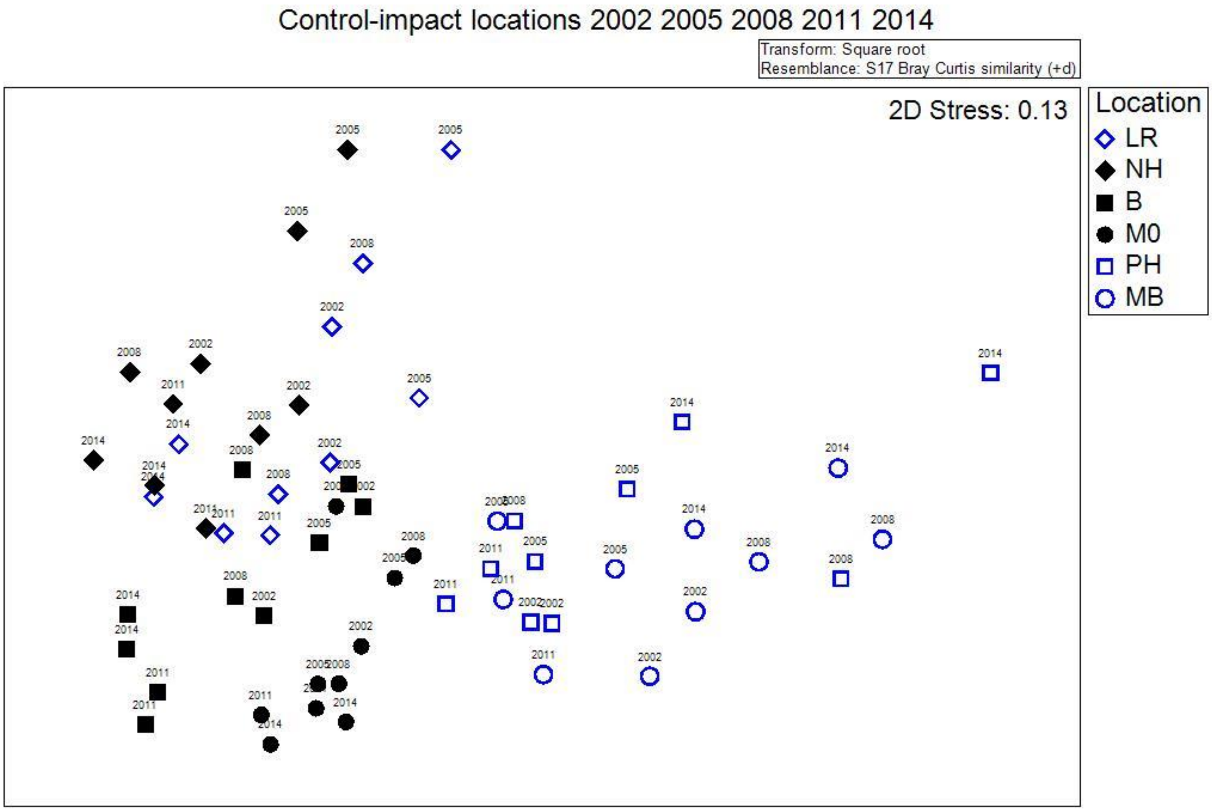


Figure 6-10 MDS ordination plot of 60 m and 80 m locations based on family level replicates that were averaged by site (1 and 2) for years 2002 2005 2008 2011 and 2014

NB Symbols of outfall locations coloured black and symbols of control locations coloured blue.

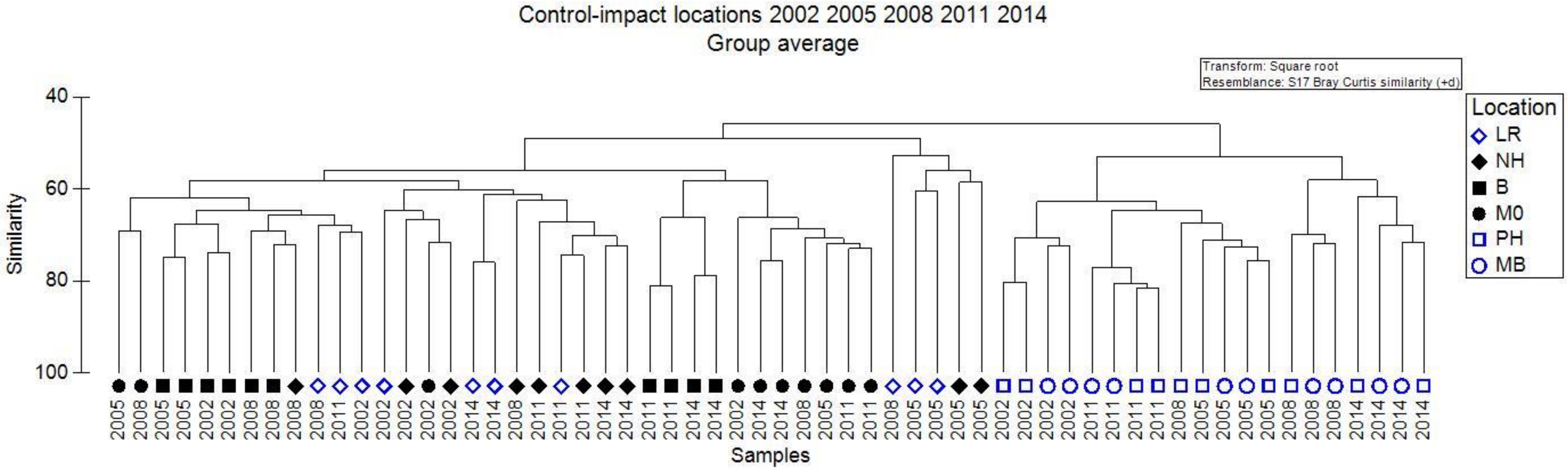


Figure 6-11 Tree diagram from cluster analysis of 60 m and 80 m locations based on family level replicates that were averaged by site (1 and 2) for years 2002 2005 2008 2011 and 2014

NB Symbols of outfall locations coloured black and symbols of control locations coloured blue.

The combination of locations from both depths allowed a balanced PERMANOVA model to be run based on family level replicates with three impact (outfall) locations (North Head, Bondi and Malabar 0 km) and three control locations (Long Reef, Port Hacking and Marley). This model included fixed factors of 'Control-Impact' and 'Year'. It also included two random factors 'Location' nested in 'Control-Impact' and 'Site' nested in 'Location'. Returned results were all significant including subsequent interaction terms (Table 6-13).

Table 6-13 PERMANOVA results based 60 m and 80 m locations family level replicates for years 2002, 2005, 2008, 2011 and 2014

Source	df	MS	Pseudo-F	P(MC)
Control/Impact	1	51040	2.2603	0.0259
Year	4	14352	4.2495	0.0001
Location(Control Impact)	4	22581	9.6075	0.0001
Control Impact x Year	4	5745.5	1.7013	0.0006
Site (Location(Control Impact))	6	2350.4	2.2633	0.0001
Location(Control Impact) x Year	16	3377	1.8183	0.0001
Site (Location(Control Impact)) x Year	24	1857.2	1.7884	0.0001

Pair-wise tests were then conducted for the interaction term 'Control-Impact by Year' for pairs of levels of factor 'Control-Impact' (Table 6-14). These results indicated taxonomic structure within control location samples differed by a similar amount at Impact location samples in four of the five years.

The pair-wise tests for the interaction term 'Control-Impact by Year' for pairs of levels of factor 'Year' (Table 6-15) indicted taxonomic variation occurred between control location samples for each pair of year comparisons. The same pattern existed for impact location samples with the exception of the 2002 and 2005 year comparison that was non-significant.

Table 6-14 Pair-wise test results of term 'Control-Impact by Year' for pairs of levels of factor 'Control-Impact' based 60 m and 80 m locations family level replicates

Within level year of 'Year' factor	t	P(MC)
2002 Control-Impact	1.3953	0.0616
2005 Control-Impact	1.2529	0.1254
2008 Control-Impact	1.5506	0.0359
2011 Control-Impact	1.2669	0.1365
2014 Control-Impact	1.5677	0.0550

Table 6-15 Pair-wise test results of term ‘Control-Impact by Year’ for pairs of levels of factor ‘Year’ based on 60 m and 80 m locations family level replicates

Within level ‘Impact’ of ‘Control-Impact’ factor	t	P(MC)
2002, 2005	1.3222	0.0779
2002, 2008	1.8086	0.0015
2002, 2011	1.9739	0.0022
2002, 2014	1.8758	0.0039
2005, 2008	1.5210	0.0188
2005, 2011	1.8529	0.0036
2005, 2014	1.7907	0.0072
2008, 2011	1.8592	0.0026
2008, 2014	2.2192	0.0002
2011, 2014	1.5414	0.0277

Within level ‘Control’ of ‘Control-Impact’ factor	t	P(MC)
2002, 2005	1.6924	0.0079
2002, 2008	1.6102	0.0171
2002, 2011	1.9376	0.0021
2002, 2014	1.5622	0.0289
2005, 2008	1.5809	0.0211
2005, 2011	2.1960	0.0006
2005, 2014	1.6834	0.0177
2008, 2011	1.7591	0.0097
2008, 2014	1.5040	0.0306
2011, 2014	1.6418	0.0220

Anderson et al (2008) states ‘…increases or decreases in the multivariate dispersion of ecological data has been identified as a potentially important indicator of stress in marine communities (Warwick and Clarke 1993; Chapman et al. 1995)’. To statistically test this aspect of the data, the PERMDISP routine was run on ‘Control-Impact’ and ‘Year’ groups of samples based on locations listed in Table 6-13. Results indicated that multivariate dispersion did occur between Control-Impact’ groups of samples (df1 = 1 df2 = 298 F = 14.642 P perm = 0.0004) as well as between years (df1 = 4 df2 = 295 F = 9.8611 P perm = 0.0001). These results indicate change occurred in taxonomic composition through time and within sites and these trends are displayed in MDS plots Figure 6-8 Figure 6-9 and Figure 6-10.

Hence taxonomic change in community structure occurred through time at both impact (outfall) and control locations and differed by similar amounts within a year for four of the five years. As such analysis of a single year of data would appear to be a prudent action in searching out finer patterns within the dataset that may become apparent when temporal variation is reduced to a single year of collected data.

6.3.3 Addition of gradient study locations

To further explore the apparent north-south gradient positive control (Malabar gradient study) locations were added and the above analyses were rerun. The locations then comprised the three positive-control locations (Malabar 3 km, 5 km, and 7 km), together with the three outfall (impact) locations (North Head, Bondi and Malabar 0 km), and the three control locations (Long Reef, Port Hacking and Marley).

The corresponding non-metric Multi-Dimensional Scaling (MDS) ordination had a marginally higher stress value of 0.21 for the two dimension plot (Figure 6-12). No clear separation occurred between outfall (impact) and reference (control) location samples. Rather gradient study locations fell between Malabar 0 km and more southern control locations of Port Hacking and Marley. Thus similar north to south and temporal patterns (Figure 6-12 and Figure 6-13) were observed like those displayed in Figure 6-8, Figure 6-9 and Figure 6-10.

The first three divisions of the tree diagram from classification analysis separated four northern average-site samples and 11 southern average-site samples. With two exceptions, the fourth division displayed a similar north south split of samples (Figure 6-14) as displayed in the first division of the tree diagram for the Control-Impact location analysis above (Figure 6-11). Although, the Malabar outfall average-site samples pooled with those to the south of Malabar 3km, 5km, 7 km, Port Hacking and Marley (Figure 6-14). The fourth division occurred at a similarity of 54%. This indicated average-site samples had greater than 54% similarity ranging up to 82% similarity in taxonomic composition (Figure 6-14), which was relatively high.

What was also evident in these ordination plots and in the tree diagrams was the lack of a clear group of impact (outfall) samples that were well separated from control samples. The lack of such a group suggests there was no measurable impact apparent from these data summary techniques.

As a further check of these patterns the CAP routine was run. CAP is design to ask are there axes in multivariate space that best separate groups (Anderson et al. 2008). An unconstrained ordination such as MDS, attempts to display the greatest total variation across the multivariate data cloud, whereas CAP was able to search out groups that may be in a different direction to the primary direction of greatest variation. A first pass of the CAP routine was run and after viewing diagnostic statistics an ‘m’ value of 23 was chosen to make the second pass. The second pass indicated a 66% allocation success and the first squared canonical correlation was reasonably large ($\delta12 = 0.87$). The Pillar’s trace statistic was significant (3.03772 $p = 0.0001$) and indicated there was more than one group of samples in multivariate space. The Cross Validation Leave-one-out Allocation of Observations to Groups statistic reflected a number of overlapped and mixed groups of samples with no one location having all of its samples being allocated solely to it (Table 6-16). Rather, miss-classified samples were mostly assigned to sites immediately north or south of that location. Although miss-classified samples of all positive-control locations (Malabar 3km 5km 7km) and the control location of Port Hacking had a broader allocation of samples and as a result had lower individual allocation success percentage (Table 6-16). The resultant CAP ordination pattern (Figure 6-15) reflects the patterns displayed in the corresponding MDS plot and tree diagram. CAP results also confirmed that there was no additional dimensionality present in the dataset.

Table 6-16 CAP Cross Validation Leave-one-out Allocation of Observations to Groups statistics from 60 m and 80 m Control, Positive Control and Impact locations based on replicate data

	Allocated group										
Original group	**LR**	**NH**	**B**	**M0**	**M3**	**M5**	**M7**	**PH**	**MB**	**Total**	**%correct**
LR	42	5	2	0	0	0	1	0	0	50	84
NH	6	40	4	0	0	0	0	0	0	50	80
B	1	11	37	0	0	0	1	0	0	50	74
M0	2	2	1	42	2	0	1	0	0	50	84
M3	0	0	0	3	33	11	2	1	0	50	66
M5	0	1	0	3	11	19	14	1	1	50	38
M7	1	0	2	3	2	14	27	0	1	50	54
PH	0	0	0	0	1	6	2	23	18	50	46
MB	0	0	0	0	0	1	0	14	35	50	70

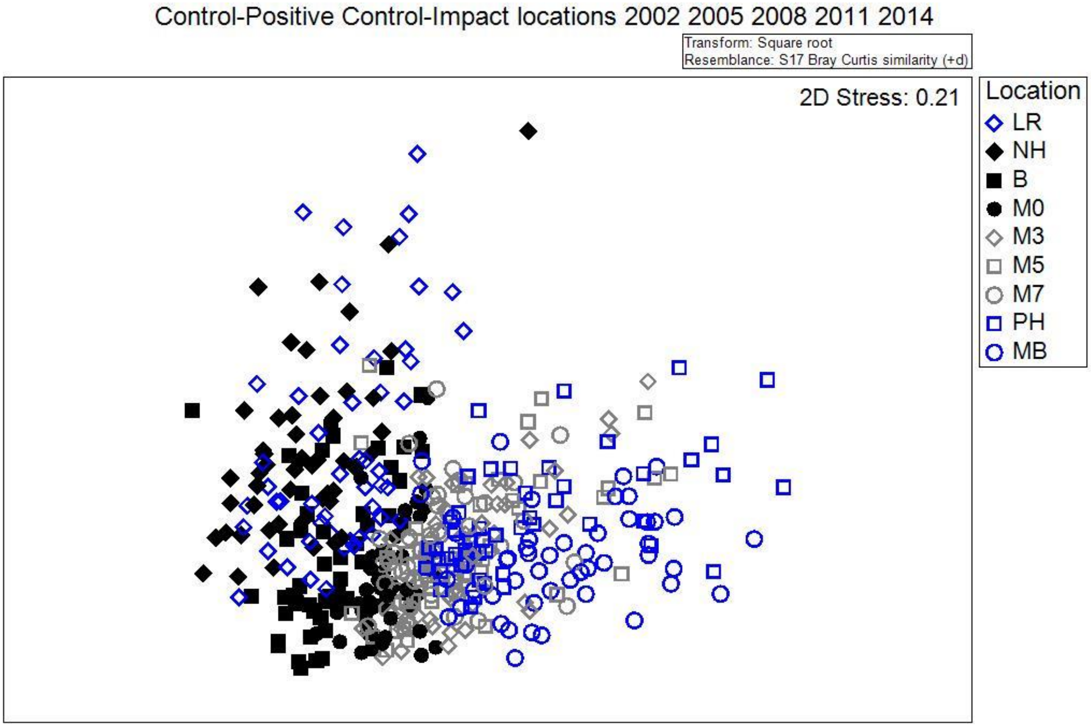


Figure 6-12 MDS ordination plot of 60 m and 80 m control, impact locations together with positive-control (Malabar gradient) locations based on family level replicates for years 2002 2005 2008 2011 and 2014

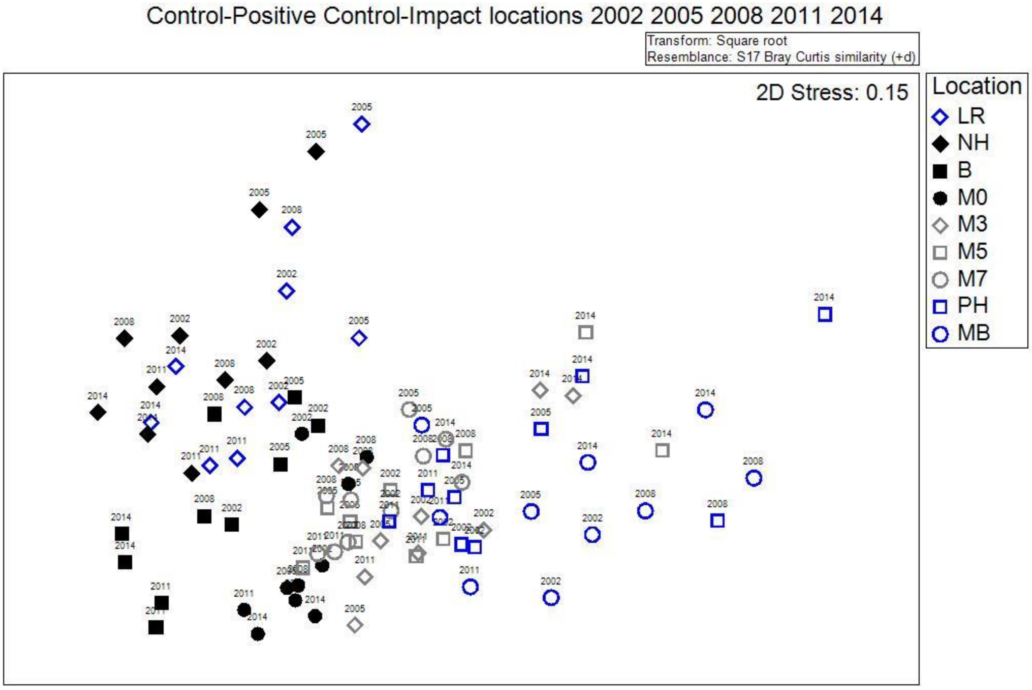


Figure 6-13 MDS ordination plot of 60 m and 80 m control, impact locations together with positive-control (Malabar gradient) locations based on family level replicates that were averaged by site (1 and 2) for years 2002 2005 2008 2011 and 2014

NB Symbols of outfall locations coloured black, symbols of positive control Malabar gradient study locations shaded grey and symbols of control locations coloured blue.

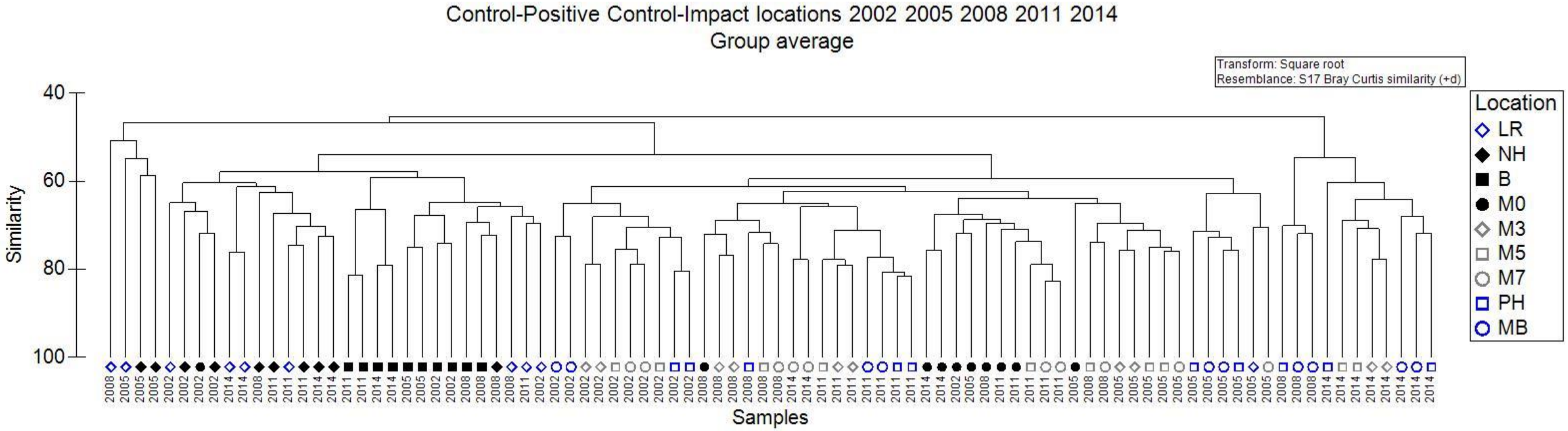


Figure 6-14 Tree diagram from cluster analysis of 60 m and 80 m control, impact locations together with positive-control (Malabar gradient) locations based on family level replicates that were averaged by site (1 and 2) for years 2002 2005 2008 2011 and 2014

NB Symbols of outfall locations coloured black, symbols of positive control Malabar gradient study locations shaded grey and symbols of control locations coloured blue.

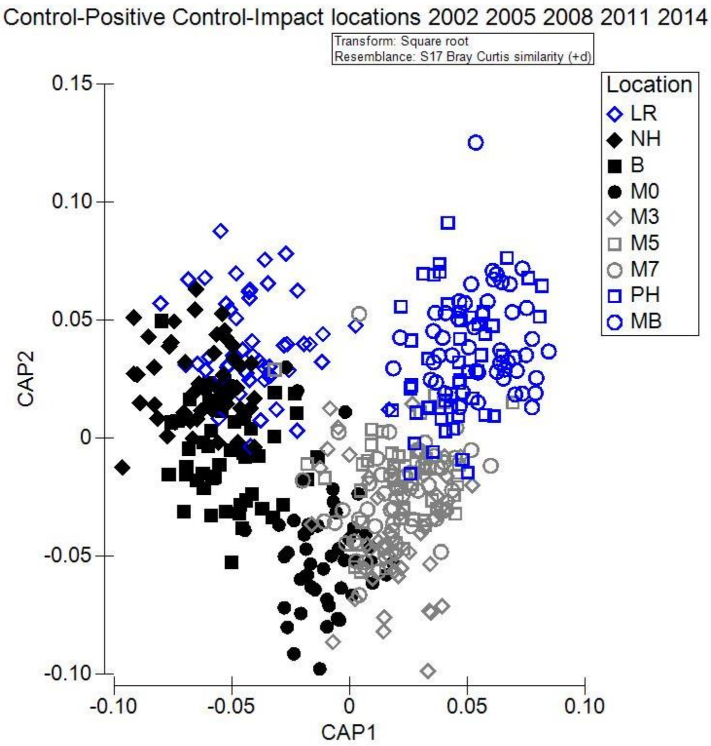


Figure 6-15 CAP ordination plot of 60 m and 80 m control, impact locations together with positive-control (Malabar gradient) locations based on family level replicates for years 2002 2005 2008 2011 and 2014

Based on data included in Figure 6-12 an asymmetrical PERMANOVA model was run. This model included fixed factors of ‘Control’, ‘Positive-Control’, ‘Impact’ and ‘Year’. The factor ‘Control-Positive Control-Impact’ had three levels of: Control; Impact; and Positive-Control. The factor ‘Year’ had five levels: 2002; 2005; 2008; 2011; and 2014. Three random factors were also included. These were ‘Location’ nested in ‘Control-Positive Control-Impact’, ‘Site’ nested in ‘Location’. Returned results were all significant including subsequent interaction terms (Table 6-17).

Table 6-17 PERMANOVA results based 60 m and 80 m locations including gradient study locations family level replicates for years 2002, 2005, 2008, 2011 and 2014

Source	df	MS	Pseudo-F	P(MC)
Control/Impact	2	37641	2.2847	0.0018
Year	4	20417	6.5795	0.0001
Location (Control Impact)	6	16475	8.2499	0.0001
Control Impact x Year	8	6144.8	1.9802	0.0001
Site (Location (Control Impact))	9	1997	2.0151	0.0001
Location (Control Impact) x Year	24	3103.2	1.8109	0.0001
Site (Location (Control Impact)) x Year	36	1713.6	1.7291	0.0001

Pair-wise tests were then conducted for the interaction term ‘Control-Positive Control-Impact’ by ‘Year’ for pairs of levels of factor ‘Control-Positive Control-Impact’ (Table 6-18). These results indicated taxonomic variation within control location samples was the same as that of impact location samples in four of the five years. In contrast the taxonomic variation within impact location samples was not the same as that of positive-control locations in four of the five years. While taxonomic variation within control location samples was the same as that of positive-control locations in four of the five years.

The pair-wise tests for the interaction term ‘Control-Positive Control-Impact’ by ‘Year’ for pairs of levels of factor ‘Year’ (Table 6-19) indicted taxonomic variation occurred between control location samples for each pair of year comparisons. The same pattern existed for positive control location samples and for impact location samples with the exception of the 2002 and 2005 year comparison that was non-significant (Table 6-19).

The largest ‘estimate of the components of variation’ in this model was for the ‘Location’ nested in ‘Control-Positive Control-Impact’ factor (290). In contrast the partitioned ‘estimate of the components of variation’ for the ‘Control-Positive Control-Impact’ factor was about half of the location level (141) while ‘Year’ was at an intermediate level (192) between these two factors. This suggested most variation in the dataset was at the location level.

Table 6-18 Pair-wise test results of term ‘Control-Positive Control-Impact by Year’ for pairs of levels of factor ‘Control-Positive Control-Impact’ based 60 m and 80 m locations family level replicates

	Within level year of ‘Year’ factor	t	P(MC)
2002	Control-Impact	1.3953	0.0643
	Positive control-Impact	1.5426	0.0137
	Control-Positive control	1.0599	0.3513
2005	Control-Impact	1.2529	0.1237
	Positive control-Impact	1.3049	0.0926
	Control-Positive control	1.7108	0.0067
2008	Control-Impact	1.5506	0.0385
	Positive control-Impact	1.6900	0.0052
	Control-Positive control	1.2511	0.1374
2011	Control-Impact	1.2669	0.1354
	Positive control-Impact	1.5736	0.0215
	Control-Positive control	1.2836	0.1015
2014	Control-Impact	1.5677	0.0571
	Positive control-Impact	2.3033	0.0018
	Control-Positive control	1.0706	0.3374

Table 6-19 Pair-wise test results of term ‘Control-Positive Control-Impact by Year’ for pairs of levels of factor ‘Year’ based on 60 m and 80 m locations family level replicates

Within level ‘Impact’ of ‘Control-Positive Control-Impact’ factor	t	P(MC)
2002, 2005	1.3222	0.0800
2002, 2008	1.8086	0.0018
2002, 2011	1.9739	0.0026
2002, 2014	1.8758	0.0045
2005, 2008	1.5210	0.0195
2005, 2011	1.8529	0.0036
2005, 2014	1.7907	0.0065
2008, 2011	1.8592	0.0019
2008, 2014	2.2192	0.0005
2011, 2014	1.5414	0.0284

Within level ‘Control’ of ‘Control-Positive Control-Impact’ factor	t	P(MC)
2002, 2005	1.6924	0.0080
2002, 2008	1.6102	0.0177
2002, 2011	1.9376	0.0022
2002, 2014	1.5622	0.0344
2005, 2008	1.5809	0.0219
2005, 2011	2.196	0.0009
2005, 2014	1.6834	0.0189
2008, 2011	1.7591	0.0103
2008, 2014	1.5040	0.0312
2011, 2014	1.6418	0.0237

Within level ‘Positive control’ of ‘Control-Positive Control-Impact’ factor	t	P(MC)
2002, 2005	1.6126	0.0145
2002, 2008	1.7536	0.0079
2002, 2011	2.2198	0.0008
2002, 2014	2.3241	0.0013
2005, 2008	1.8195	0.0041
2005, 2011	2.3823	0.0002
2005, 2014	2.4333	0.0009
2008, 2011	2.0988	0.0007
2008, 2014	2.4906	0.0007
2011, 2014	2.9401	0.0005

Anderson et al (2008) states '…increases or decreases in the multivariate dispersion of ecological data has been identified as a potentially important indicator of stress in marine communities (Warwick and Clarke 1993; Chapman et al. 1995)'. To statistically test this aspect of the data, the PERMDISP routine was run on 'Control-Positive Control-Impact' and 'Year' groups of samples based on locations listed in Figure 6-8. Results indicated that multivariate dispersion did occur between Control-Positive Control-Impact' groups of samples (df1 = 2 df2 = 447 F = 34.153 P perm = 0.0001) as well as between years (df1 = 4 df2 = 445 F = 15.985 P perm = 0.0001). These results indicate change occurred in taxonomic composition through time and within locations. These trends are displayed in MDS plots Figure 6-12 and Figure 6-13.

The above taxonomic composition results indicate change did occur in community composition between years and between locations. Without a temporally stable consistent spatial pattern in community structure these results suggest no measurable impact on the benthic community from wastewater discharges from the deepwater ocean outfall diffuser arrays.

EPA (1998) stated 'Deep ocean outfalls elsewhere are known to have produced significant effects on macrofauna (eg see Pearson and Rosenberg 1978, Thompson and Dorsey 1989, Anderson et al. 1989, Becker et al. 1989, Stull 1989, Ferraro et al. 1991, Bothner et al. 1994), either due to the effects of toxicants and/or the effects of excessive nutrients.' EPA (1996) also state 'A list of organisms that are considered to be indicators of pollution was summarised from literature by Pearson and Rosenberg (1978) and it includes species from polychaete families: Capitellidae, Spionidae, Orbiniidae, Cirratulidae, Neridae, Nephtyidae, Dorvilleidae, Goniadidae, Hesionidae, Lumbrineridae and Phyllodocidae.' EPA (1996) goes onto cite other studies that had representatives of some families at healthy (reference) locations such as Capitellidae, Cirratulidae, Lumbrineridae and Nephtyidae. Gibbs (1988) quoted a number of previous studies of benthic communities in ocean bays and nearshore waters. A reduction in species and individuals in the immediate vicinity of the outfall was observed together with increases in a few species notably polychaetes such as Capitella of the family Capitellidae. It should be noted this literature was mainly from the northern hemisphere experience.

If a measurable ecological impact was present a likely structure of this impact was described from a nine year post-commissioning study of a 60 m deepwater ocean outfall off Victoria, British Columbia. That study detected a localised measurable impact in benthic communities within 100m of the outfall diffuser array with reduced taxonomic richness and higher abundance of those taxa (Taylor et al. 1998). Taylor et al. (1998) suggested if highly toxic conditions existed close to the outfall or high organic loadings occurred then a decrease in both taxonomic richness and abundance would be expected.

To inspect data for these patterns the SIMPER routine was run for all nine control, outfall and gradient study locations of the 2002, 2005, 2008, 2011 and 2014 surveys (Appendix F).

Inspection of SIMPER results revealed nine of the 11 taxa (Capitellidae, Spionidae, Orbiniidae, Cirratulidae, Nephtyidae, Dorvilleidae, Goniadidae, Lumbrineridae and Phyllodocidae) listed by Pearson and Rosenberg (1978) were recorded across all three types of locations of impact (outfall), positive-control (gradient) and control (reference) (Table 6-20) over the five assessment years. Of these nine indicator taxa, three were recorded at each of the nine locations in each of the five assessment years (Table 6-20). Notably none of these indicator taxa occurred solely at impact locations (Appendix F).

Table 6-20 Summary of indicator taxa from SIMPER analysis of locations by year based on family level replicates

Taxon	Impact	Positive Control	Control	Occurrences out of 45 collections (9 locations by 5 years)
Capitellidae	10	12	9	31
Cirratulidae	15	15	15	45
Dorvilleidae	4	2	1	8
Goniadidae	9	8	4	21
Hesionidae	0	0	0	0
Lumbrineridae	15	15	15	45
Neridae	0	0	0	0
Nephtyidae	13	14	15	42
Orbiniidae	15	15	12	42
Phyllodocidae	15	12	10	37
Spionidae	15	15	15	45

Taxa that comprised the top 60% cumulative contribution to the community structure in SIMPER results represented those taxa that contributed greater than 2% of the community structure within a location-year group of samples (Appendix F). A comparison of the number of taxa that comprised the top 60% cumulative contribution to the community structure versus the total number of taxa for each location-year group of samples (Table 6-21). The total number of taxa and the number of taxa that formed the top 60% cumulative contribution varied between years for each location, there was no obvious pattern of lower diversity (lower numbers of taxa) at outfall locations (Table 6-21).

Table 6-21 Summary of the total number of taxa (100%) for each location-year family level replicate samples of SIMPER analysis together with number of taxa that contributed to the top 60% cumulative contribution for these same sample groups

		2002		2005		2008		2011		2014	
	Location	60%	100%	60%	100%	60%	100%	60%	100%	60%	100%
Impact	NH	13	**80**	8	**51**	12	**72**	11	**68**	11	**72**
	B	14	**81**	12	**69**	11	**76**	14	**82**	11	**87**
	M0	12	**70**	13	**72**	11	**75**	14	**89**	9	**66**
Positive Control	M3	9	**57**	13	**72**	13	**79**	13	**69**	9	**44**
	M5	12	**69**	13	**76**	11	**70**	14	**76**	6	**41**
	M7	12	**74**	12	**67**	11	**69**	13	**77**	12	**59**
Control	LR	12	**71**	9	**63**	8	**60**	12	**75**	10	**72**
	PH	11	**64**	13	**54**	9	**58**	17	**75**	7	**37**
	MB	10	**55**	12	**68**	6	**41**	13	**70**	8	**50**

SIMPER results indicate there was not a simplification of community structure at outfall locations when compared to local control locations (Appendix F).

SIMPER results revealed the polychaete Maldanidae was dominant at the Malabar 0 km location and one of the dominant taxa at other southern 80 m locations, and was present at the northern locations across the 2002 to 2014 interpretive years (Appendix F). This taxon is described as an indicator of low organic input conditions (Dean, 2008).

Hence taxonomic change through time was evident at both impact (outfall) and control locations in addition to the pattern that variation in taxonomic composition of impact and control samples was the same within a year for four of the five years. As such analysis of a single year of data would appear to be a prudent action in searching out finer patterns within the dataset that may become apparent when temporal variation is reduced to a single year of collected data.

6.3.4 Overview of benthic fauna

Following are summary statistics for the biota collected from the 60 m (Table 6-22) and 80 m (Table 6-23) locations in 2014. Locations that were closer together were generally similar in number and type of taxa, but more variable with respect to the number of individuals within taxa.

Table 6-22 Summary statistics for benthic samples taken from 60 m depth in 2014

Taxa	Long Reef	North Head	Bondi
total number of taxa	117	115	127
number of Polychaete taxa	29	33	27
number of Crustacean taxa	52	50	58
number of Mollusc taxa	27	24	31
number of Echinoderm taxa	3	2	2
number of other worm Phyla taxa	4	4	6
number of other Phyla taxa	2	2	3
total number of individuals	3452	3586	8032
number of Polychaetes	519	1219	4787
number of Crustaceans	2555	2159	2666
number of Molluscs	345	144	446
number of Echinoderms	17	28	40
number of other worm Phyla	14	34	87
number of other Phyla	2	2	6

Table 6-23 Summary statistics for benthic samples taken from 80 m depth in 2014

Taxa	Malabar 0 km (C)	Malabar 0 km (A)	Malabar 3 km	Malabar 5 km	Malabar 7 km	Port Hacking	Marley
total number of taxa	105	101	70	74	86	64	73
number of Polychaete taxa	27	27	20	21	27	20	22
number of Crustacean taxa	47	49	30	30	35	27	28
number of Mollusc taxa	21	17	14	14	16	10	17
number of Echinoderm taxa	3	3	3	3	3	3	2
number of other worm Phyla taxa	4	3	2	4	3	2	3
number of other Phyla taxa	3	2	1	2	2	2	1
total number of individuals	5468	5810	817	642	1410	425	1216
number of Polychaetes	3962	4166	479	351	671	218	474
number of Crustaceans	1100	1078	241	178	561	122	167
number of Molluscs	89	123	50	68	108	65	190
number of Echinoderms	291	419	25	27	49	12	17
number of other worm Phyla	14	14	6	7	13	4	364
number of other Phyla	12	10	16	11	8	4	4

6.3.5 Benthic population-related parameter analysis 60 m locations

While identification to species level is required for population-level analysis, such identification is not practical. Higher taxa such as Polychaetes and Crustaceans, and taxonomic parameters (eg numbers of individuals and taxa) are considered in the univariate analysis. From 2011, only the nearer reference site of Long Reef was sampled. This produced an asymmetrical design of one control location and two impact locations for the 60 m depth. Comparisons are made on this basis.

ANOVA was conducted on the benthic macrofauna summary statistics obtained for each of the five assessment years (1999, 2002, 2005, 2008, 2011 and 2014). Significant differences are highlighted in Table 6-24. It is evident in Table 6-24 that, while significant differences have been identified, only two tests separate the two outfall locations from the two reference locations for the 1999 to 2014 data. These are for Crustacean taxa during 1999 and the number of individual Echinoderms during 2002. It was evident that no consistent demonstration of difference between outfall locations and control locations existed in 1999 to 2014 data. Expected patterns would be Bondi = North Head > Long Reef =Terrigal for 1999 to 2008 and Bondi = North Head > Long Reef 2011 and 2014.

Table 6-24 Results of ANOVA on benthic macrofauna summary statistics (60 m locations)

1999	
summary statistics based on taxa	
total number of taxa	Terrigal = Long Reef = North Head = Bondi
number of Polychaete taxa	Terrigal = Long Reef = North Head = Bondi
number of Crustacean taxa	Bondi = North Head > Long Reef = Terrigal
number of Mollusc taxa	Bondi > Terrigal = North Head = Long Reef
number of Echinoderm taxa	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla taxa	Terrigal = Long Reef = North Head = Bondi
number of other Phyla taxa	Terrigal = Long Reef = North Head = Bondi
summary statistics based on abundance	
total number of individuals	Terrigal = Long Reef = North Head = Bondi
number of Polychaetes	Terrigal = Long Reef = North Head = Bondi
number of Crustaceans	Terrigal = Long Reef = North Head = Bondi
number of Molluscs	Terrigal = Long Reef = North Head = Bondi
number of Echinoderms	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla	Terrigal = Long Reef = North Head = Bondi
number of other Phyla	Terrigal = Long Reef = North Head = Bondi
2002	
summary statistics based on taxa	
total number of taxa	Terrigal = Long Reef = North Head = Bondi
number of Polychaete taxa	Terrigal = Long Reef = North Head = Bondi
number of Crustacean taxa	Terrigal = Long Reef = North Head = Bondi
number of Mollusc taxa	Terrigal = Long Reef = North Head = Bondi
number of Echinoderm taxa	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla taxa	Terrigal = Long Reef = North Head = Bondi
number of other Phyla taxa	Terrigal = Long Reef = North Head = Bondi
summary statistics based on abundance	
total number of individuals	Terrigal = Long Reef = North Head = Bondi
number of Polychaetes	Bondi > North Head = Long Reef = Terrigal
number of Crustaceans	Terrigal = Long Reef = North Head = Bondi
number of Molluscs	Terrigal = Long Reef = North Head = Bondi
number of Echinoderms	North Head = Bondi > Long Reef = Terrigal
number of other worm Phyla	North Head > Bondi = Terrigal = Long Reef
number of other Phyla	Terrigal = Long Reef = North Head = Bondi
2005	
summary statistics based on taxa	
total number of taxa	Terrigal = Long Reef = North Head = Bondi
number of Polychaete taxa	Bondi = Terrigal > Long Reef = North Head
number of Crustacean taxa	Terrigal = Long Reef = North Head = Bondi
number of Mollusc taxa	Terrigal = Long Reef = North Head = Bondi

number of Echinoderm taxa	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla taxa	Terrigal = Long Reef = North Head = Bondi
number of other Phyla taxa	Terrigal = Long Reef = North Head = Bondi
summary statistics based on abundance	
total number of individuals	Bondi > Terrigal = Long Reef = North Head
number of Polychaetes	Bondi > Terrigal = Long Reef = North Head
number of Crustaceans	Bondi > Long Reef = Terrigal = North Head
number of Molluscs	Terrigal = Long Reef = North Head = Bondi
number of Echinoderms	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla	Terrigal = Long Reef = North Head = Bondi
number of other Phyla	Terrigal = Long Reef = North Head = Bondi
2008	
summary statistics based on taxa	
total number of taxa	Bondi = North Head = Terrigal > Long Reef
number of Polychaete taxa	North Head = Terrigal = Bondi > Long Reef
number of Crustacean taxa	Terrigal = Long Reef = North Head = Bondi
number of Mollusc taxa	Terrigal = Long Reef = North Head = Bondi
number of Echinoderm taxa	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla taxa	Bondi = North Head = Terrigal > Long Reef
number of other Phyla taxa	Terrigal = Long Reef = North Head = Bondi
summary statistics based on abundance	
total number of individuals	Terrigal = Long Reef = North Head = Bondi
number of Polychaetes	Bondi > Terrigal = North Head = Long Reef
number of Crustaceans	Terrigal = Long Reef = North Head = Bondi
number of Molluscs	Terrigal > Long Reef = Bondi = North Head
number of Echinoderms	Terrigal = Long Reef = North Head = Bondi
number of other worm Phyla	Terrigal = Long Reef = North Head = Bondi
number of other Phyla	Terrigal = Long Reef = North Head = Bondi
2011	
summary statistics based on taxa	
total number of taxa*	Bondi > Long Reef = North Head
number of Polychaete taxa	Bondi = Long Reef = North Head
number of Crustacean taxa*	Bondi = Long Reef > North Head
number of Mollusc taxa*	Bondi > Long Reef = North Head
number of Echinoderm taxa	Bondi = Long Reef = North Head
number of other worm Phyla taxa	Bondi = North Head = Long Reef
number of other Phyla taxa	Bondi = Long Reef = North Head
summary statistics based on abundance	
total number of individuals*	Bondi > North Head = Long Reef
number of Polychaetes*^	Bondi > North Head = Long Reef
number of Crustaceans	Bondi = Long Reef = North Head
number of Molluscs*^	Bondi > Long Reef = North Head

number of Echinoderms*	Bondi = North Head = Long Reef
number of other worm Phyla*	Bondi = North Head = Long Reef
number of other Phyla	Bondi = North Head = Long Reef
2014	
summary statistics based on taxa	
total number of taxa*	Bondi > Long Reef = North Head
number of Polychaete taxa	Bondi = Long Reef = North Head
number of Crustacean taxa*	Bondi > North Head = Long Reef
number of Mollusc taxa*	Bondi = Long Reef > North Head
number of Echinoderm taxa*^	Bondi = Long Reef = North Head
number of other worm Phyla taxa*	Bondi > North Head = Long Reef
number of other Phyla taxa	Bondi = Long Reef = North Head
summary statistics based on abundance	
total number of individuals*^	Bondi > North Head = Long Reef
number of Polychaetes*^	Bondi > North Head = Long Reef
number of Crustaceans	Bondi = Long Reef = North Head
number of Molluscs*	Bondi = Long Reef > North Head
number of Echinoderms	Bondi = North Head = Long Reef
number of other worm Phyla*^	Bondi > North Head = Long Reef
number of other Phyla	Bondi = Long Reef = North Head

*ANOVA significant; ^homogeneity of variance achieved when log10 transformed, however, SNK pattern same whether untransformed or log10 transformed; homogeneity of variance met for all other untransformed variables

6.3.6 Benthic community analysis – 60 m Long Reef control location

As outlined above, the Terrigal control location was not sampled in 2011 and 2014. As such analysis was restricted to the Long Reef control location for the years 2002, 2005, 2008, 2011 and 2014 to explore if taxonomic change over time occurred. Analysing Long Reef over the five years provided a balanced dataset that took into account the recent advances in our understanding of multivariate statistical analysis techniques. Recent research indicated PERMANOVA results were robust in the presence of heterogeneity in multivariate dispersion provided calculations were based upon a balanced dataset (Anderson and Walsh, 2013).

A Non-Metric Multi-Dimensional Scaling (MDS) ordination with all replicates of the control locations Long Reef and Terrigal was run, with either a square root or fourth root transformation. This yielded stress values of 0.2 and 0.21 for two dimensions. A second run or the ordination routine with a third dimension yielded stress values of 0.15 and 0.16 respectively.

The three dimension ordination plot for the square root transformation data is presented in Figure 6-16. Temporal change in assemblage composition was apparent in this plot particularly between 2005 and 2014 (Figure 6-16).

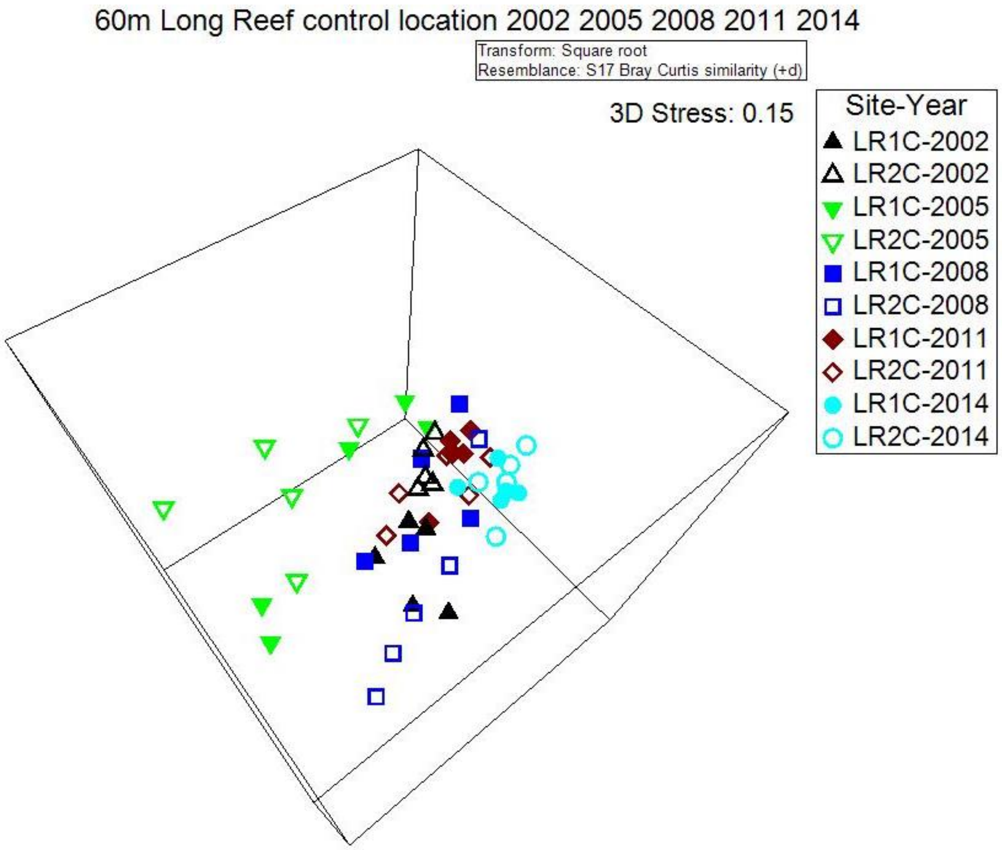


Figure 6-16 MDS ordination plot of 60 m Long Reef control location for years 2002, 2005, 2008, 2011 and 2014 based on family level replicates

The CAP routine was run as a further check. CAP is designed to ask ‘are there axes in multivariate space that best separate groups?’ (Anderson et al. 2008). An unconstrained ordination such as MDS, attempts to display the greatest total variation across the multivariate data cloud, whereas CAP was able to search out groups that may be in a different direction to the primary direction of greatest variation. A first pass of the CAP routine was run and after viewing diagnostic statistics an ‘m’ value of 20 was chosen to make the second pass. The second pass indicated an 86% allocation success and the first squared canonical correlation was reasonably large (δ12 = 0.877). The Pillar’s trace statistic was significant (3.13982 P = 0.0001) and indicated there was more than one group of samples in multivariate space (Figure 6-17). CAP results confirmed the pattern displayed in the MDS plot (Figure 6-16) and confirmed there was no additional dimensionality present in the dataset.

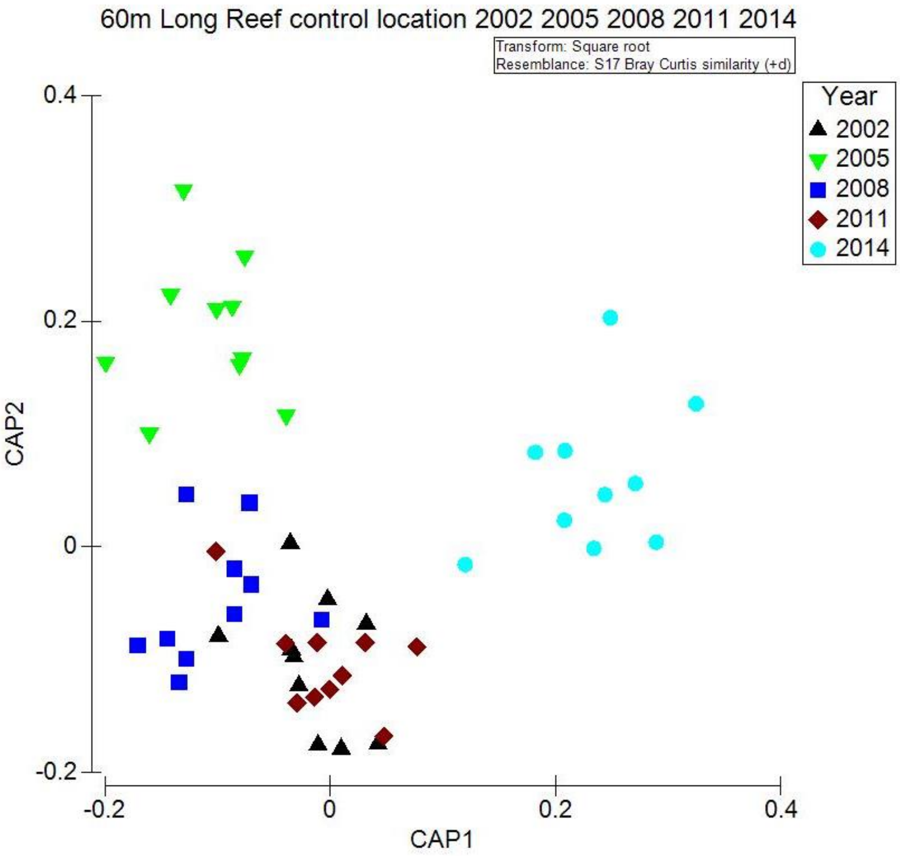


Figure 6-17 CAP ordination plot of 60 m Long Reef control location for years 2002, 2005, 2008, 2011 and 2014 based on family level replicates

A PERMANOVA model was run based on the factor ‘Year’ for the Long Reef control location. ‘Year’ had five levels: 2002, 2005, 2008, 2011 and 2014. The factor ‘Year’ was significant different (df = 4, MS = 5608.2 Pseudo F = 3.9509 P (perm) = 0.0001). Pair-wise tests of ‘Year’ were conducted and indicated there were differences in community structure between years (Table 6-25).

Table 6-25 Pair-wise test results from PERMANOVA of 60 m Long Reef location based on family level replicates

Year comparisons	T	P (perm)
2002, 2005	1.8279	0.0008
2002, 2008	1.5706	0.0027
2002, 2011	1.6275	0.0016
2002, 2014	2.2616	0.0002
2005, 2008	1.6288	0.0037
2005, 2011	2.1364	0.0001
2005, 2014	2.6530	0.0001
2008, 2011	1.8466	0.0011
2008, 2014	2.2614	0.0001
2011, 2014	1.9854	0.0001

To graphically illustrate this change through time, an MDS ordination plot based upon centroids for each year with trajectories overlayed for year is presented in Figure 6-18.

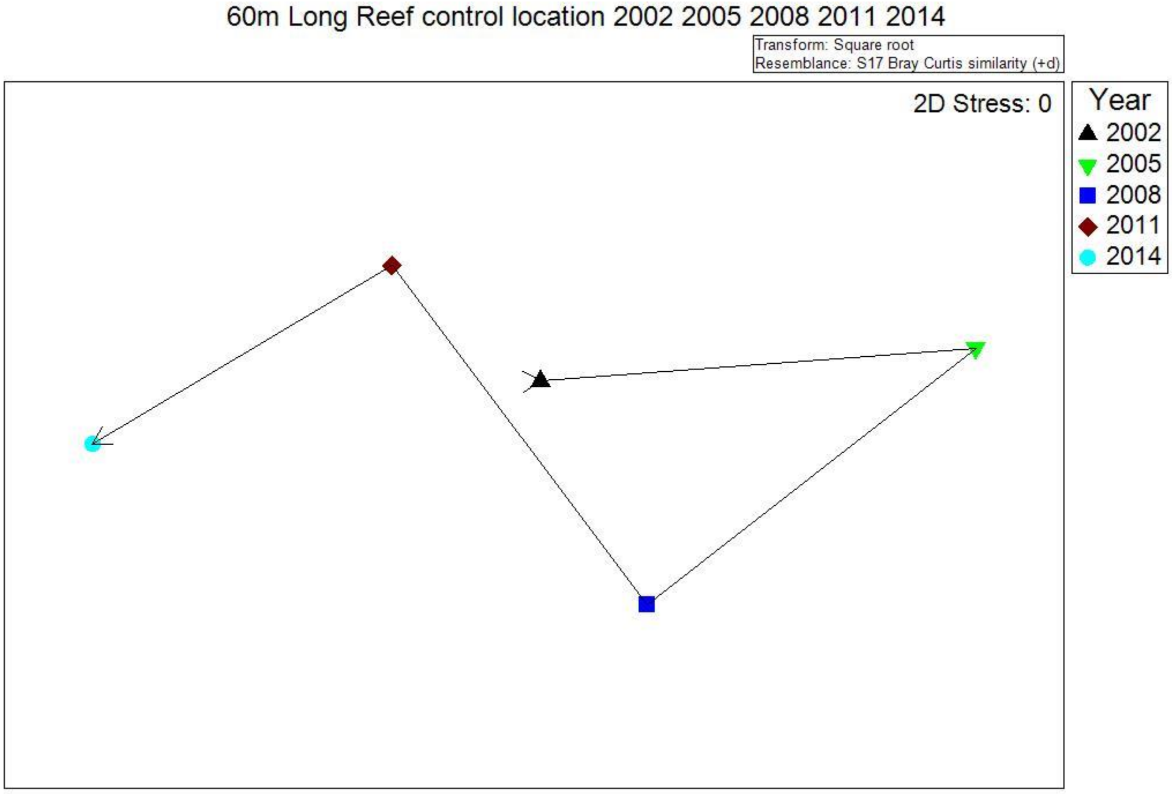


Figure 6-18 MDS ordination plot of centroids for 60 m Long Reef control location for years 2002, 2005, 2008, 2011 and 2014

To test the multivariate dispersion aspect of this dataset, PERMDISP was run. Results were significantly different between years at the Long Reef control location (df1 = 4 df2 = 45 F= 12.2, P (perm) = 0.0001).

In summary, the temporal differences were identified for the 60 m Long Reef control location, which indicated that additional natural variation was introduced into a multi-year dataset. To reduce this natural influence, assessment of potential change in community structure as a result of wastewater discharges from the deepwater ocean outfalls was conduct on 2014 assessment year data as a prudent step in statistical analysis of the Ocean Sediment Program data.

6.3.7 2014 benthic community analysis – 60 m reference and outfall locations

The following analyses look at 2014 data from the 60 m control-outfall locations based on family level data.

A MDS ordination with all replicates of the control location Long Reef and outfall locations of Bondi and North Head was run with either a square root or fourth root transformation. This yielded stress values of 0.17 and 0.19 for two dimensions. The addition of a third dimension reduced stress values to 0.10 and 0.13 for square root and fourth root transformations. In this plot samples from the same location were spread out to a similar amount as those of other locations. This suggested homogeneous dispersion existed between groups of samples. There was also no clear separation between locations, particularly between the outfall locations of Bondi and North Head from the reference location of Long Reef, which suggested no impact had occurred from deepwater discharges (Figure 6-19).

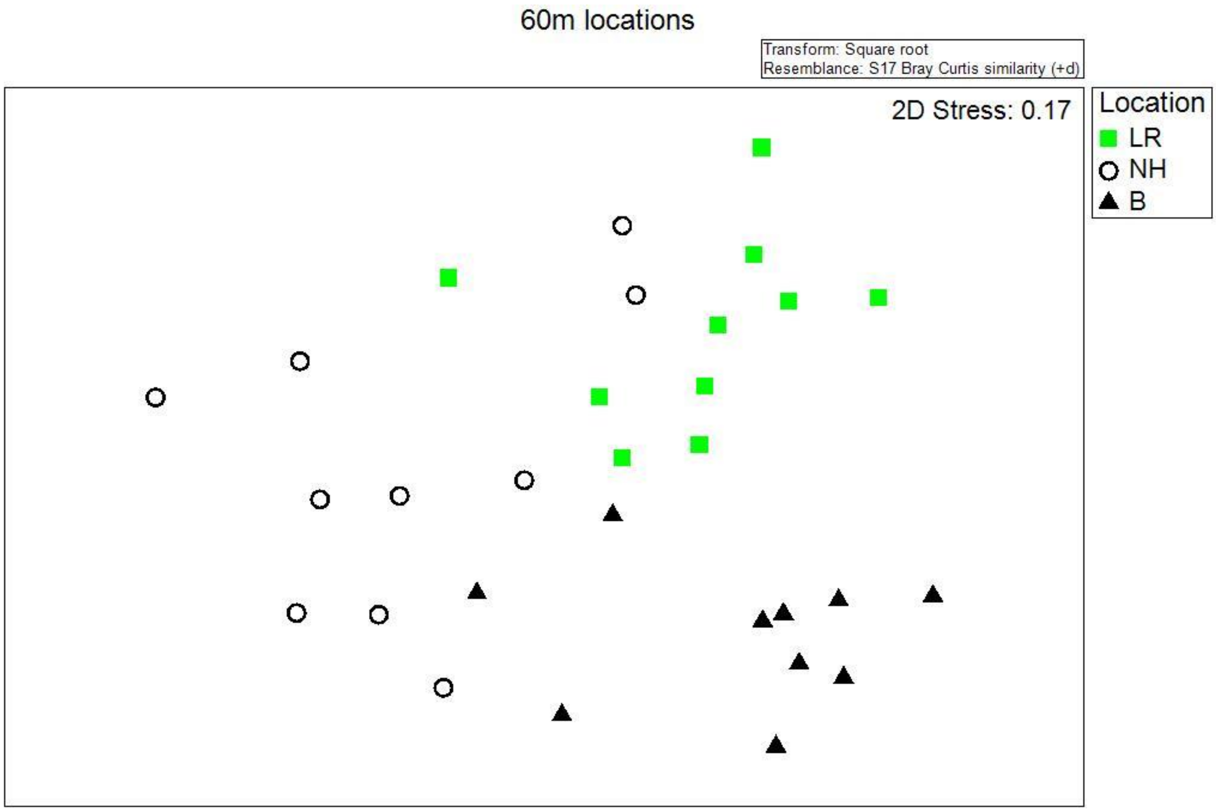


Figure 6-19 MDS ordination plot of 60 m locations based on family level replicates

The corresponding dendrogram from cluster analysis based on the square root transformation (Figure 6-20) indicated each outfall site had a generally differing community composition, all there were a few samples that had enough taxa in common to be more representative of other locations. If an impact existed due to the operation of the deep ocean outfalls, it would be expected that the first splits in the dendrogram would be between the control (Long Reef) and impact locations (Bondi, North Head). This was not the case in Figure 6-20. Classification results support the pattern displayed in the ordination plot (Figure 6-19).

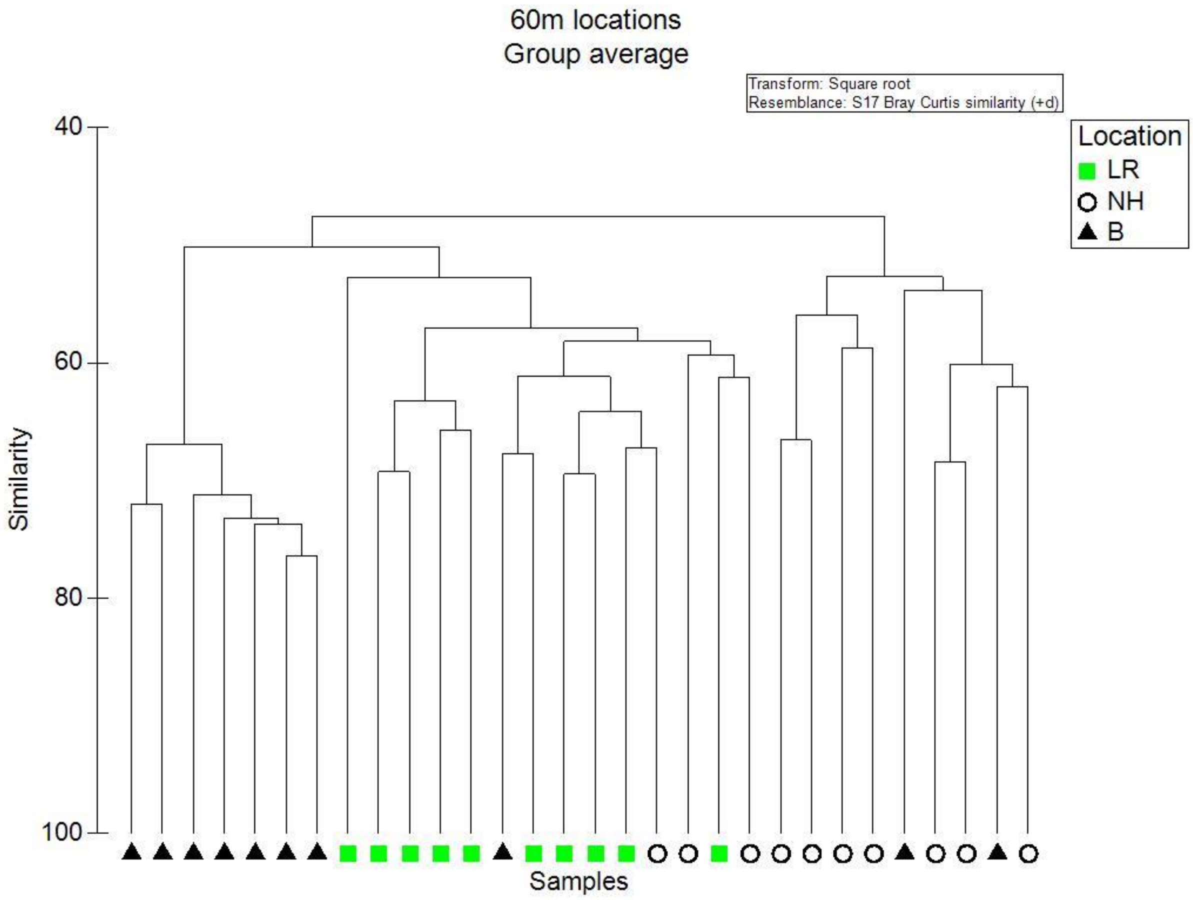


Figure 6-20 Dendrogram of 60 m locations for 2014 based on family level replicates

The CAP routine was run as a further check. CAP is design to ask ‘are there axes in multivariate space that best separate groups?’ (Anderson et al. 2008). An unconstrained ordination such as MDS, attempts to display the greatest total variation across the multivariate data cloud, whereas CAP was able to search out groups that may be in a different direction to the primary direction of greatest variation. A first pass of the CAP routine was run and after viewing diagnostic statistics an ‘m’ value of 7 was chosen to make the second pass. The second pass indicated an 83% allocation success and the first squared canonical correlation was reasonably large ($\delta 12 = 0.86$). The Pillar’s trace statistic was significant (1.52575 $P = 0.0001$) and indicated there was more than one group of samples in multivariate space. The Cross Validation Leave-one-out Allocation of Observations to Groups statistic confirmed three relatively distinct groups of samples and these groups are displayed in the CAP ordination plot (Figure 6-21). CAP results confirmed the patterns displayed in the MDS and dendrogram plots and confirmed no additional dimensionality was present in the dataset.

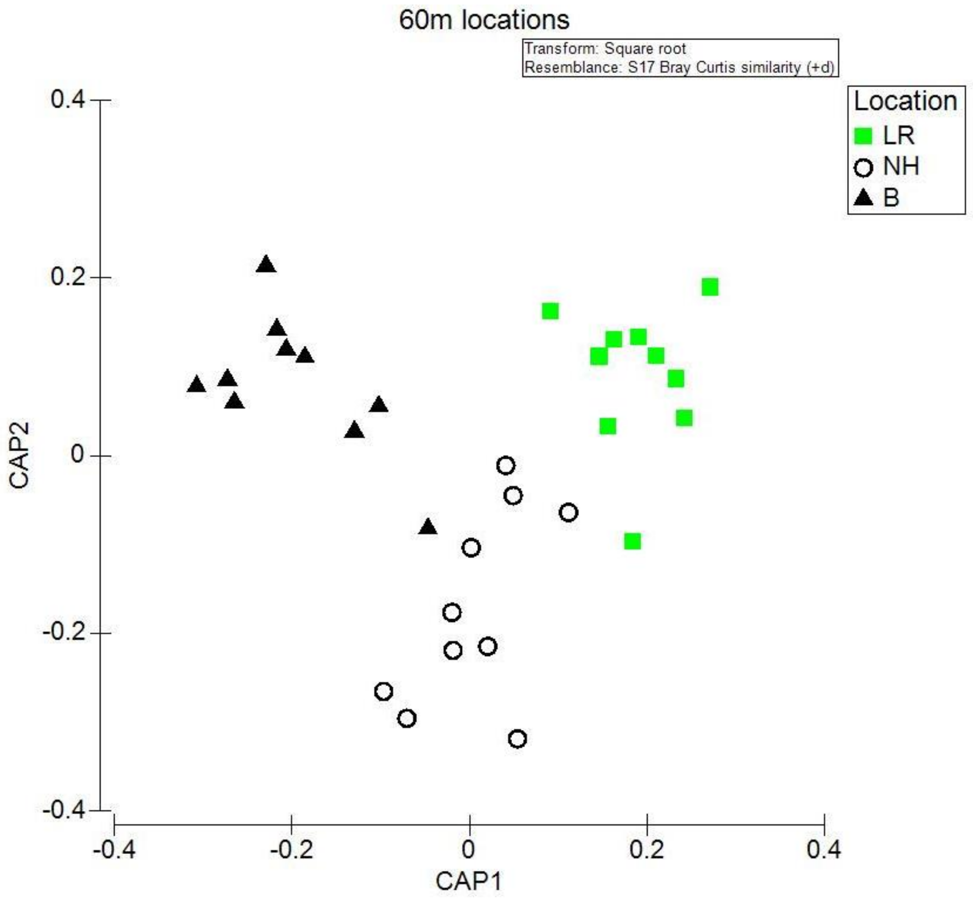


Figure 6-21 CAP ordination plot of 60 m Locations based on family level replicates

An asymmetrical PERMANOVA model was run based on family level replicates. This model included a fixed factor of ‘Control-Impact’ and two random factors: ‘Location’ nested in ‘Control-Impact’, and ‘Site’, nested in ‘Location’.

A non-significant difference was returned for the ‘Control-Impact’ factor (df = 1 MS = 4193.6 Pseudo F = 0.79293 P(MC) = 0.6323) and ‘Site (Location)’ (df = 3 MS = 1248.8 Pseudo F = 1.4295 p = 0.0656). A significant difference was returned for ‘Location (Control-Impact)’ (df = 1 MS = 5288.7 Pseudo F = 4.2351 P(MC) = 0.0022). A negative value was returned for the estimate of the component of variation for the ‘Control / Impact’ factor (-82.136). A negative value suggests removal of this term from the model is appropriate. In other words the ‘Control / Impact’ factor did not contribute to the variation in the model when variation was partitioned according to the inputted model terms.

These PERMAOVA model results indicated that the equilibrium in community structure was not altered by discharge of wastewater from the deepwater outfalls; that is, no measurable impact was caused by the discharge of treated wastewater from Bondi and North Head treatment plants. It also indicated that natural differences existed between locations and this was also identified for control locations in the section above.

Anderson et al. (2008) states ‘…increases or decreases in the multivariate dispersion of ecological data has been identified as a potentially important indicator of stress in marine communities (Warwick and Clarke 1993, Chapman et al. 1995)’. To statistically test this aspect of the data, the PERMDISP routine was run on Location groups of samples displayed in Figure 6-19.

Results indicated a similar dispersion in samples collected from each location (df1 = 2 df2 = 27 F= 2.6474, p perm = 0.1379); that is, while each location had a generally different composition of taxa, the variability of taxa collected in samples from each location was similar across the three locations as suggested by the MDS plot (Figure 6-19). Pair-wise test results were also non-significant: Bondi compared to Long Reef (t = 0.80305 P perm = 0.4975), Bondi compared to North Head (t = 2.0934 P perm = 0.0740), and Long Reef compared to North Head (t = 1.7217 P perm = 0.1432). These results also indicate wastewater discharges from the deepwater outfall diffusers had no measurable impact on benthic communities.

SIMPER, another species-dependent multivariate method, was employed. This routine employs Bray Curtis similarities to examine the contribution of individual taxa to the average similarity between groups and within groups. This analysis was based on family level replicates of each location, with a square root transformation and Bray-Curtis resemblance association measure.

SIMPER indicated that average % dissimilarity between Locations ranged from 51% to 52% (Table 6-26). This in turn indicated that differences existed in taxonomic composition between locations but a number of taxa were also present across the location pairs. The average % similarity of replicates within Locations was higher for Bondi, at 61% similarity, while replicates of Long Reef and North Head were less similar in taxonomic composition with an average similarity of 53% and 58% (Table 6-27). This suggested Bondi samples had a few more taxa in common than at the other two locations. These results also suggest no apparent impact from wastewater discharges from the deepwater ocean outfalls.

Table 6-26 Average % dissimilarity between 60 m Locations based on family level replicates, square root transformation and Bray-Curtis resemblance association measure

	B	NH
NH	52	
LR	50	51

Table 6-27 Average % similarity within 60 m Locations based on family level replicates, square root transformation and Bray-Curtis resemblance association measure

	B	NH	LR
2011	61	53	58

6.3.8 Benthic population-related parameter analysis 80 m locations

ANOVA was conducted on the benthic macrofauna summary statistics obtained for each of the six assessment years (1999, 2002, 2005, 2008, 2011 and 2014). Significant differences are highlighted in Table 6-28. None of the biological parameters measured consistently showed a significant difference between outfall and reference locations from year to year. The pattern shown in 2014 indicated outfall locations had higher taxa richness and abundance for polychaetes, crustaceans and echinoderms. Expected patterns would be Malabar 0C > Port Hacking = Marley Beach = Shoalhaven Bight for 1999. While for 2002 to 2008 it would be Malabar 0C = Malabar 0A > Port Hacking = Marley Beach = Shoalhaven Bight. From 2008 and 2011 the expected pattern would be Malabar 0C = Malabar 0A > Port Hacking = Marley Beach.

Table 6-28 Results of ANOVA on benthic macrofauna summary statistics (80 m locations)

	1999								
summary statistics based on taxa									
total number of taxa	Marley Beach	=	Malabar 0C	=	Port Hacking	>	Shoal haven Bight 2	=	Shoalhaven Bight 1
number of Polychaete taxa	Marley Beach	>	Port Hacking	=	Malabar 0C	>	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Crustacean taxa	Malabar 0C	>	Marley Beach	=	Port Hacking	>	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Mollusc taxa	Marley Beach	=	Port Hacking	=	Malabar 0C	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderm taxa	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other worm Phyla taxa	Marley Beach	=	Shoal Haven Bight 2	=	Malabar 0C	=	Port Hacking	=	Shoalhaven Bight 1
number of other 102hyla taxa	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
summary statistics based on abundance									
total number of individuals	Marley Beach	=	Malabar 0C	=	Shoal Haven Bight 2	=	Port Hacking	=	Shoalhaven Bight 1
number of Polychaetes	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Crustaceans	Malabar 0C	>	Marley Beach	=	Port Hacking	=	Shoalhaven Bight 2	=	Shoalhaven Bight 1
number of Molluscs	Marley Beach	>	Port Hacking	=	Malabar 0C	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderms	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other worm Phyla	Marley Beach	>	Shoalhaven Bight 2	>	Shoalhaven Bight 1	>	Malabar 0C	=	Port Hacking
number of other Phyla	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2

2002											
summary statistics based on taxa											
total number of taxa	Malabar 0C	=	Shoalhaven Bight 1	=	Malabar 0A	=	Port Hacking	>	Marley Beach	=	Shoalhaven Bight 2
number of Polychaete taxa	Shoalhaven Bight 1	=	Malabar 0A	=	Port Hacking	=	Malabar 0C	=	Marley Beach	=	Shoalhaven Bight 2
number of Crustacean taxa	Malabar 0C	=	Malabar 0A	=	Shoalhaven Bight 1	=	Port Hacking	>	Marley Beach	=	Shoalhaven Bight 2
number of Mollusc taxa	Port Hacking	=	Marley Beach	>	Malabar 0A	=	Malabar 0C	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderm taxa	Shoalhaven Bight 1	=	Malabar 0A	=	Malabar 0C	=	Shoalhaven Bight 2	=	Port Hacking	=	Marley Beach
number of other worm Phyla taxa	Malabar 0A	=	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other Phyla taxa	Shoalhaven Bight 1	>	Malabar 0A	=	Shoalhaven Bight 2	=	Port Hacking	=	Malabar 0C	=	Marley Beach
summary statistics based on abundance											
total number of individuals	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	>	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Polychaetes	Port Hacking	=	Malabar 0C	=	Marley Beach	=	Malabar 0A	>	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Crustaceans	Malabar 0C	=	Malabar 0A	>	Port Hacking	=	Shoalhaven Bight 1	=	Marley Beach	=	Shoalhaven Bight 2
number of Molluscs	Port Hacking	=	Marley Beach	>	Malabar 0C	=	Malabar 0A	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderms	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Shoalhaven Bight 1	=	Marley Beach	=	Shoalhaven Bight 2
number of other worm Phyla	Shoalhaven Bight 2	=	Marley Beach	>	Shoalhaven Bight 1	=	Port Hacking	=	Malabar 0C	=	Malabar 0A
number of other Phyla	Shoalhaven Bight 1	=	Malabar 0A	=	Port Hacking	=	Shoalhaven Bight 2	=	Malabar 0C	=	Marley Beach

2005											
summary statistics based on taxa											
total number of taxa	Malabar 0C	=	Malabar 0A	=	Marley Beach	=	Shoal haven Bight 1	=	Shoalhaven Bight 2	=	Port Hacking
number of Polychaete taxa	Malabar 0C	=	Malabar 0A	>	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoal hven Bight 2
number of Crustacean taxa	Shoalhaven Bight 1	=	Malabar 0C	=	Malabar 0A	=	Shoalhaven Bight 2	=	Marley Beach	=	Port Hacking
number of Mollusc taxa	Malabar 0A	=	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderm taxa	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Malabar 0C	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other worm Phyla taxa	Malabar 0C	=	Malabar 0A	=	Marley Beach	=	Shoalhaven Bight 1	=	Port Hacking	=	Shoalhaven Bight 2
number of other Phyla taxa	Malabar 0A	=	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
summary statistics based on abundance											
total number of individuals	Malabar 0C	=	Malabar 0A	>	Shoalhaven Bight 1	=	Shoalhaven Bight 2	=	Marley Beach	=	Port Hacking
number of Polychaetes	Malabar 0C	=	Malabar 0A	>	Shoalhaven Bight 1	=	Shoalhaven Bight 2	=	Marley Beach	=	Port Hacking
number of Crustaceans	Shoalhaven Bight 1	=	Shoalhaven Bight 2	=	Malabar 0C	=	Malabar 0A	>	Marley Beach	=	Port Hacking
number of Molluscs	Malabar 0A	=	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderms	Malabar 0A	>	Malabar 0C	=	Marley Beach	=	Port Hacking	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other worm Phyla	Malabar 0C	=	Malabar 0A	=	Marley Beach	=	Shoalhaven Bight 1	=	Port Hacking	=	Shoalhaven Bight 2
number of other Phyla	Malabar 0A	=	Malabar 0C	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2

2008											
summary statistics based on taxa											
total number of taxa	Malabar 0C	=	Malabar 0A	>	Shoalhaven Bight 1	=	Port Hacking	=	Shoalhaven Bight 2	=	Marley Beach
number of Polychaete taxa	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Crustacean taxa	Malabar 0C	=	Malabar 0A	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2	=	Port Hacking	>	Marley Beach
number of Mollusc taxa	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderm taxa	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other worm Phyla taxa	Malabar 0C	=	Malabar 0A	>	Shoalhaven Bight 1	=	Port Hacking	=	Shoalhaven Bight 2	=	Marley Beach
number of other Phyla taxa	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
summary statistics based on abundance											
total number of individuals	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalaven Bight 1	=	Shoalhaven Bight 2
number of Polychaetes	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Crustaceans	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Molluscs	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of Echinoderms	Malabar 0C	>	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 2	=	Shoalhaven Bight 1
number of other worm Phyla	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2
number of other Phyla	Malabar 0C	=	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Shoalhaven Bight 1	=	Shoalhaven Bight 2

2011							
summary statistics based on taxa							
total number of taxa*	Malabar 0C	=	Malabar 0A	=	Port Hacking	>	Marley Beach
number of Polychaete taxa	Malabar 0C	=	Malabar 0A	=	Port Hacking	>	Marley Beach
number of Crustacean taxa*	Malabar 0C	>	Malabar 0A	=	Port Hacking	=	Marley Beach
number of Mollusc taxa	Port Hacking	=	Marley Beach	=	Malabar 0A	=	Malabar 0C
number of Echinoderm taxa	Malabar 0A	=	Port Hacking	=	Marley Beach	=	Malabar 0C
number of other worm Phyla taxa	Malabar 0A	=	Marley Beach	=	Port Hacking	=	Malabar 0C
number of other Phyla taxa	Malabar 0C	=	Port Hacking	=	Malabar 0A	=	Marley Beach
summary statistics based on abundance							
total number of individuals*	Malabar 0C	>	Malabar 0A	>	Marley Beach	>	Port Hacking
number of Polychaetes*	Malabar 0C	>	Malabar 0A	>	Marley Beach	>	Port Hacking
number of Crustaceans*^	Malabar 0C	=	Malabar 0A	>	Port Hacking	=	Marley Beach
number of Molluscs*^	Marley Beach	=	Port Hacking	>	Malabar 0A	>	Malabar 0C
number of Echinoderms*	Malabar 0A	>	Malabar 0C	=	Port Hacking	=	Marley Beach
number of other worm Phyla*^	Marley Beach	>	Malabar 0A	=	Port Hacking	=	Malabar 0C
number of other Phyla	Malabar 0C	=	Marley Beach	=	Port Hacking	=	Malabar 0A

2014							
summary statistics based on taxa							
total number of taxa*	Malabar 0A	=	Malabar 0C	>	Marley Beach	>	Port Hacking
number of Polychaete taxa*	Malabar 0C	=	Malabar 0A	>	Marley Beach	=	Port Hacking
number of Crustacean taxa*	Malabar 0C	=	Malabar 0A	>	Marley Beach	=	Port Hacking
number of Mollusc taxa*	Malabar 0A	=	Marley Beach	=	Malabar 0C	=	Port Hacking
number of Echinoderm taxa*	Malabar 0C	=	Malabar 0A	>	Marley Beach	=	Port Hacking
number of other worm Phyla taxa*	Marley Beach	>	Malabar 0C	=	Malabar 0A	=	Port Hacking
number of other Phyla taxa	Malabar 0A	=	Malabar 0C	=	Marley Beach	=	Port Hacking
summary statistics based on abundance							
total number of individuals*^	Malabar 0C	=	Malabar 0A	>	Marley Beach	>	Port Hacking
number of Polychaetes*^	Malabar 0C	=	Malabar 0A	>	Marley Beach	>	Port Hacking
number of Crustaceans*^	Malabar 0C	=	Malabar 0A	>	Marley Beach	=	Port Hacking
number of Molluscs	Marley Beach	=	Malabar 0A	=	Malabar 0C	=	Port Hacking
number of Echinoderms*^	Malabar 0C	=	Malabar 0A	>	Marley Beach	=	Port Hacking
number of other worm Phyla*^	Marley Beach	>	Malabar 0A	=	Malabar 0C	=	Port Hacking
number of other Phyla*^	Malabar 0A	=	Malabar 0C	=	Marley Beach	=	Port Hacking

*ANOVA significant; ^homogeneity of variance achieved when log^{10} transformed, homogeneity of variance met for all other untransformed variables

6.3.9 Benthic community analysis – 80 m control locations

Control locations for the 80 m depth were Port Hacking and Marley. Results follow for the 80 m control locations analysis based on family taxonomic level data for years 1999, 2002, 2005, 2008, 2011 and 2014.

A Non-metric Multi-Dimensional Scaling (MDS) ordination was initially run with all replicates of the control locations, Port Hacking and Marley, and either a square root or fourth root transformation. This yielded stress values of 0.24 and 0.25 for two dimensions. As Clarke and Warwick (2001) indicate, stress values in the range of 0.2 to 0.3 should be treated with caution. As a strategy to reduce stress, a third dimension was added and yielded stress values of 0.18 and 0.19 respectively.

An additional strategy adopted to reduce stress and improve fit of the MDS analysis, involved the pooling of replicates. Site (1 and 2) was averaged for each year for 2002, 2005, 2008, 2011 and 2014, based on family level data. Square root and fourth transformations were investigated. Resultant stress values were 0.15 and 0.10 for the square root transformation for two and three dimensions. Fourth root transformation returned similar stress values of 0.16 and 0.09 for two and three dimensions.

The two dimensional plot based on square root transformation of average reference site data is presented in Figure 6-22. The stress value of that plot was 0.15. Separation of years is apparent in Figure 6-22. This indicated that a change in assemblage composition through time occurred at the reference (control) locations. Also obvious in this plot is that ‘within years’ sites of a location were generally more similar (Figure 6-22).

The ordination pattern was supported by the corresponding tree diagram (dendrogram) from the cluster analysis of 80 m control sites for years 1999, 2002, 2005, 2008, 2011 and 2014, based on family level replicates that were averaged by site (1 and 2) for each year (Figure 6-23). The tree diagram also suggested average site samples from 2014 were most taxonomically similar to those of 1999 and 2008, while averaged site samples from 2002, 2005 and 2011 were more taxonomically similar.

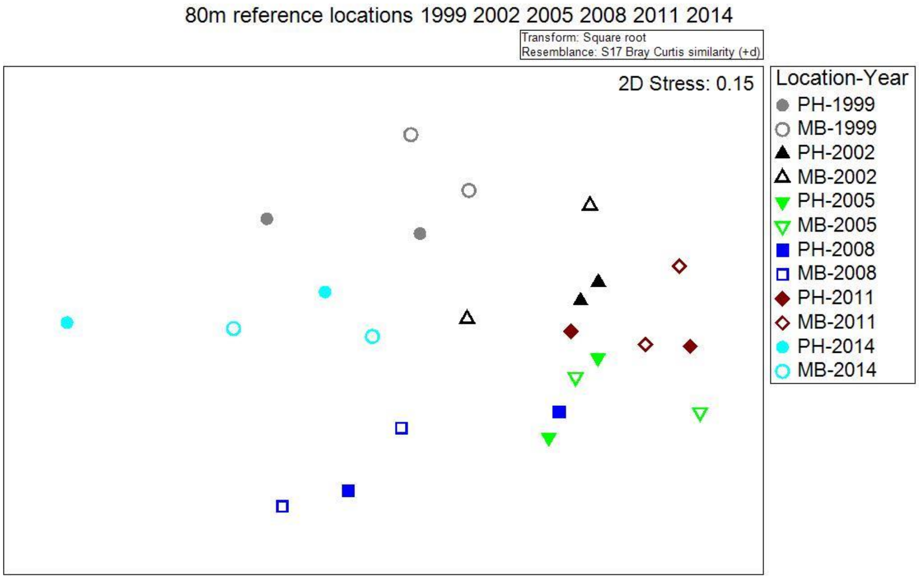


Figure 6-22 MDS ordination plot of 80 m control sites for years 1999, 2002, 2005, 2008, 2011 and 2014 based on family level replicates that were averaged by site (1 and 2) for each year

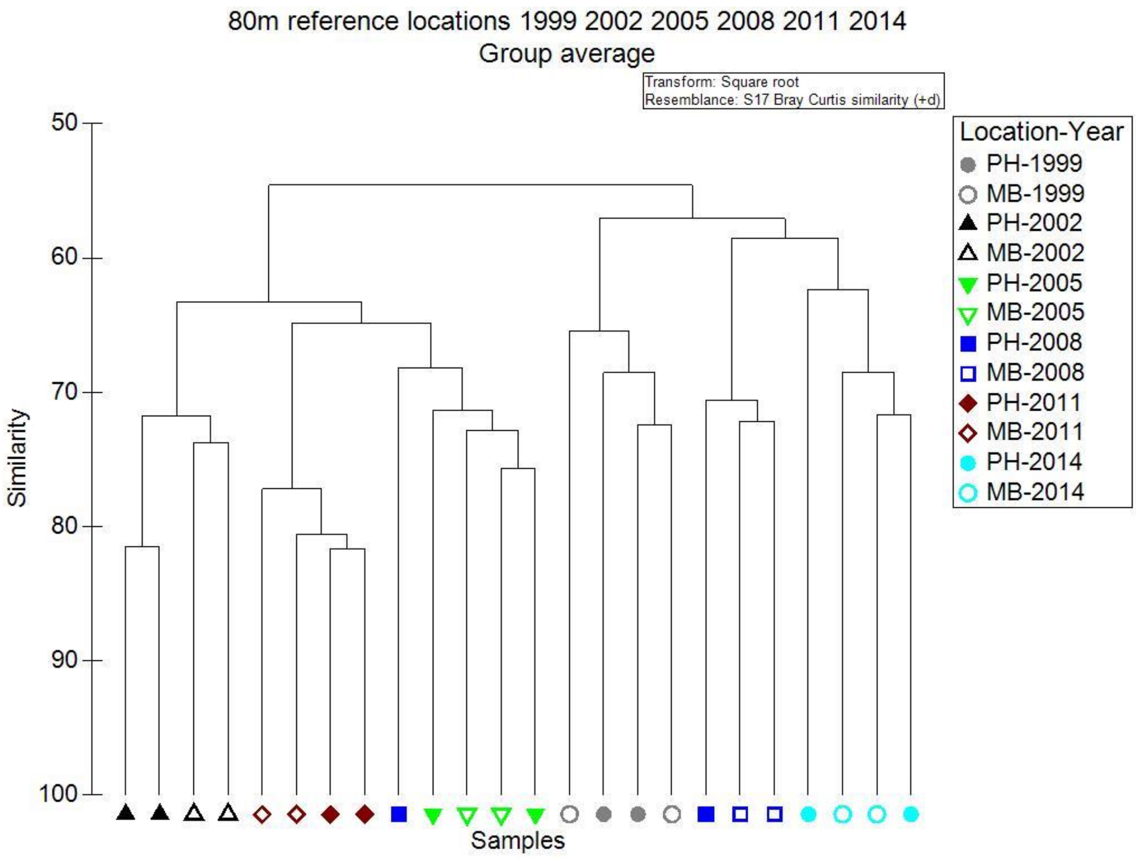


Figure 6-23 Tree diagram of 80 m control locations for years 1999, 2002, 2005, 2008, 2011 and 2014 based on family level replicates that were averaged by site (1 and 2) for each year

PERMDISP results indicated heterogeneity of dispersion occurred between Location-year groups of samples (F = 6.6716, df1 = 11, df3 = 108, P(perm) = 0.0001). Pairwise tests reflected a mixture of significant and non-significant results (Table 6-29).

A PERMANOVA model with the single factor ‘Location-year’ based on replicate data indicated measurable differences occurred (df = 11, MS = 6810.6 Pseudo F = 6.5459 P(perm) = 0.0001). Corresponding pair-wise tests indicated measurable differences in taxonomic composition occurred for a number of the comparisons for these two reference locations over time (Table 6-29).

Table 6-29 Pair-wise test results from PERMANOVA and PERMDISP of 80 m locations based on family level replicates, with square root transformation and Bray-Curtis resemblance association measure

	PERMANOVA		PERMDISP	
Sample groups	**t**	**P (perm)**	**t**	**P (perm)**
MB-2002, MB-2005	2.4361	0.0001	0.7118	0.5461
MB-2002, MB-2008	2.6117	0.0002	0.4916	0.6456
MB-2002, MB-2011	2.7768	0.0001	2.5434	0.0249
MB-2002, MB-2014	2.2242	0.0001	1.4273	0.1936
MB-2002, PH-2002	1.7406	0.0002	2.6296	0.0392

	PERMANOVA		PERMDISP	
Sample groups	**t**	**P (perm)**	**t**	**P (perm)**
MB-2002, PH-2005	2.3212	0.0001	0.0240	0.9823
MB-2002, PH-2008	2.1331	0.0001	2.3305	0.0481
MB-2002, PH-2011	2.9069	0.0001	4.0863	0.0018
MB-2002, PH-2014	2.5347	0.0001	1.8754	0.0985
MB-2002, PH-1999	2.451	0.0001	0.1547	0.8859
MB-2002, MB-1999	2.3457	0.0001	0.3061	0.7787
MB-2005, MB-2008	3.2025	0.0001	1.4078	0.1669
MB-2005, MB-2011	2.5906	0.0001	2.3920	0.0327
MB-2005, MB-2014	2.987	0.0001	2.1587	0.0431
MB-2005, PH-2002	2.3089	0.0001	2.4297	0.0498
MB-2005, PH-2005	1.2930	0.0277	0.5733	0.6166
MB-2005, PH-2008	2.2719	0.0002	2.9779	0.0024
MB-2005, PH-2011	2.5278	0.0001	4.2768	0.0026
MB-2005, PH-2014	3.0948	0.0001	2.5990	0.0174
MB-2005, PH-1999	3.1863	0.0002	0.5851	0.5590
MB-2005, MB-1999	2.8354	0.0001	1.0199	0.3688
MB-2008, MB-2011	3.2232	0.0001	3.2530	0.0068
MB-2008, MB-2014	1.8655	0.0002	1.0978	0.3144
MB-2008, PH-2002	3.2189	0.0001	3.1629	0.0153
MB-2008, PH-2005	2.7547	0.0001	0.3705	0.7410
MB-2008, PH-2008	1.4967	0.0132	2.0763	0.0663
MB-2008, PH-2011	3.2905	0.0001	4.8937	0.0002
MB-2008, PH-2014	2.2268	0.0001	1.5799	0.1571
MB-2008, PH-1999	2.6516	0.0001	0.6937	0.4949
MB-2008, MB-1999	2.9834	0.0001	0.1364	0.9006
MB-2011, MB-2014	2.6739	0.0001	3.5309	0.0017
MB-2011, PH-2002	2.8479	0.0001	0.5840	0.6072
MB-2011, PH-2005	2.5411	0.0001	2.0923	0.0780
MB-2011, PH-2008	2.4642	0.0001	4.1042	0.0003
MB-2011, PH-2011	1.5543	0.0007	1.6499	0.1536
MB-2011, PH-2014	3.265	0.0001	3.8700	0.0012
MB-2011, PH-1999	3.2207	0.0001	2.5507	0.0215
MB-2011, MB-1999	3.0361	0.0001	2.7132	0.0179
MB-2014, PH-2002	2.8808	0.0002	3.5361	0.0037

	PERMANOVA		PERMDISP	
Sample groups	**t**	**P (perm)**	**t**	**P (perm)**
MB-2014, PH-2005	2.7077	0.0001	1.2208	0.2843
MB-2014, PH-2008	1.7046	0.0006	1.0152	0.3734
MB-2014, PH-2011	2.8002	0.0001	4.7868	0.0004
MB-2014, PH-2014	1.3998	0.0155	0.4617	0.6769
MB-2014, PH-1999	2.0191	0.0001	1.6093	0.1313
MB-2014, MB-1999	2.4173	0.0001	1.1176	0.2948
PH-2002, PH-2005	2.4449	0.0001	2.2954	0.0646
PH-2002, PH-2008	2.3932	0.0001	4.1110	0.0017
PH-2002, PH-2011	2.8588	0.0001	0.7484	0.5301
PH-2002, PH-2014	3.1372	0.0001	3.8551	0.0022
PH-2002, PH-1999	3.0636	0.0001	2.6125	0.0316
PH-2002, MB-1999	2.9709	0.0001	2.7886	0.0239
PH-2005, PH-2008	1.8148	0.0003	2.0840	0.0938
PH-2005, PH-2011	2.2982	0.0001	3.3646	0.0090
PH-2005, PH-2014	2.7115	0.0001	1.6325	0.1448
PH-2005, PH-1999	2.7179	0.0001	0.1499	0.8989
PH-2005, MB-1999	2.5611	0.0001	0.2334	0.8324
PH-2008, PH-2011	2.2843	0.0001	5.1602	0.0003
PH-2008, PH-2014	1.8743	0.0006	0.5748	0.6088
PH-2008, PH-1999	2.1703	0.0001	2.5000	0.0215
PH-2008, MB-1999	2.4137	0.0001	2.0487	0.0811
PH-2011, PH-2014	3.3625	0.0001	5.0557	0.0001
PH-2011, PH-1999	3.2288	0.0001	4.1897	0.0009
PH-2011, MB-1999	3.1044	0.0001	4.1693	0.0019
PH-2014, PH-1999	1.9673	0.0001	2.0601	0.0629
PH-2014, MB-1999	2.4687	0.0001	1.5686	0.1732
PH-1999, MB-1999	2.0146	0.0001	0.4681	0.6738

Another PERMANOVA test was run on the following model. Terms included in the model were ‘Location’ and ‘Time’ and the interaction term ‘Location X Time’. Replicates of the two sites provided replication within each location, while years provided replicates within time. The interaction term ‘Location X Time’ (df = 5, MS = 2419.6 Pseudo F = 2.3256 P(perm) = 0.0001) was statistically significant. Pair-wise tests of ‘Location X Time’ were conducted and indicated community structure of Marley and Port Hacking was different each year (1999 t = 2.0146 P(perm) = 0.0001; 2002 t = 1.7406 P(perm) = 0.0002; 2005 t = 1.2930 P(perm) = 0.0299; 2008 t

= 1.4967 P(perm) = 0.0160; 2011 t = 1.5543 P(perm) = 0.0014; 2014 t = 1.3998, P(perm) = 0.0154).

To graphically illustrate this change through time, an MDS ordination plot with trajectories overlayed for the immediate year pairs is presented in Figure 6-24. The under laying MDS analysis was based upon centroids for each location by year.

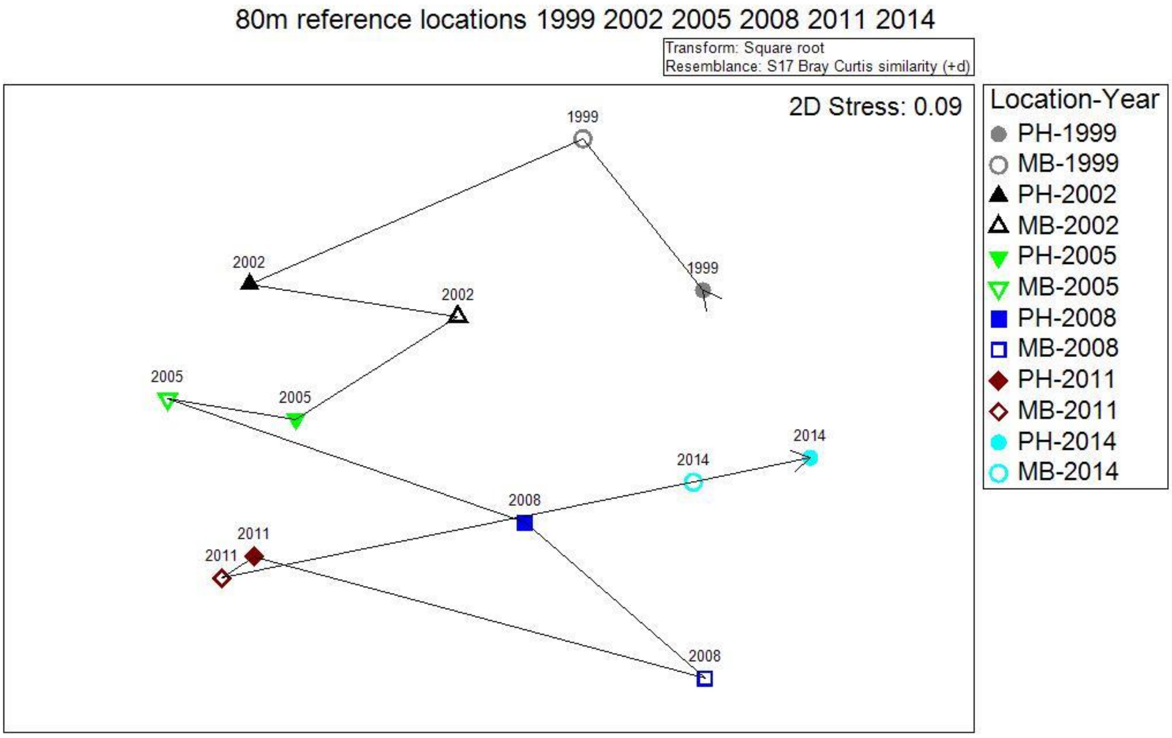


Figure 6-24 MDS ordination plot of centroids for 80 m control locations of Marley and Port Hacking for years 1999, 2002, 2005, 2008, 2011 and 2014

In summary, the measurable temporal differences in community structure were identified within and between 80 m reference (control) locations. This indicated that additional natural variation would be introduced into a dataset when more years were included. The same trend was also identified for the 60 m Long Reef control location. To reduce this natural influence, assessment of potential change in community structure as a result of wastewater discharges from the deepwater ocean outfalls was also explored for the recent 2014 assessment year data.

6.3.10 2014 benthic community analysis – 80 m control and impact locations

The following analyses look at 2014 data from the 80 m control-impact (outfall) locations based on family level data.

A Non-metric Multi-Dimensional Scaling (MDS) ordination with all replicates of the control locations of Port Hacking and Marley, and the outfall location of Malabar was run, with either a square root or fourth root transformation. This yielded stress values of 0.11 and 0.15 for two dimensions.

There was separation between impact and control location samples shown in Figure 6-25. The MDS plot also indicated the outfall samples were more tightly clustered suggesting similar taxonomic composition and abundances in each sample compared with samples from reference locations.

The separation and tighter clustering displayed in the MDS plot was also displayed in the corresponding tree diagram (Figure 6-26) from the cluster analysis based on the square root transformation. This tree diagram indicated the outfall site had differing community composition from that of the two control locations at about 30% similarity. It also displayed outfall samples with overall higher similarity than that displayed for the reference locations.

The separation displayed in the MDS plot and tree diagram was put into further context by testing of the ‘Control-Impact’ term in a PERMANOVA model. An asymmetrical PERMANOVA model was run based on family level replicates. This model included a fixed factor of ‘Control-Impact’, and two random factors: ‘Location’ nested in ‘Control-Impact’; and ‘Site’ nested in ‘Location’. A significant difference was returned for each of the three model factors: ‘Control-Impact’ factor (df = 1 MS = 20582 Pseudo F = 4.1105 P(MC) = 0.0456); ‘Location (Control-Impact)’ (df = 1 MS = 5007.2 Pseudo F = 2.9528 P(MC) = 0.0091); and ‘Site (Location)’ (df = 3 MS = 1695.7 Pseudo F = 1.7086 P(MC) = 0.0014). Partitioning of variation in this model reflects the term ‘Control-Impact’ accounted for almost half of the variation, the level of the returned P-value (0.0456) was just below the 0.05 significance level.

The CAP routine was run as a further check. CAP is design to ask ‘are there axes in multivariate space that best separate groups?’ (Anderson et al. 2008). An unconstrained ordination such as MDS, attempts to display the greatest total variation across the multivariate data cloud, whereas CAP was able to search out groups that may be in a different direction to the primary direction of greatest variation. A first pass of the CAP routine was run and after viewing diagnostic statistics an ‘m’ value of 3 was chosen to make the second pass. The second pass indicated a 100% allocation success and the first squared canonical correlation was reasonably large (δ12 = 0.96). The Pillar’s trace statistic was significant (1.74442 p = 0.0001) and indicated there was more than one group of samples in multivariate space. The Cross Validation Leave-one-out Allocation of Observations to Groups statistic confirmed three distinct groups of samples and these groups are displayed in the CAP ordination plot (Figure 6-27). CAP results confirmed the patterns displayed in the MDS and dendrogram plots and confirmed no additional dimensionality was present in the dataset.

Anderson et al (2008) states ‘…increases or decreases in the multivariate dispersion of ecological data has been identified as a potentially important indicator of stress in marine communities (Warwick and Clarke 1993, Chapman et al, 1995)’. To statistically test this aspect of the data, the PERMDISP routine was run on Location groups of samples displayed in Figure 6-25.

Results indicated heterogeneity in dispersion existed between groups of samples collected from each location (df1 = 2 df2 = 27 F = 9.9153 P(perm) = 0.002). Corresponding pair-wise test indicated significant difference for comparisons of Malabar with Marley (t = 3.0002 P(perm) = 0.0008) and Malabar with Port Hacking (t = 4.9011 P(perm) = 0.00004). Whereas a non-significant difference was indicated for the Marley and Port Hacking comparison (t = 1.3181 P(perm) = 0.2423). These pairwise results are graphically displayed in the MDS ordination plot with the tighter clustering of Malabar samples compared to each of the looser clusters of reference location samples.

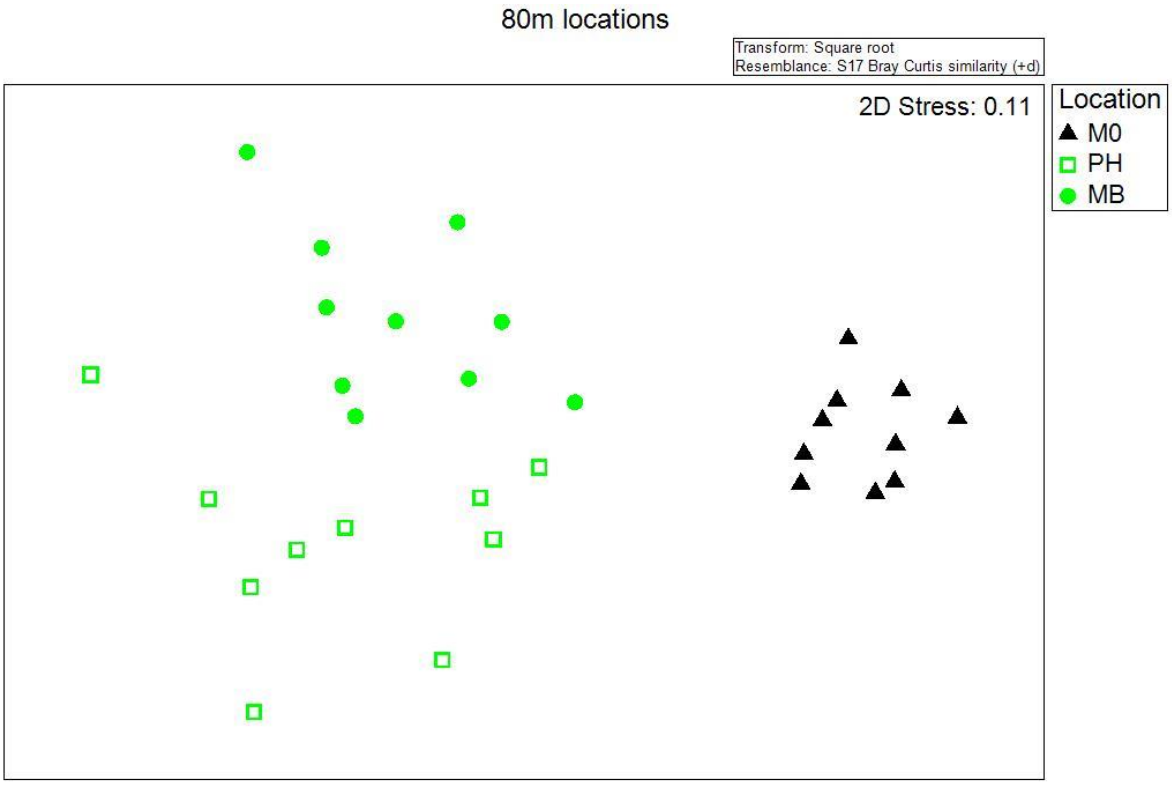


Figure 6-25 MDS ordination plot of 80 m locations based on family level replicates

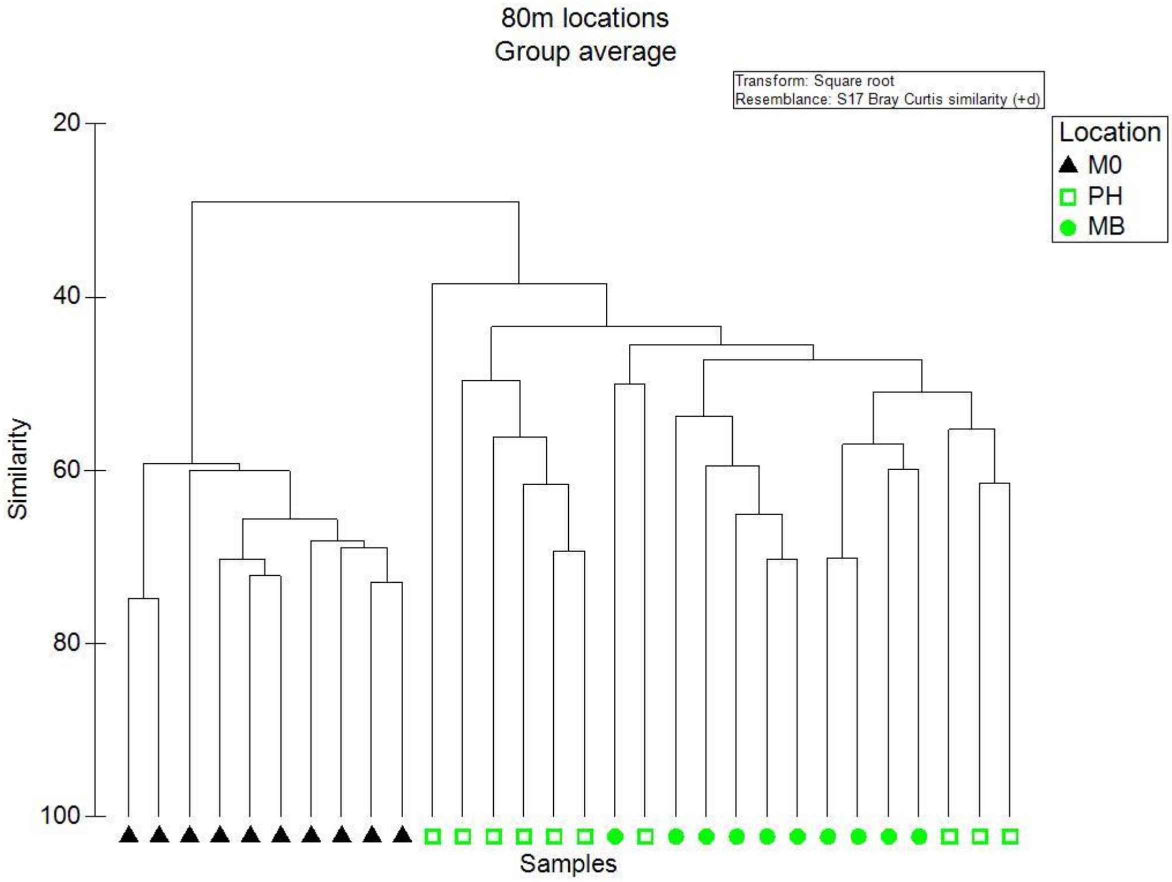


Figure 6-26 Tree diagram of 80 m locations based on family level replicates

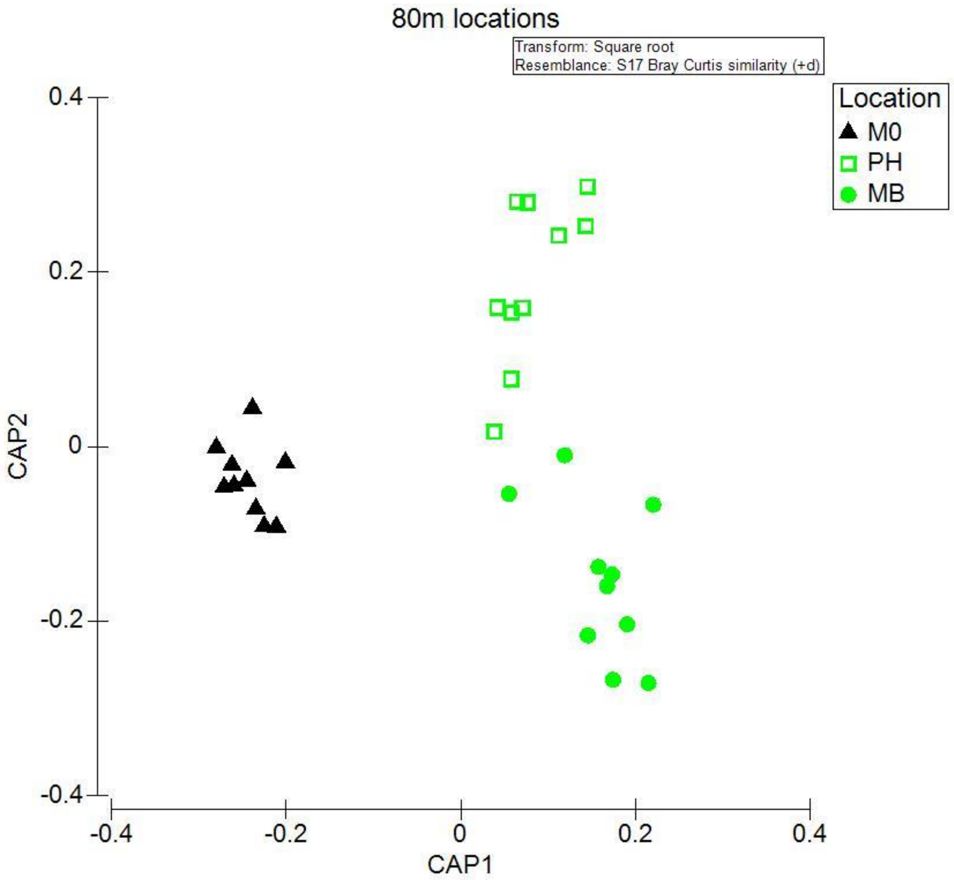


Figure 6-27 CAP ordination plot of 80 m locations based on family level replicates

To further assess if a measurable impact had occurred in the benthic community additional analysis of the above three locations together with Malabar gradient study (positive-control) locations of Malabar 3 km, 5 km and 7 km was then performed. This provided further context of the Malabar 0 km location. In the figures Malabar location names have been displayed as M0, M3, M5 and M7 for 0 km, 3 km, 5 km, and 7 km locations.

Initially, a Non-metric Multi-Dimensional Scaling (MDS) ordination with all replicates of the control locations of Port Hacking and Marley, and outfall locations of Malabar 0 km, 3 km, 5 km and 7 km was run, with either a square root or fourth root transformation. This yielded stress values of 0.18 and 0.21 for two dimensions.

Perusal of the two dimensional ordination plot (Figure 6-28) based on the square root transformation, reflected no clear spatial (north to south) gradient in location arrangement. If an impact was occurring a clear north to south order would be expected.

Inspection of the corresponding tree diagram (Figure 6-29) reflected the broader pattern in the MDS plot with the exception of indicating Port Hacking samples were more varied in taxonomic composition as appeared to be the case for Malabar 3 km and 5 km locations (Figure 6-28).

As a further check the CAP routine was run. A first pass of the CAP routine was run and after viewing diagnostic statistics an ‘m’ value of 12 was chosen to make the second pass. The second pass indicated a 77% allocation success and the first squared canonical correlation was reasonably large (δ12 = 0.95). The Pillar’s trace statistic was significant (3.25949 p = 0.0001) and indicated there was more than one group of samples in multivariate space. The Cross

Validation Leave-one-out Allocation of Observations to Groups statistics reflected the MDS and dendrogam plot patterns where there were some distinct groups of samples from a location while some other locations did not have as a distinct taxonomic composition as some samples were closer in composition to other locations (Table 6-30). These statistics together with the CAP plot (Figure 6-30) confirmed there was no additional dimensionality than that displayed in the MDS plot (Figure 6-28).

Table 6-30 CAP Cross Validation Leave-one-out Allocation of Observations to Groups statistics from 80 m locations including gradient locations

	Allocated group							
Original group	**M0**	**M3**	**M5**	**M7**	**PH**	**MB**	**Total**	**%correct**
M0	10	0	0	0	0	0	10	100
M3	0	8	2	0	0	0	10	80
M5	0	4	3	1	2	0	10	30
M7	0	0	1	9	0	0	10	90
PH	0	0	2	1	7	0	10	70
MB	0	0	0	0	1	9	10	90

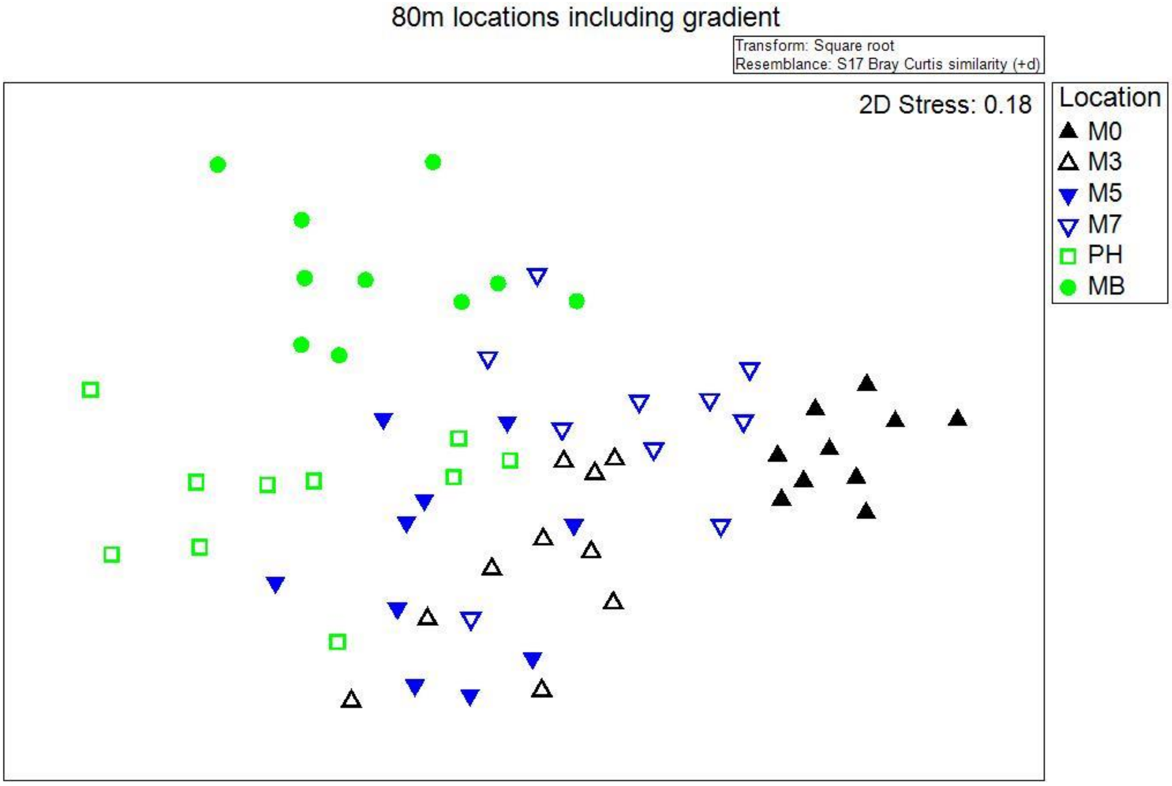


Figure 6-28 MDS ordination plot of 80 m locations including gradient locations based on family level replicates

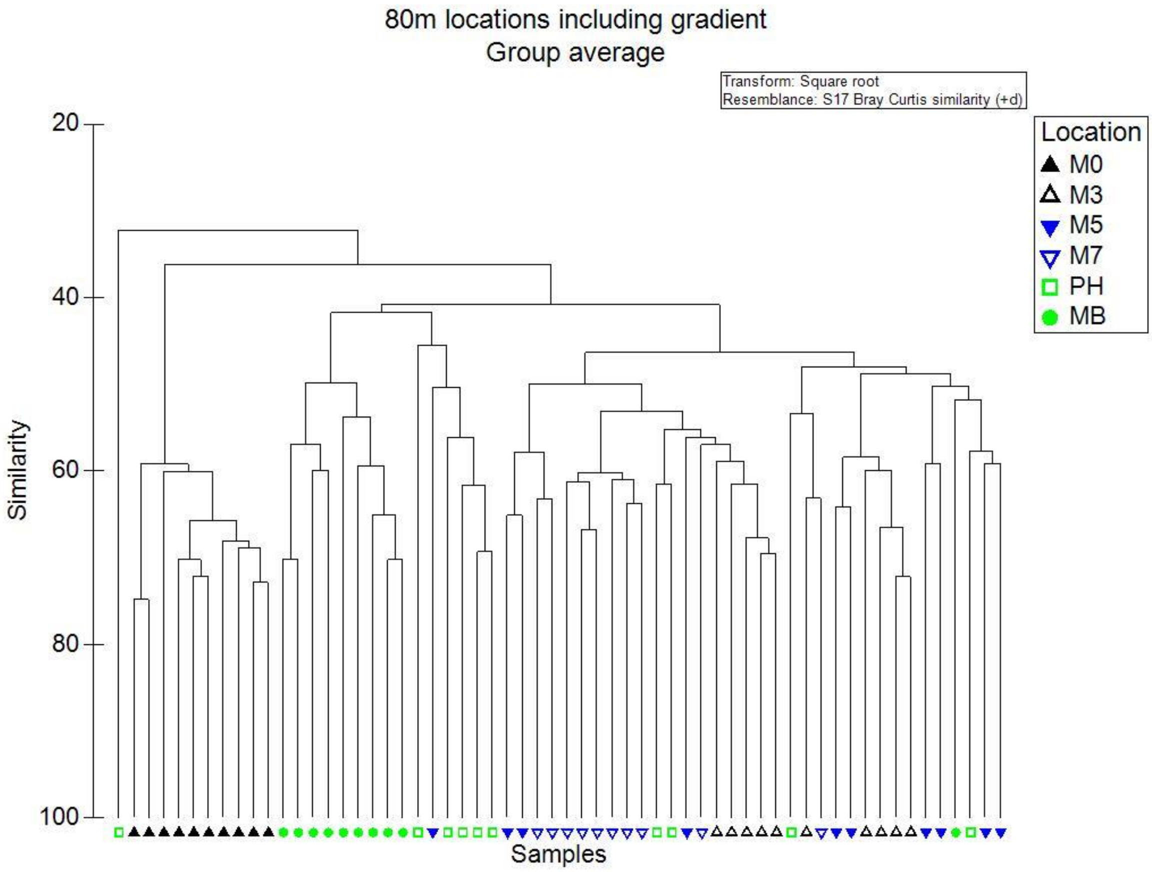


Figure 6-29 Tree diagram of 80 m locations including gradient locations based on family level replicates

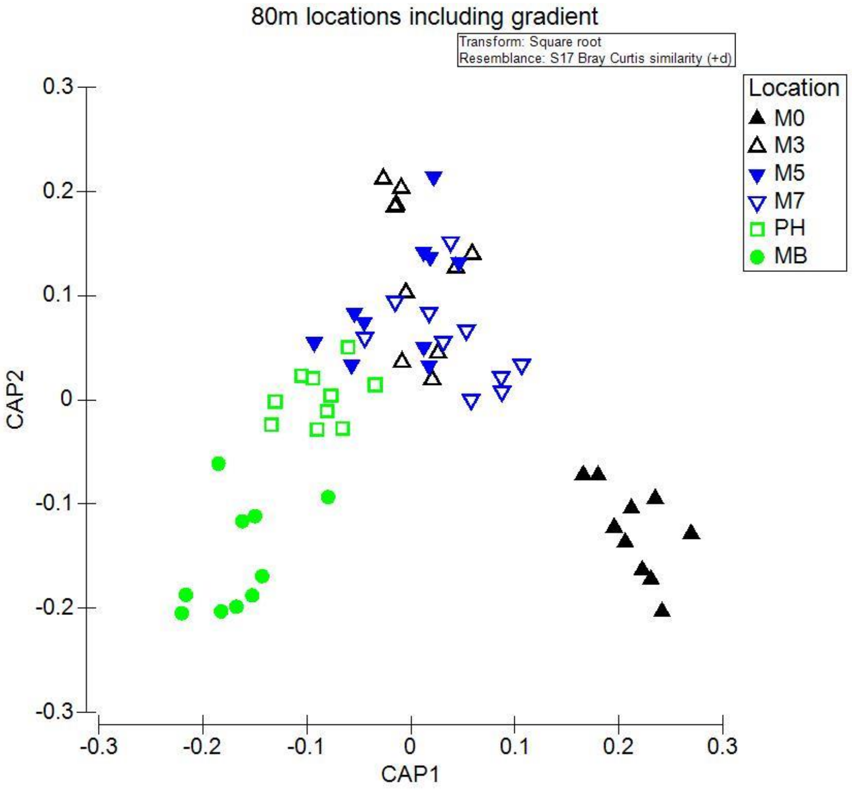


Figure 6-30 CAP ordination plot of 80 m locations including gradient locations based on family level replicates

The PERMDISP routine was run on the six Location groups of samples as displayed in Figure 6-28. Results indicated heterogeneous dispersion in samples collected (df1 = 5 df2 = 54 F = 5.3798 P(perm) = 0.0018). Pair-wise test results of the benthic community at the Malabar outfall location were different to the other locations (Table 6-31). This could indicate a measurable impact as Anderson et al (2008) states '…increases or decreases in the multivariate dispersion of ecological data has been identified as a potentially important indicator of stress in marine communities (Warwick and Clarke 1993; Chapman et al. 1995)'.

Table 6-31 Pair-wise test results from PERMDIPS of 80 m locations based on family level replicates

PERMDISP		
Groups	t	p(perm)
M0,M3	2.2217	0.0446
M0,M5	5.4875	0.0001
M0,M7	3.5707	0.0029
M0,MB	3.0002	0.0009
M0,PH	4.9011	0.0003
M3,M5	2.1839	0.0569
M3,M7	1.0906	0.3458
M3,MB	0.94308	0.3975
M3,PH	2.4513	0.0389
M5,M7	0.97144	0.3574
M5,MB	0.84186	0.4336
M5,PH	0.75511	0.4771
M7,MB	0.01805	0.9880
M7,PH	1.4616	0.1986
MB,PH	1.3181	0.2502

The similarity percentages (SIMPER) routine was used to explore which taxa were principally responsible for differences between sets of samples defined a-priori. This routine employed Bray Curtis similarities to examine the contribution of individual taxa to the average similarity between groups and within groups. SIMPER indicated that average % dissimilarity between Locations ranged from 53% to 73% (Table 6-32). This in turn indicated differences existed in taxonomic composition between locations, but a number of taxa were also present across the location pairs. The average % similarity of replicates within Locations ranged from 46% to 63% similarity (Table 6-33). These results suggest benthic community assemblages were less similar the further locations were apart.

Table 6-32 Average % dissimilarity between 80 m Locations based on family level replicates, square root transformation and Bray-Curtis resemblance association measure

	M0	M3	M5	M7	PH
M3	60				
M5	67	50			
M7	55	53	57		
PH	73	58	56	63	
MB	71	62	60	61	58

Table 6-33 Average % similarity within 80 m Locations based on family level replicates, square root transformation and Bray-Curtis resemblance association measure

M0	M3	M5	M7	PH	MB
63	56	49	52	52	46

The above asymmetrical PERMANOVA model was extended with the inclusion of positive-control locations. This model only differed with three levels (control, positive-control, impact) of the fixed factor of ‘Control-Impact’ rather than two. A significant difference was returned for each of the three model factors: ‘Control-Impact’ factor (df = 2 MS = 13824 Pseudo F = 3.2768 P(MC) = 0.0024); ‘Location (Control-Impact)’ (df = 3 MS = 4218.9 Pseudo F = 2.7085 P(MC) = 0.0004); and ‘Site (Location)’ (df = 6 MS = 1557.6 Pseudo F = 1.5074 P(MC) = 0.0048). Corresponding pairwise tests of the ‘Control-Impact’ factor indicated significant differences for all three comparisons:

- Impact versus Positive-control t = 1.867 P(MC) = 0.018
- Impact versus Control t = 2.0274 P(MC) = 0.0398
- Positive-control versus Control t =1.5521 P(MC) = 0.0275

The addition of gradient study location data in the multivariate analysis indicated those samples more closely resembled the control locations than that of the Malabar 0 km location. This 2014 pattern was in contrast to 2011 multivariate analysis pattern (Sydney Water 2011), which suggested benthic community structure may have been influenced by the Georges River estuary. Thus the observed pattern may be an outcome of temporal change in community structure over time that aligned with changes at other positive-control and control locations having community structures. While pictorially it had an apparent pattern that could be consistent with a measurable impact for wastewater discharge at the Malabar outfall location the PERMANOVA model test results did not clearly confirm this impact. Rather differences were indicated between all three location types under PERMANOVA testing, which questioned the pictorial results. Further exploration of this pattern was undertaken in the gradient study.

6.3.11 Malabar gradient study univariate analysis

ANOVA was conducted on the benthic macrofauna univariate summary statistics obtained for each of the six assessment years (1999, 2002, 2005, 2008, 2011 and 2014) for the Malabar 0 km, 3 km, 5 km and 7 km locations. Some significant differences were highlighted between the locations (Table 6-34). However, a statistically significant gradient from Malabar 0 km to Malabar 7 km was not observed for any parameter in any year. In 2005, no significant differences were found for any of the parameters analysed.

Table 6-34 Results of ANOVA on benthic macrofauna summary statistics (Malabar gradient)

1999							
summary statistics based on taxa							
total number of taxa	Malabar 3	=	Malabar 5	=	Malabar 0C	=	Malabar 7
number of Polychaete taxa	Malabar 3	=	Malabar 5	=	Malabar 0C	=	Malabar 7
number of Crustacean taxa	Malabar 3	=	Malabar 5	=	Malabar 0C	=	Malabar 7
number of Mollusc taxa	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Echinoderm taxa	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other worm Phyla taxa	Malabar 0C	=	Malabar 7	=	Malabar 5	=	Malabar 3
number of other Phyla taxa	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
summary statistics based on abundance							
total number of individuals	Malabar 3	>	Malabar 5	=	Malabar 0C	=	Malabar 7
number of Polychaetes	Malabar 3	>	Malabar 0C	=	Malabar 5	=	Malabar 7
number of Crustaceans	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Molluscs	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Echinoderms	Malabar 3	>	Malabar 7	=	Malabar 5	=	Malabar 0C
number of other worm Phyla	Malabar 0C	>	Malabar 5	=	Malabar 7	=	Malabar 3
number of other Phyla	Malabar 5	=	Malabar 3	=	Malabar 0C	=	Malabar 7

2002									
summary statistics based on taxa									
total number of taxa	Malabar 7	=	Malabar 0C	=	Malabar 5	=	Malabar 0A	>	Malabar 3
number of Polychaete taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Crustacean taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Mollusc taxa	Malabar 5	=	Malabar 7	=	Malabar 0A	=	Malabar 0C	=	Malabar 3
number of Echinoderm taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other worm Phyla taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other Phyla taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
summary statistics based on abundance									
total number of individuals	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Polychaetes	Malabar 7	=	Malabar 3	=	Malabar 0C	=	Malabar 0A	=	Malabar 5
number of Crustaceans	Malabar 0C	=	Malabar 0A	=	Malabar 7	=	Malabar 5	=	Malabar 3
number of Molluscs	Malabar 7	>	Malabar 5	=	Malabar 0C	=	Malabar 0A	=	Malabar 3
number of Echinoderms	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other worm Phyla	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other Phyla	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7

2011

summary statistics based on taxa									
total number of taxa*	Malabar 0C	=	Malabar 0A	=	Malabar 5	=	Malabar 7	=	Malabar 3
number of Polychaete taxa	Malabar 5	=	Malabar 3	=	Malabar 0C	=	Malabar 0A	=	Malabar 7
number of Crustacean taxa*	Malabar 0C	>	Malabar 0A	>	Malabar 7	=	Malabar 5	=	Malabar 3
number of Mollusc taxa*	Malabar 7	>	Malabar 5	=	Malabar 0C	=	Malabar 0A	=	Malabar 3
number of Echinoderm taxa*^	Malabar 5	=	Malabar 0A	=	Malabar 7	=	Malabar 3	=	Malabar 0C
number of other worm Phyla taxa	Malabar 3	=	Malabar 5	=	Malabar 7	=	Malabar 0A	=	Malabar 0C
number of other Phyla taxa*	Malabar 0C	=	Malabar 5	=	Malabar 0A	=	Malabar 7	=	Malabar 3
summary statistics based on abundance									
total number of individual*s	Malabar 0C	>	Malabar 0A	=	Malabar 5	=	Malabar 7	=	Malabar 3
number of Polychaetes*	Malabar 0C	>	Malabar 0A	=	Malabar 5	=	Malabar 3	=	Malabar 7
number of Crustaceans*	Malabar 0A	>	Malabar 0C	=	Malabar 7	=	Malabar 5	=	Malabar 3
number of Molluscs*	Malabar 7	=	Malabar 5	=	Malabar 0A	=	Malabar 3	=	Malabar 0C
number of Echinoderms*	Malabar 0A	=	Malabar 7	=	Malabar 5	=	Malabar 0C	=	Malabar 3
number of other worm Phyla	Malabar 3	=	Malabar 5	=	Malabar 0A	=	Malabar 7	=	Malabar 0C
number of other Phyla*	Malabar 0C	=	Malabar 5	=	Malabar 0A	=	Malabar 7	=	Malabar 3

*ANOVA significant; ^heterogeneity of variance remained when log^{10} transformed presented untransformed, homogeneity of variance met for all other untransformed variables

2005

summary statistics based on taxa									
total number of taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Polychaete taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Crustacean taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Mollusc taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Echinoderm taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other worm Phyla taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other Phyla taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 7	=	Malabar 5
summary statistics based on abundance									
total number of individuals	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Polychaetes	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Crustaceans	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Molluscs	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Echinoderms	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other worm Phyla	Malabar 0C	=	Malabar 0A	=	Malabar 5	=	Malabar 7	=	Malabar 3
number of other Phyla	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 7	=	Malabar 5

2008

summary statistics based on taxa									
total number of taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Polychaete taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Crustacean taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Mollusc taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Echinoderm taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other worm Phyla taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of other Phyla taxa	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 7	=	Malabar 5
summary statistics based on abundance									
total number of individuals	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Polychaetes	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Crustaceans	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar7
number of Molluscs	Malabar 0A	=	Malabar 0C	=	Malabar 3	=	Malabar 5	=	Malabar 7
number of Echinoderms	Malabar 0C	>	Malabar 0A	=	Malabar 3	=	Malabar 7	=	Malabar 5
number of other worm Phyla	Malabar 0A	=	Malabar 0C	=	Malabar 5	=	Malabar 7	=	Malabar 3
number of other Phyla	Malabar 3	>	Malabar 7	=	Malabar 5	=	Malabar 0A	=	Malabar 0C

2014

summary statistics based on taxa									
total number of taxa*	Malabar 0C	=	Malabar 0A	=	Malabar 7	>	Malabar 3	=	Malabar 5
number of Polychaete taxa*	Malabar 0C	=	Malabar 0A	>	Malabar 7	=	Malabar 3	=	Malabar 5
number of Crustacean taxa*	Malabar 0A	=	Malabar 0C	=	Malabar 7	>	Malabar 3	=	Malabar 5
number of Mollusc taxa*	Malabar 0A	=	Malabar 7	=	Malabar 0C	=	Malabar 3	=	Malabar 5
number of Echinoderm taxa	Malabar 0C	=	Malabar 0A	=	Malabar 7	=	Malabar 5	=	Malabar 3
number of other worm Phyla taxa	Malabar 0C	=	Malabar 0A	=	Malabar 7	=	Malabar 5	=	Malabar 3
number of other Phyla taxa	Malabar 0C	=	Malabar 0A	=	Malabar 3	=	Malabar 5	=	Malabar 7
summary statistics based on abundance									
total number of individuals*^	Malabar 0C	=	Malabar 0A	>	Malabar 7	>	Malabar 3	=	Malabar 5
number of Polychaetes*^	Malabar 0C	=	Malabar 0A	>	Malabar 7	=	Malabar 3	=	Malabar 5
number of Crustaceans*^	Malabar 0C	=	Malabar 0A	=	Malabar 7	>	Malabar 3	=	Malabar 5
number of Molluscs*	Malabar 0A	=	Malabar 7	=	Malabar 0C	=	Malabar 5	=	Malabar 3
number of Echinoderms*^	Malabar 0C	=	Malabar 0A	>	Malabar 7	=	Malabar 3	=	Malabar 5
number of other worm Phyla	Malabar 0A	=	Malabar 0C	=	Malabar 7	=	Malabar 5	=	Malabar 3
number of other Phyla	Malabar 3	=	Malabar 0C	=	Malabar 5	=	Malabar 0A	=	Malabar 7

*ANOVA significant; ^heterogeneity of variance remained when $\log^{10}$ transformed presented untransformed, homogeneity of variance met for all other untransformed variables

6.3.12 Malabar gradient study multivariate analysis

The 80 m multivariate analyses presented above looked at variation among sample locations for these locations with context to the 80 m control (reference) locations. The following analysis focuses on ‘taxonomic-turnover’ along the spatial gradient between Malabar 0 km and 7 km locations. This analysis provided another way to interrogate the data to see if a measurable impact had occurred.

This analysis was based upon the ‘Distance-based linear models’ (DISTLM) routine with spatial geographic (distance between location samples) and chemistry (various metals) variables grouped as sets of predictor variables. Anderson et al. (2008) states ‘By analysing the data in sets, one can explicitly examine the proportion of variation in the species data that is explained by the environmental variables over and above the amount explained by the spatial variables alone.’

As DISTLM is a regression technique. Regression results are weakened when strongly correlated variables are included. To increase sensitivity of the DISTLM analysis, variables were omitted to account for multi-collinearity within the predictor variables. Omitted variables included: total cadmium; total chromium, total copper; total iron; total lead; total nickel; and total zinc. These variables were well correlated ($r > 0.85$) with total mercury for the Malabar 0 km to 7 km locations. If an included variable was implicated by DISTLM as explaining some of the variation in the biotic (benthic macroinvertebrate sample) pattern, it could actually be one or a combination of omitted variables or be a surrogate for some other unmeasured variable. This consideration of regression results was outlined by Clarke and Warwick (2001) and Anderson et al. (2008).

The spatial variable was fitted first, followed by the chemistry set of variables, which allowed a test of the hypothesis, of no relationship between the benthic macroinvertebrates and the chemistry variables given the spatial variable (Anderson et al, 2008).

Adjusted R2 values were requested from the model as these took into account the different numbers of variables between the sets. A consideration outlined by Anderson et al (2008).

Modelled output of DISTLM was displayed in a constrained dbRDA ordination plot. To assess the adequacy of a plot, both fitted variation and total variation were inspected. If fitted variation exceeds 70% then the plot is likely to capture most of the salient pattern in the fitted DISTLM model (Anderson et al, 2008). The amount of total variation is also important to consider as if the total variation is a paltry amount then the dbRDA axis maybe of little overall relevance in the multivariate system as a whole (Anderson et al, 2008).

In the dbRDA plot (Figure 6-31) of the Malabar 0 km and 7 km locations, that had the spatial variable fitted first, and set of chemistry variables fitted second, the fit was good and accounted for about 89% of the variation. However, total variation only explained about 29% of the variation in the multivariate data cloud based on adjusted R2 values. Of this 29% of total variation, the geographic variable only accounted for 23%, while the chemistry variable set accounted for 6%. This amount of total variation was at the ‘paltry’ end, and as such suggests, the model has little relevance and that other unmeasured factors were important at driving the patterns in benthic macroinvertebrate communities.

A way of visualising the relationships of predictor variables is to examine the default vector overlay that comes out as part of the dbRDA plot (Figure 6-31). The total mercury vector also represented the seven omitted metal variables due to multi-collinearity considerations outlined above. The longer the vector, the bigger the effect it has had in the construction of dbRDA axes being viewed. The lack of impact in the benthic community from wastewater discharged from the Malabar deepwater ocean outfall diffusers was shown in this plot (Figure 6-31), as metal vectors did not align with the distance (spatial) vector as would be expected if a measurable impact was to occur. In fact these metal vectors were at 90o to the distance vector.

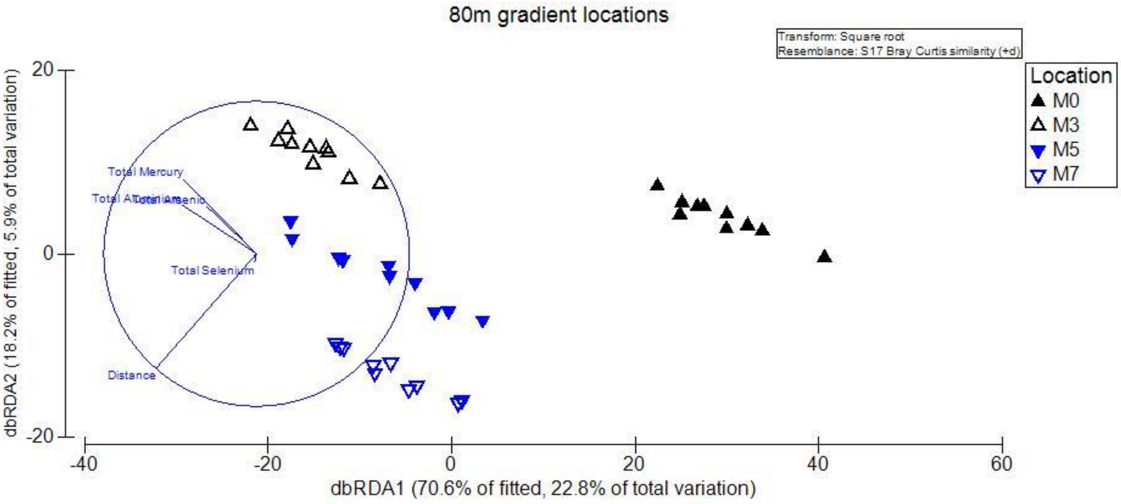


Figure 6-31 dbRDA plot of 80 m Malabar gradient locations based on family level replicates with square root transformation with vector overlay of spatial and chemistry variables shown

NB to allow for multi-collinearity total mercury in Figure 6-31also represented total cadmium, total chromium, total copper, total iron, total lead, total nickel and total zinc.

Included into a second DISTLM model run were 80 m reference locations that were at 10 km and 17 km distance from the Malabar 0 km location. As for the first model run, two sets of variables were included. Again the spatial variable was fitted first. The total metal variable of zinc was well correlated to other total metals of cadmium, chromium, iron, and nickel while mercury was well correlated with copper, lead and silver. As such, these well correlated variables were omitted to account for multi-collinearity. Hence aluminium, arsenic, selenium, mercury, zinc, formed the chemistry set of variables.

The dbRDA plot (Figure 6-32) of the Malabar 0 km, 3 km, 5 km, 7 km and Port Hacking (10 km) and Marley (17 km) locations had quite good fitted variation at about 83% based on adjusted R2 values. However, total variation only explained about 27% of the variation in the multivariate data cloud. Of this 27% total variation, the geographic variable accounted for just 19% and the chemistry set of variables accounted for 8%. This amount of total variation was also at the ‘paltry’ end, and as such suggests, the model has little relevance and that other unmeasured factors were important at driving the patterns in benthic macroinvertebrate communities. The lack of impact in the benthic community from wastewater discharged from the Malabar deepwater ocean outfall diffusers was also shown in this plot (Figure 6-32), as metal vectors did not align with the distance (spatial) vector as would be expected if a measurable impact was to occur. In fact these metal vectors were also at 90^{o} to the distance vector.

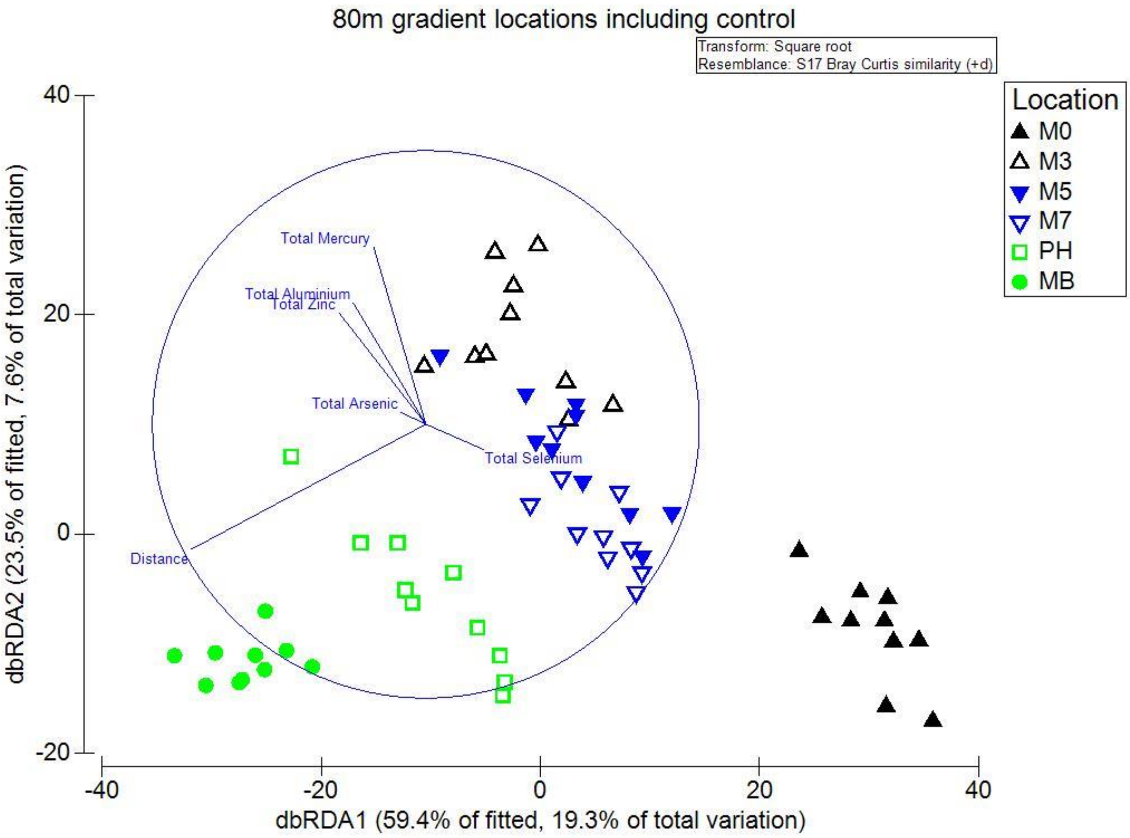


Figure 6-32 dbRDA plot of 80 m Malabar gradient and control locations based on family level replicates with square root transformation with vector overlay of spatial and chemistry variables shown

NB to account for multi-collinearity total zinc in Figure 6-32 also represented total metals of cadmium, chromium, iron, nickel. While Mercury represented copper, lead, and silver.

The above model was rerun with the inclusion of assessment years 2002, 2005, 2008, 2011 and 2014. A relatively similar pattern to the 2014 year data was displayed in the dbRDA plot (Figure 6-33) of the six locations over the five assessment years although the Malabar 3 km location was not as pronounced. This pattern also displayed metal vectors at about 90^{o} to the distance vector. Notably the amount of fitted and total variation decreased with the additional of multiple assessment year data. The amount of total variation was again at the ‘paltry’ end accounting for just 12%, with the geographic variable accounting for 9%, while the chemistry variable set accounted for 3% (Figure 6-33).

Colour coding of Figure 6-33 by year reflected change in community structure between years at each location. This extended model also suggests that other unmeasured factors were important at driving the patterns in benthic macroinvertebrate communities beyond the geographic and chemistry variables fitted into this model.

Thus gradient study results did not indicate a measurable impact to the benthic communities from wastewater discharge, and that other unmeasured factors were important at driving the patterns in benthic macroinvertebrate communities.

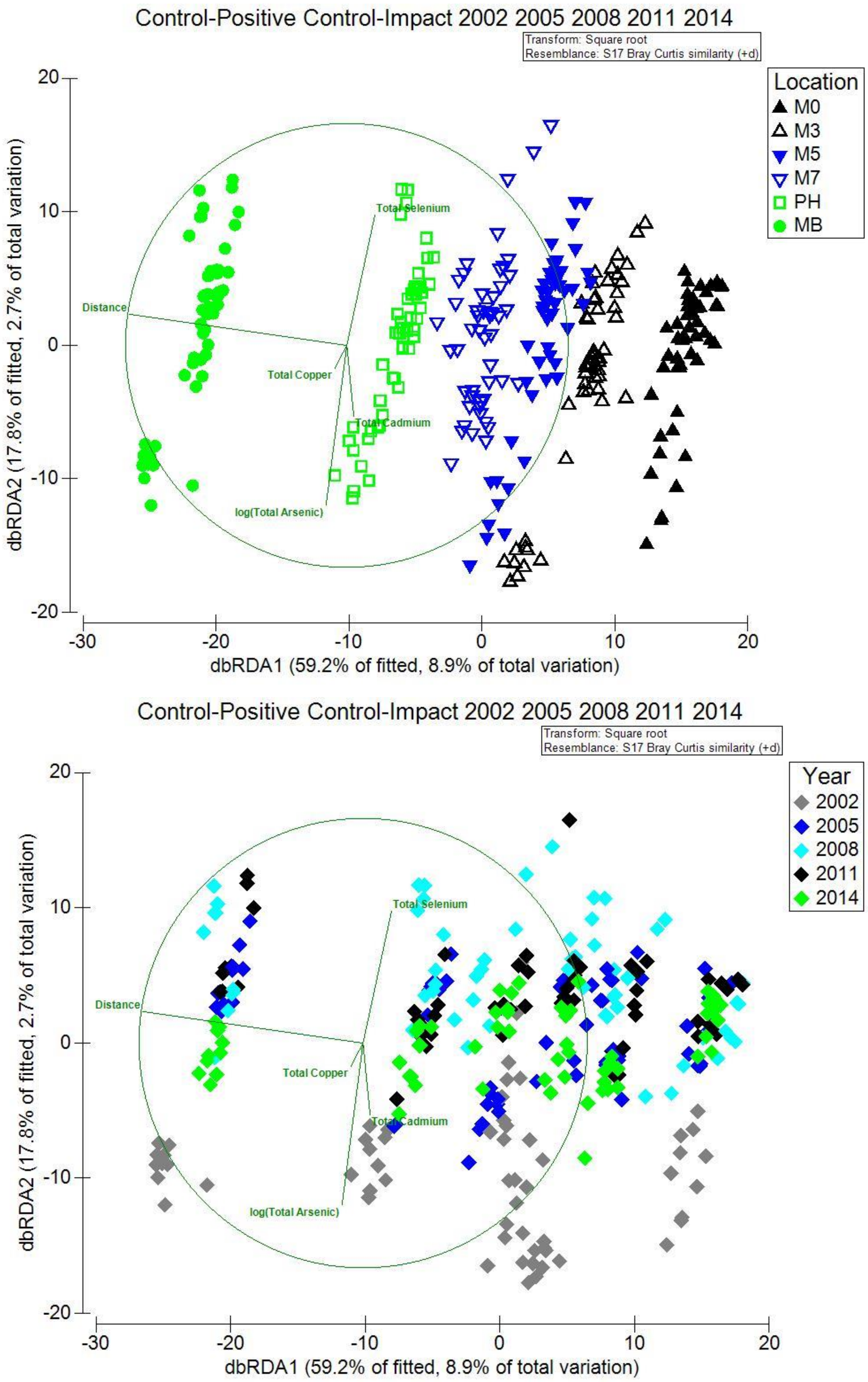


Figure 6-33 dbRDA plot of 80 m Malabar gradient and control locations with vector overlay of chemicals with samples colour coded by location and then by year

NB to allow for multi-collinearity total copper in Figure 6-33 also represented total aluminium, total iron; total lead; total mercury, total nickel; and total zinc.

7 Discussion

Approximately 80% of Sydney's sewage is treated at the North Head, Bondi and Malabar wastewater treatment plants and is discharged through three deepwater outfalls located between 2 and 4 km off shore, in waters between 65 m and 80 m deep. As a general description, these deep ocean outfalls discharge wastewater through multiple diffusers that spread it over 500 to 750 m, which achieves rapid dilution. The purpose of the diffusers is to release wastewater into the ocean at concentrations that are unlikely to be toxic once mixing has occurred. Wastewater from the three deepwater ocean outfalls contains particulate matter to which contaminants may be attached. Under particular environmental conditions, negatively buoyant particles may settle and this may lead to a possible accumulation of contaminants in the sediments.

The long-term objective of the Ocean Sediment Program (specified in the original licence conditions derived from EPA (1998)) is to address the following questions:

1. Is there a chronic impact of wastewater from Sydney's deepwater ocean outfalls?
2. Is there any spreading of a potential existing impact from wastewater discharge around the Malabar deepwater ocean outfall?

These two questions require different sampling strategies. Under the EPA design the first question uses near outfall sampling locations at all three outfalls and control locations that do not receive waste water discharges. While the second question looks at a gradient study south from the Malabar deepwater ocean outfall.

In other words this analyses assesses whether or not chemical accumulation (disturbance) has occurred in the sediment and whether or not a measurable impact on the benthic community has then occurred in the marine environment from wastewater discharge through these deepwater ocean outfalls.

7.1 Background conditions

Matthai and Birch (2000) describe the mid shelf zone (60 m to approximately 200 m depth) as a low energy depositional zone with elevated levels of mud relative to the near shore and offshore shelf zones, and the near shore zone as a dynamic environment with sediment movement resulting from wave action and oceanic currents. The zone of elevated mud levels extended almost continuously the entire length of the study area (Jervis Bay to Port Stephens) and was described as the depositional area for particulate material discharged from the coastal estuaries (Matthai and Birch, 2000). The areas of elevated metal concentrations in the mid shelf zone adjacent to each of the main cities of Wollongong, Sydney and Newcastle support this description.

In his study prior to the commissioning of deepwater outfalls, Schneider (1994) identified the mid shelf area adjacent to Sydney Harbour as the most contaminated part of the study area. That study, utilising a grid sampling pattern extending as far south as the north headland of Botany Bay, was able to localise areas of deposition of contaminants. The 'hot spot' offshore from Sydney Harbour was the most prominent feature. Given that the study was conducted prior to the commissioning of the deepwater outfalls, the sources of contaminants are likely to have been discharged through the estuaries together with possible deposition of some of the settleable material from the former shoreline sewage outfalls.

It is into these background conditions that Sydney’s deepwater ocean outfalls discharge.

7.2 Oceanography

Conclusions from the case study titled ‘Assessing long term oceanographic fluctuations using deep water ocean outfall plume models’ (Volume 2) looked at the operation of the deepwater ocean outfalls and the results from the near-field modelling carried out between 1 May 2006 and 30 June 2014. Compared with the original design assumptions, the plumes from the deepwater ocean outfalls continue to operate better than anticipated in terms of dilutions achieved and frequency of surfacing plumes.

During the 2014 sediment sampling program, both the wave-induced bottom currents and the bulk currents were sufficiently strong to initiate sediment movement on many occasions.

Generally the plume rise from the three deepwater ocean outfalls was less than 40 m above the sea floor, although this value was highly variable over the 2006 to 2014 period. On rare occasions the plumes did rise to the sea surface. Modelling has determined the plumes remain submerged for 96%, which exceeds design criteria of 90%. Corresponding modelled plume dilutions vary but generally lie between 100:1 and 1000:1. These dilutions exceeded the design criteria of 40:1 at least 98% of the time.

Negatively buoyant particles present in the wastewater were modelled to intersect with the sea floor up to and generally within 10 km of the out fall in 2005. This figure was generally within 5 km of the outfalls in 2008 and 2011. In 2014 negatively buoyant particles were likely to intersect with the sea floor up to and generally within 10 km of the outfall. The active ocean environment and the wide area of spread of negatively buoyant particles discharged from the deepwater ocean outfalls suggest that impacts associated with the particulate matter discharged through the outfalls will be difficult to effectively quantify.

Sampling during 2014 followed a period of about average costal precipitation but lower than average inland precipitation, more like the 2005 and 2011 assessment years. As such contributions of contaminants from adjacent catchments were less likely than in wetter periods, when the sediment contribution from Sydney catchments was likely to be greater.

7.3 Chemistry comparison with ANZECC (2000) guidelines

7.3.1 Wastewater quality

Of the eight measured chemistry variables that have assigned ANZECC (2000) marine water quality guideline values for protection of 95% of species, the diluted modelled concentrations were all below these guideline values with the exception of modelled concentrations of copper that were near, equalled or just exceeded the guideline value, and as such may pose a risk of an adverse environmental effect. The protection of 95% of species level is suggested by ANZECC (2000) for slightly too moderately disturbed systems. Given the background conditions offshore of the Sydney region prior to commissioning of the deepwater ocean outfalls, this level is perhaps the most applicable level for comparison of study results.

Toxicity assessment of wastewater from these three deepwater ocean outfall discharging plants have met toxicity limits set out in respective EPA Environment Protection Licences since introduction in 2004. More recent results of toxicity testing and licence details can be found at http://www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/waterquality/epa-reports/wastewater-treatment-plants/index.htm

7.3.2 Sediment chemistry

Similar deepwater ocean outfalls that discharge into a similar environment occur off Victoria, British Columbia in Canada. Monitoring of those deepwater ocean outfalls indicated sediment chemistry, sediment toxicity and benthic community measurable impacts were contained within 100 to 400 m around the 200 m long diffuser arrays (Talyor et al, 1998). This monitoring was based on a set of sampling locations that resembled spokes on a wheel with sites situated along each spoke.

Extensive rocky reefs off Sydney prevent such a radial sampling design. The EPAs spatial monitoring design employed by Sydney Water compares sampling locations near each of the outfalls and at control locations. Placement of sites under our program was constrained by these areas of extensive areas of rocky reefs within the 90 m depth contour off Sydney. These reefs are particularly rugged off Long Reef and North Head. In amongst these rocky reefs are areas of sediment infilled drowned valley systems (see Figure 3 in Fagan et al, 1992). The placement of North Head sites together with the northern Bondi site as shown on Figure 3-1 illustrates the constraint of these rocky reefs and that those sites are beyond 400 m from the diffuser arrays. This constraint also influenced site placement around the Malabar 0 km location. This constraint was lifted for locations further south as extensive rocky reefs are situated closer to the coast as the depth drops off more quickly than at the northern locations (Fagan et al, 1992).

The observed difference in median fine sediment particle size between northern 80 m locations and the southern 60 m locations could reflect that sediment reworking activity at the 80 m depth is slightly less than at the 60 m depth. The areas of extensive rocky reefs that extend further off the coast north of Malabar 0 km location may have some role in sediment movement and may have constrained delivery of sediment from the Georges River estuarine to the southern 80 m locations (Malabar 0 km, 3 km, 5 km, 7 km, Port Hacking and Marley). Plume modelling of negatively buoyant particle settlement suggests NNE sediment movement is overall less than SSW sediment movement. As the Malabar 0 km is positioned to the north of the estuary mouth the lesser observed fines at that location may be partly explained by the current movement, and or it could be a combination of the above influences that see relatively higher percentage of fines sediment particles at the 80 m depth compared with the 60 m depth.

Around each of the deepwater ocean outfalls there was no apparent build-up of fine sediment over time. Rather fluctuation over time was the apparent trend. Without a build-up in fine sediment it was unlikely that additional metal build-up in metal concentrations would occur. If a build-up in metal concentrations did occur, it could result in an adverse ecological impact in the benthic sediment communities. As this was not the case, a measurable ecological impact was unlikely.

Overall patterns in the median percentages of fine sediment particles were similar to those observed for total organic carbon. There was also an apparent lack of build-up of total organic carbon in the sediment, which suggested contributions from wastewater discharge have not been a major source of organic enrichment around the outfalls over the monitoring period. This suggestion is supported by the presence of the polychaete indicator taxon Maldanidae, which was dominant at the Malabar 0 km location and was also one of the dominant taxa at other southern 80 m locations, and also occurred at northern locations across the 2002 to 2014 interpretive years. This taxon is described as an indicator of low organic input conditions (Dean, 2008).

The existence of low organic conditions perhaps reflects the effective effluent dispersion outcome of the ‘Assessing long term oceanographic fluctuations using deep water ocean outfall plume models’ case study of Volume 2. Effective effluent dispersion is a key factor in avoiding anoxic conditions developing in the ocean sediments. As Dean (2008) conclude after a review of polychaetes as indicators of marine pollution that ‘It is often not the total amount of organic material deposited into a region but the amount relative to the ability of that region to break down that material. Too much organic input may lead to anoxic conditions in the sediments and this is what will affect the benthic community.’

To further explore potential build-up of chemical concentrations in the sediments ANCOVA models were run based on the fine sediment fraction (particles <0.063 mm). Results of these ANCOVA models found few chemicals collected in 2014 that may have indicated a potential disturbance. Copper was identified at both 60 m and 80 m depths. The plot of copper concentrations in sediment indicated levels well below the lower ANZECC (2000) sediment quality guideline trigger level. This result suggested at those recorded levels sediment copper concentrations were an unlikely source of disturbance to benthic invertebrate communities.

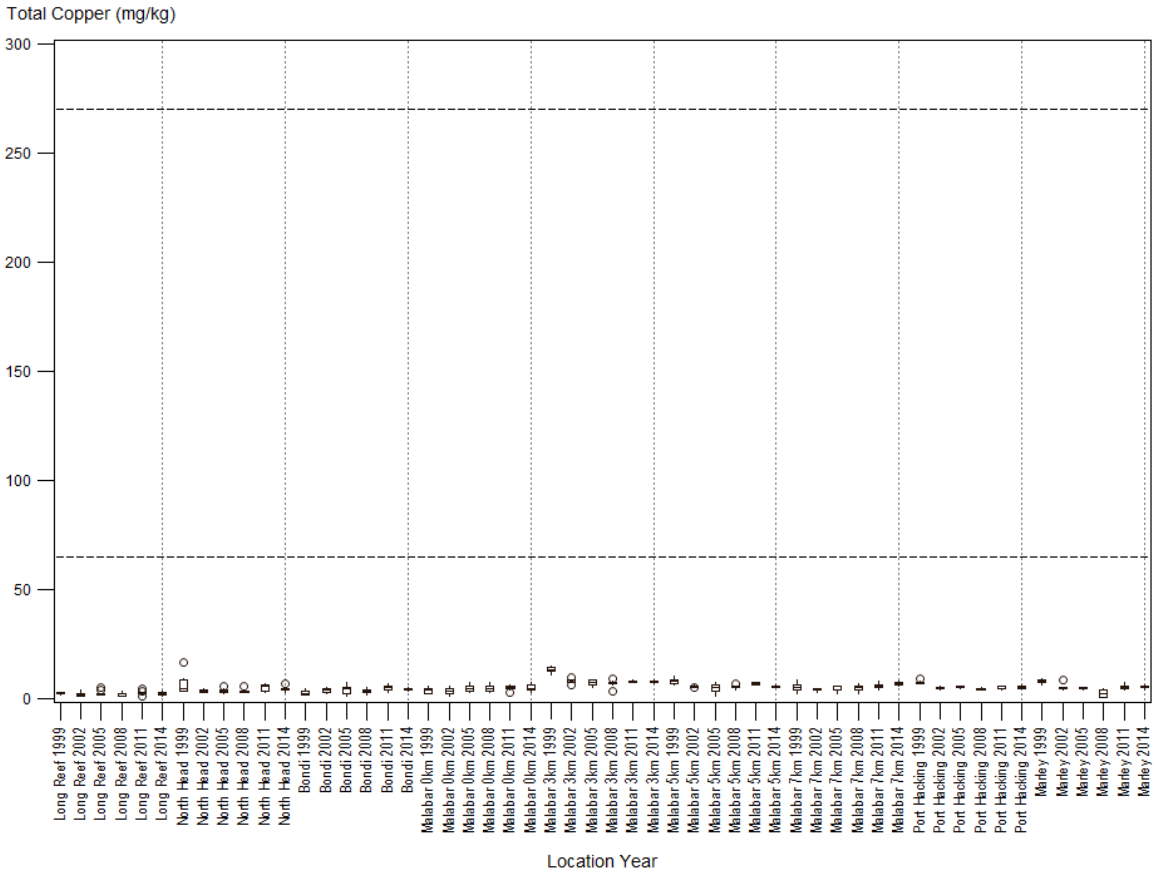


Figure 7-1 Copper concentrations in sediments at each location by interpretive year

These sediment quality guideline trigger levels are a prompt for further investigations to determine whether there is indeed an environmental risk associated with an exceedance. Under this monitoring program the sediment chemistry monitoring was undertaken as a further investigation of the water chemistry toxicity monitoring. Investigation of benthic community patterns was also undertaken as a further investigation of the sediment chemistry.

Other metal concentration comparisons with ANZECC (2000) sediment quality guideline trigger levels indicated chromium, lead, nickel, silver and zinc were below the respective lower trigger values at all nine locations. Exceedances were observed for arsenic and mercury at some locations.

The trend observed since 1999 for the metalloid arsenic at the North Head deepwater ocean outfall location was recorded again in 2014 with a number of measurements between the lower and upper ANZECC (2000) high and low trigger levels.

In 2014 two out of ten samples collected from the control location at Long Reef recorded mercury values between the lower and upper ANZECC (2000) sediment quality guideline levels. Another sample from the positive control location at Malabar 3 km also fell within this range. While at the North Head deepwater outfall location, one sample had a value that exceeded the upper guideline value. Mercury concentrations in the remaining 86 samples collected in 2014 were below the lower ANZECC (2000) guideline value including other samples collected at the three locations outlined above.

These odd collections of mercury at levels above guideline values at all three types of locations (control - Long Reef, positive control - Malabar 3 km and outfall – North Head) suggest sources other than the outfalls were responsible for the patchy hotspot presence in offshore sediments. The source of mercury at North Head could be from Sydney Harbour as it was noted as being a major source of contaminants in sediments including mercury prior to activation of the deepwater outfalls. In the shallower near coast zone suspension and resuspension of sediment is more active than in deeper waters further offshore. In 60 m to 80 m deep water, some 2-4 km offshore, some settling of sediment does occur. The diffuser arrays lie in this zone. The sample collection for the Ocean Sediment Program is focused in this zone, and may be detecting other sources of contamination.

Common pesticides have been suggested by ANZECC (2000) as one of the common sources of toxicity in sediment chemistry. Studies undertaken before activation of the deepwater ocean outfalls in the early 1990’s recorded the presence of some common pesticides in sediments near the former shoreline outfalls of North Head and Malabar together with their presence in offshore samples that had the apparent sources of the Sydney Harbour and Botany Bay. In the 100 sediment samples collected from North Head and Malabar deepwater outfalls since 2002, only laboratory detection level values have been returned for organochlorine pesticides. As such organochlorine pesticides are an unlikely source of disturbance to benthic invertebrate communities near the deepwater ocean outfalls.

Organic chemical concentrations when normalised to 1% total organic carbon content reflected organic chemical concentrations were below the respective lower sediment quality guideline trigger levels at Malabar 0 km location for virtually all samples collected between 1999 and 2014. While organic chemical concentrations when normalised to 1% total organic carbon for the North Head location were generally between the respective lower and upper sediment quality guideline trigger levels for the 1999 to 2014 interpretive years. Notably levels recorded in 2014 were within the ranges seen in the past interpretive years.

Thus comparison of sediment chemical concentrations across the interpretive years suggests no apparent build-up of chemicals in the benthic sediments over the last decade of monitoring.

7.4 Spatial and temporal assessment of all locations from both depths

A list of organisms that are considered to be indicators of pollution was summarised from literature by Pearson and Rosenberg (1978) and it included a number of species from polychaete families (EPA 1996b) that favour high organic situations (Dean, 2008). Multivariate SIMPER results revealed nine of these 11 taxa (Capitellidae, Spionidae, Orbiniidae, Cirratulidae, Nephtyidae, Dorvilleidae, Goniadidae, Lumbrineridae and Phyllodocidae). These taxa were recorded across all three types of locations of impact (outfall), positive control (gradient) and control (healthy reference) over the five survey years (2002 to 2014). Of these nine indicator taxa, three were recorded at each of the nine locations in each of the five assessment years. Notably none of these indicator taxa occurred solely at impact locations. These distributions could reflect the background conditions off Sydney’s coast that have been influenced by anthropogenic discharges through the estuaries.

The polychaete Maldanidae was dominant at the Malabar 0 km location and was one of the dominant taxa at other southern 80 m locations, and present at the northern 60 m locations across the 2002 to 2014 interpretive years. This taxon is described as an indicator of low organic input conditions (Dean, 2008).

Multivariate analysis of 2002 to 2014 benthic community data were unable to determine any consistent spatial patterns in benthic invertebrate communities that could be attributed to the expected presence of a disturbance in the benthic communities from wastewater discharges from the North Head, Bondi and Malabar deepwater ocean outfalls. Rather two gradients were apparent, a north to south spatial gradient and a temporal gradient. The temporal gradient reflected change occurred in benthic community structure between assessment years at both outfall and control locations.

When additional gradient study locations were combined with control and outfall locations these two gradient patterns were enhanced. Thus these analyses did not indicate a pattern that represented a measurable change in the benthic community structure from wastewater discharge.

Multi assessment-year (2002, 2005, 2008, 2011 and 2014) analysis of control (reference) locations also revealed statistically different community structure occurred between years at both 60 m and 80 m depths. At the 80 m depth where there were two control locations, statistically different community structure was also demonstrated between these locations. These results also indicated that there was sufficient statistical power to detect difference between locations.

In an effort to minimise the obvious natural influence of community structure change over time, 2014 year data were explored and the findings are summarised below.

7.5 Spatial assessment of northern 60 m depth locations of Long Reef, North Head and Bondi

It has been widely reported that metal contamination in sediments will be predominantly associated with the amount of fine sediment (mud). To control for varying levels of mud in sediment samples the ANCOVA statistical technique adjusted (controlled) for this component of variation between samples. Notably mercury was not significantly different between these three (North Head, Bondi and Long Reef) locations. This suggests the odd observations of mercury recorded in 2014 were likely to be from sources other than the outfalls as outlined above. ANCOVA determined that significant differences existed between locations for 11 of the 12 chemicals tested from the 60 m depth. Of these 11 chemicals three metals silver, zinc and copper had a result consistent with contamination that might be due to the deepwater ocean outfalls (North Head = Bondi ≠ Long Reef).

While in 2014 all metal chemicals could be analysed with ANCOVA, this was not the case in past assessment years, as a number of metals failed the assumptions of ANCOVA. This would appear to represent another temporal change.

Univariate analyses were conducted on the number of taxa in higher taxonomic groups and their corresponding recorded abundances in each assessment year from 1999 to 2014. Results of these analyses did not display a consistent spatial pattern in benthic invertebrate communities that could be attributed to wastewater discharge from either North Head or Bondi deepwater ocean outfall diffuser arrays.

Out of the six higher taxonomic groups tested with univariate analysis, only the ‘number of polychaetes’ showed consistency through time. As recorded in 2002, 2005, 2008, 2011 and 2014 years, the number of polychaetes was significantly greater at Bondi compared to North Head and Long Reef locations. A high number of polychaetes could be expected if wastewater discharge was having a measureable impact. However, this invertebrate indicator trend was in contrast to the chemicals results that showed North Head location to have the higher levels of the most contaminants measured.

Outcomes of multivariate analysis techniques were also unable to identify patterns in the 2014 data that could be attributable to the presence of wastewater discharge. Rather this testing indicated benthic community structures were distinct at each location. This was also a feature of the overall 2002 to 2014 analysis outlined above.

Given the above results, it raises the question as to whether the contaminants being measured are the environmental factors that contribute most to benthic community structure, or whether other factors are contributing to the benthic community patterns being observed. The Malabar gradient study summarised below provided a look at measurements of benthic invertebrate communities and chemical concentrations.

7.6 Spatial assessment of southern 80 m depth locations of Malabar, Port Hacking and Marley Beach

ANCOVA testing indicated significant differences were returned for ten other chemicals, only copper had a result consistent with contamination that might be due to the outfall (Malabar 0 km ≠ Port Hacking = Marley Beach).

As indicated under univariate analysis of 60 m depth locations, a similar outcome presented from univariate analyses of 80 m depth locations in each assessment year from 1999 to 2014. Results of those analyses were unable to determine any consistent spatial pattern in benthic invertebrate communities that could be attributed to disturbance from chemical accumulation in the sediments near the Malabar deepwater ocean outfall.

The 2014 benthic invertebrate multivariate analysis pattern was in contrast to 2011 pattern. The 2011 pattern suggested benthic community structure may have been influenced by the Georges River estuary (Sydney Water 2011). Thus the pictorial benthic community pattern in 2014 for 80 m depth locations appears to be an artefact of temporal change in community structure over time at a number of locations. Change in community structure over time was demonstrated in the combined analysis of all nine locations for the five assessment years. While pictorially it had an apparent pattern that could be consistent with a measurable impact for wastewater discharge PERMANOVA model test results did not clearly confirm this impact. Rather differences were also indicated between all three locations under PERMANOVA testing, which questioned the pictorial results. Further exploration of this pattern was undertaken in the gradient study.

7.7 Gradient study of the Malabar deepwater ocean outfall

Measurable impacts were found within 400 m of the diffuser arrays for similar deepwater ocean outfalls with diffuser arrays that discharge into a similar environment occur off Victoria, British Columbia in Canada (Talyor et al, 1998). Measurable impacts were not found in the measured range of 800 m to 3 km of these outfalls which suggests diminished contamination with distance from these outfalls.

Assessment of oceanographic data under the sediment model suggested negatively buoyant particles discharged from the deepwater ocean outfalls generally reach the seabed both north and south of the outfall (depending on current direction). As noted above the area over which these particles settle is generally within 5 to 10 km of the Sydney deepwater ocean outfalls.

ANCOVA was also used to look at the gradient from Malabar 0 km to 7 km locations for diminished contamination with distance. That is Malabar 0 km ≠ Malabar 3 km ≠ Malabar 5 km ≠ Malabar 7 km. While significant differences were returned for ten of the 12 chemicals, no spatial pattern as described above was observed. Instead the Malabar 3 km location was identified as having higher metal concentrations for a number of the metals measured. Although for eight of nine metals with ANZECC (2000) sediment quality guideline trigger values these were below this level. There was also no general decrease from the 3 km location to the 5 km and 7 km location. Rather ANCOVA indicated the Malabar 0 km location was equal to the 5 km and 7 km locations.

Recorded results south from the Malabar 3 km location may have been influence by the combination of the constraint of rocky reeks to the north of Malabar and sediment input from the Georges River estuary.

Multivariate taxonomic turnover analysis techniques were used to model the gradient study locations (Malabar 0 km, 3 km, 5 km and 7 km) against recorded chemistry results from those locations. The 2014 model run did not identify patterns in the benthic invertebrate communities that were attributable a diminishing gradient south of the Malabar outfall. Another run of the model with additional assessment year data (2002, 2005, 2008, 2011 and 2014) was made. Evident in the corresponding dbRDA plot was change in community structure through time at each location including southern control locations that were at and beyond the particle settling zone.

Univariate analysis of each assessment year from 1999 to 2014 also did not determine any consistent spatial patterns in benthic invertebrate communities that could be attributed to the presence of a diminishing gradient south of the Malabar outfall.

8 Conclusion

The case study titled 'Assessing long term oceanographic fluctuations using deep water ocean outfall plume models' (presented in Volume 2) concluded the plumes from the deepwater ocean outfalls continue to operate better than anticipated in terms of dilutions achieved and frequency of surfacing plumes when compared to the original design criteria. Those study results suggest that effective dilution of wastewater into oceanic waters is occurring. This initial dilution is then assisted by natural oceanic processes that sort and transport sediment on the ocean floor. Monitoring in the 2-4 km offshore zone under the ocean sediment program provides a check of this modelling over the longer term.

In the early stages of monitoring, it was acknowledged that biological communities are naturally variable and a long-term data set would be required to identify impacts. As the outfalls are in continuous operation, and if a water quality disturbance has occurred, an impact in the benthic community may be detected. Such an impact should result in a temporally consistent pattern in the benthic community. This pattern should become clearer, more so than random background fluctuation, with each consecutive measurement.

Out of the early studies of the deepwater ocean outfalls, Philips and Pritchard (1996) suggested that: '..further monitoring is required, particularly to address concerns about long term accumulations of sewage particulates and associated contaminants in offshore sediments and the effect that this may have on biological communities.' Thus if an accumulation of fine sediments was observed, an ecological impact may become measurable.

A multitude of sophisticated statistical techniques have been employed to look at assessment year data from 2002 to 2014. None have identified a measurable difference in either chemical or morphologically based benthic community data that is clearly attributable to wastewater discharge through the deepwater ocean outfalls. These techniques have consistently identified significant differences through space and time at the location and site spatial levels, but all appear to be associated with other sources of variation not attributable to wastewater discharge.

Under a 'weight of evidence' approach, an argument can be proposed that:

- the apparent lack of build-up of total organic carbon in the sediment over the monitoring period suggests contributions from wastewater discharge have not been a major source of organic enrichment around the outfalls
- there was also an apparent lack of build-up of fine sediment (particles <0.063 mm) around the outfalls. This suggested disturbance from additional metal build-up in the ocean sediments was unlikely to have occurred
- the oceanographic modelling also continues to imply the effective operation of the diffuser arrays above design criteria. Modelling indicates dispersion of negatively buoyant particles present in the wastewater generally intersect with the sea floor within 5 km from each outfall, although in some years this zone has been as large as 10 km
- under a separate program, visual inspection via a remotely controlled submersible vessel has confirmed the outfall diffuser arrays are working
- significant differences are routinely detected between control (reference) locations indicating that the analyses have sufficient statistical power to find differences

- build-up of chemical concentrations around the outfalls does not appear to have occurred over the last 15 years (1999 to 2014), and former historical contamination probably explains the odd higher concentrations detected
- wastewater toxicity limits of respective environment protection licences have been met for all three deepwater ocean outfall plants since introduction in 2004
- no measureable impact in benthic communities was identified under spatial studies of outfall and control locations based on assessment year data from 2002, 2005, 2008, 2011 and 2014 years. That is, a temporally consistent impact was not detected as would be expected from continuous operation of the outfalls.
- no measureable impact in benthic communities was determined from taxonomic turnover studies of the Malabar gradient locations for 2014 data and from the broader period of assessment years of 2002, 2005, 2008, 2011 and 2014. That is an expected gradual change in benthic community structure with distance was not detected
- also not detected solely at impact locations were any of the nine taxa cited by Environment Protection Authority in 1996 as indictors of pollution
- the above results support the Environment Protection Authority results from an extensive, five-year environmental monitoring program (EMP) that looked at the environmental performance of the deepwater ocean outfalls during the first two years of their operation. Results from the EMP found that 'the deepwater outfalls performed well during the first two years of their operation: they mitigated most of the environmental problems previously experienced when shoreline outfalls were operating without creating any major new problems in the ocean waters in the short term' (Philip and Pritchard, 1996)

In conclusion, after more than a decade and a half of study, no significant increase in sediment chemical contamination has been detected. There has also been no permanent measurable change in morphologically based benthic community structure adjacent to Sydney's deepwater ocean outfalls or at distance from the Malabar deepwater ocean outfall. This suggests that the deepwater outfalls and their diffuser arrays are achieving their intended purpose to disperse and mix wastewater to concentrations that are non-toxic to the benthic communities of the ocean off Sydney.

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10 Appendices

10.1 Appendix A Coordinates for grid centre locations

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number - x co-ord (0-5)	Random number - y co-ord (0-5)	Grid Easting	Grid Northing
Long Reef 1								
Site 1C	349791.41	6266903.05	349666.41	6266778.05	2	5	349766.41	6267028.05
Site 2C	349791.41	6266903.05	349666.41	6266778.05	0	0	349666.41	6266778.05
Site 3C	349791.41	6266903.05	349666.41	6266778.05	1	2	349716.41	6266878.05
Site 4C	349791.41	6266903.05	349666.41	6266778.05	3	5	349816.41	6267028.05
Site 5C	349791.41	6266903.05	349666.41	6266778.05	4	2	349866.41	6266878.05
Long Reef 2								
Site 1C	349315.23	6264892.5	349190.23	6264767.5	4	2	349390.23	6264867.5
Site 2C	349315.23	6264892.5	349190.23	6264767.5	3	2	349340.23	6264867.5
Site 3C	349315.23	6264892.5	349190.23	6264767.5	2	5	349290.23	6265017.5
Site 4C	349315.23	6264892.5	349190.23	6264767.5	2	5	349290.23	6265017.5
Site 5C	349315.23	6264892.5	349190.23	6264767.5	1	2	349240.23	6264867.5
North Head 1								
Site 1C	347436.95	6257934.94	347311.95	6257809.94	0	5	347311.95	6258059.94
Site 2C	347436.95	6257934.94	347311.95	6257809.94	1	2	347361.95	6257909.94
Site 3C	347436.95	6257934.94	347311.95	6257809.94	5	0	347561.95	6257809.94
Site 4C	347436.95	6257934.94	347311.95	6257809.94	4	2	347511.95	6257909.94
Site 5C	347436.95	6257934.94	347311.95	6257809.94	4	0	347511.95	6257809.94
North Head 2								
Site 1C	347463.41	6256056.66	347338.41	6255931.66	4	5	347538.41	6256181.66
Site 2C	347463.41	6256056.66	347338.41	6255931.66	3	4	347488.41	6256131.66

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number - x co-ord (0-5)	Random number - y co-ord (0-5)	Grid Easting	Grid Northing
Site 3C	347463.41	6256056.66	347338.41	6255931.66	4	3	347538.41	6256081.66
Site 4C	347463.41	6256056.66	347338.41	6255931.66	2	0	347438.41	6255931.66
Site 5C	347463.41	6256056.66	347338.41	6255931.66	1	1	347388.41	6255981.66
Bondi 1								
Site 1C	343415.85	6248226.1	343290.85	6248101.1	3	0	343440.85	6248101.1
Site 2C	343415.85	6248226.1	343290.85	6248101.1	5	2	343540.85	6248201.1
Site 3C	343415.85	6248226.1	343290.85	6248101.1	1	2	343340.85	6248201.1
Site 4C	343415.85	6248226.1	343290.85	6248101.1	3	2	343440.85	6248201.1
Site 5C	343415.85	6248226.1	343290.85	6248101.1	4	1	343490.85	6248151.1
Bondi 2								
Site 1C	344024.31	6250792.2	343899.31	6250667.2	2	2	343999.31	6250767.2
Site 2C	344024.31	6250792.2	343899.31	6250667.2	3	0	344049.31	6250667.2
Site 3C	344024.31	6250792.2	343899.31	6250667.2	5	3	344149.31	6250817.2
Site 4C	344024.31	6250792.2	343899.31	6250667.2	5	4	344149.31	6250867.2
Site 5C	344024.31	6250792.2	343899.31	6250667.2	0	1	343899.31	6250717.2
Malabar (0 km) 1								
Site 1C	342807.4	6238966.99	342682.4	6238841.99	3	3	342832.4	6238991.99
Site 2C	342807.4	6238966.99	342682.4	6238841.99	5	3	342932.4	6238991.99
Site 3C	342807.4	6238966.99	342682.4	6238841.99	2	0	342782.4	6238841.99
Site 4C	342807.4	6238966.99	342682.4	6238841.99	1	0	342732.4	6238841.99
Site 5C	342807.4	6238966.99	342682.4	6238841.99	0	1	342682.4	6238891.99
Site 1A	342807.4	6238966.99	342682.4	6238841.99	1	4	342732.4	6239041.99
Site 2A	342807.4	6238966.99	342682.4	6238841.99	0	4	342682.4	6239041.99
Site 3A	342807.4	6238966.99	342682.4	6238841.99	2	2	342782.4	6238941.99
Site 4A	342807.4	6238966.99	342682.4	6238841.99	5	3	342932.4	6238991.99

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number - x co-ord (0-5)	Random number - y co-ord (0-5)	Grid Easting	Grid Northing
Site 5A	342807.4	6238966.99	342682.4	6238841.99	2	0	342782.4	6238841.99
Malabar (0 km) 2								
Site 1C	343468.76	6239125.72	343343.76	6239000.72	0	1	343343.76	6239050.72
Site 2C	343468.76	6239125.72	343343.76	6239000.72	1	2	343393.76	6239100.72
Site 3C	343468.76	6239125.72	343343.76	6239000.72	2	3	343443.76	6239150.72
Site 4C	343468.76	6239125.72	343343.76	6239000.72	3	0	343493.76	6239000.72
Site 5C	343468.76	6239125.72	343343.76	6239000.72	0	1	343343.76	6239050.72
Site 1A	343468.76	6239125.72	343343.76	6239000.72	1	2	343393.76	6239100.72
Site 2A	343468.76	6239125.72	343343.76	6239000.72	4	3	343543.76	6239150.72
Site 3A	343468.76	6239125.72	343343.76	6239000.72	1	5	343393.76	6239250.72
Site 4A	343468.76	6239125.72	343343.76	6239000.72	2	0	343443.76	6239000.72
Site 5A	343468.76	6239125.72	343343.76	6239000.72	3	1	343493.76	6239050.72
Malabar (3 km) 1								
Site 1C	341378.85	6236506.71	341253.85	6236381.71	1	3	341303.85	6236531.71
Site 2C	341378.85	6236506.71	341253.85	6236381.71	2	5	341353.85	6236631.71
Site 3C	341378.85	6236506.71	341253.85	6236381.71	3	4	341403.85	6236581.71
Site 4C	341378.85	6236506.71	341253.85	6236381.71	5	0	341503.85	6236381.71
Site 5C	341378.85	6236506.71	341253.85	6236381.71	4	2	341453.85	6236481.71
Malabar (3 km) 2								
Site 1C	341590.48	6236612.53	341465.48	6236487.53	5	3	341715.48	6236637.53
Site 2C	341590.48	6236612.53	341465.48	6236487.53	4	5	341665.48	6236737.53
Site 3C	341590.48	6236612.53	341465.48	6236487.53	6	0	341765.48	6236487.53
Site 4C	341590.48	6236612.53	341465.48	6236487.53	2	2	341565.48	6236587.53
Site 5C	341590.48	6236612.53	341465.48	6236487.53	0	2	341465.48	6236587.53
Malabar (5 km) 1								

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number - x co-ord (0-5)	Random number - y co-ord (0-5)	Grid Easting	Grid Northing
Site 1C	340638.12	6234628.44	340513.12	6234503.44	0	4	340513.12	6234703.44
Site 2C	340638.12	6234628.44	340513.12	6234503.44	2	2	340613.12	6234603.44
Site 3C	340638.12	6234628.44	340513.12	6234503.44	5	3	340763.12	6234653.44
Site 4C	340638.12	6234628.44	340513.12	6234503.44	2	0	340613.12	6234503.44
Site 5C	340638.12	6234628.44	340513.12	6234503.44	3	5	340663.12	6234753.44
Malabar (5 km) 2								
Site 1C	340902.67	6234469.71	340777.67	6234344.71	4	3	340977.67	6234494.71
Site 2C	340902.67	6234469.71	340777.67	6234344.71	1	5	340827.67	6234594.71
Site 3C	340902.67	6234469.71	340777.67	6234344.71	2	0	340877.67	6234344.71
Site 4C	340902.67	6234469.71	340777.67	6234344.71	3	1	340927.67	6234394.71
Site 5C	340902.67	6234469.71	340777.67	6234344.71	1	2	340827.67	6234444.71
Malabar (7 km) 1								
Site 1C	339527.03	6233041.16	339402.03	6232916.16	2	5	339502.03	6233166.16
Site 2C	339527.03	6233041.16	339402.03	6232916.16	2	0	339502.03	6232916.16
Site 3C	339527.03	6233041.16	339402.03	6232916.16	0	1	339402.03	6232966.16
Site 4C	339527.03	6233041.16	339402.03	6232916.16	0	5	339402.03	6233166.16
Site 5C	339527.03	6233041.16	339402.03	6232916.16	1	3	339452.03	6233066.16
Malabar (7 km) 2								
Site 1C	339394.75	6232723.7	339269.75	6232598.7	0	1	339269.75	6232648.7
Site 2C	339394.75	6232723.7	339269.75	6232598.7	4	1	339469.75	6232648.7
Site 3C	339394.75	6232723.7	339269.75	6232598.7	5	4	339519.75	6232798.7
Site 4C	339394.75	6232723.7	339269.75	6232598.7	1	5	339319.75	6232848.7
Site 5C	339394.75	6232723.7	339269.75	6232598.7	2	3	339369.75	6232748.7
Port Hacking 1								
Site 1C	336749.29	6228649.7	336624.29	6228524.7	4	2	336824.29	6228624.7

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number - x co-ord (0-5)	Random number - y co-ord (0-5)	Grid Easting	Grid Northing
Site 2C	336749.29	6228649.7	336624.29	6228524.7	5	5	336874.29	6228774.7
Site 3C	336749.29	6228649.7	336624.29	6228524.7	0	1	336624.29	6228574.7
Site 4C	336749.29	6228649.7	336624.29	6228524.7	0	2	336624.29	6228624.7
Site 5C	336749.29	6228649.7	336624.29	6228524.7	2	0	336724.29	6228524.7
Port Hacking 2								
Site 1C	336749.29	6228411.6	336624.29	6228286.6	0	3	336624.29	6228436.6
Site 2C	336749.29	6228411.6	336624.29	6228286.6	1	0	336674.29	6228286.6
Site 3C	336749.29	6228411.6	336624.29	6228286.6	2	2	336724.29	6228386.6
Site 4C	336749.29	6228411.6	336624.29	6228286.6	3	1	336774.29	6228336.6
Site 5C	336749.29	6228411.6	336624.29	6228286.6	1	5	336674.29	6228536.6
Marley 1								
Site 1C	331643.55	6221348.22	331518.55	6221223.22	2	5	331618.55	6221473.22
Site 2C	331643.55	6221348.22	331518.55	6221223.22	3	1	331668.55	6221273.22
Site 3C	331643.55	6221348.22	331518.55	6221223.22	4	1	331718.55	6221273.22
Site 4C	331643.55	6221348.22	331518.55	6221223.22	3	0	331668.55	6221223.22
Site 5C	331643.55	6221348.22	331518.55	6221223.22	3	2	331668.55	6221323.22
Marley 2								
Site 1C	331722.92	6221163.04	331597.92	6221038.04	3	3	331747.92	6221188.04
Site 2C	331722.92	6221163.04	331597.92	6221038.04	5	0	331847.92	6221038.04
Site 3C	331722.92	6221163.04	331597.92	6221038.04	0	2	331597.92	6221138.04
Site 4C	331722.92	6221163.04	331597.92	6221038.04	4	5	331797.92	6221288.04
Site 5C	331722.92	6221163.04	331597.92	6221038.04	3	0	331747.92	6221038.04

10.1 Appendix B Chemistry graphical presentation compared to ANZECC (2000) ISQG

The summary plots for metals and organic chemicals are in the form of a box plot. The bottom and top edges of the box are located at the sample 25th and 75th percentiles. The centre horizontal line is drawn at the 50th percentile (median). Vertical lines, or whiskers, are drawn from the box to the most extreme point within 1.5 interquartile ranges. Values outside this range are marked with a circle. Dotted lines represent ANZECC (2000) high and low ISQG trigger values.

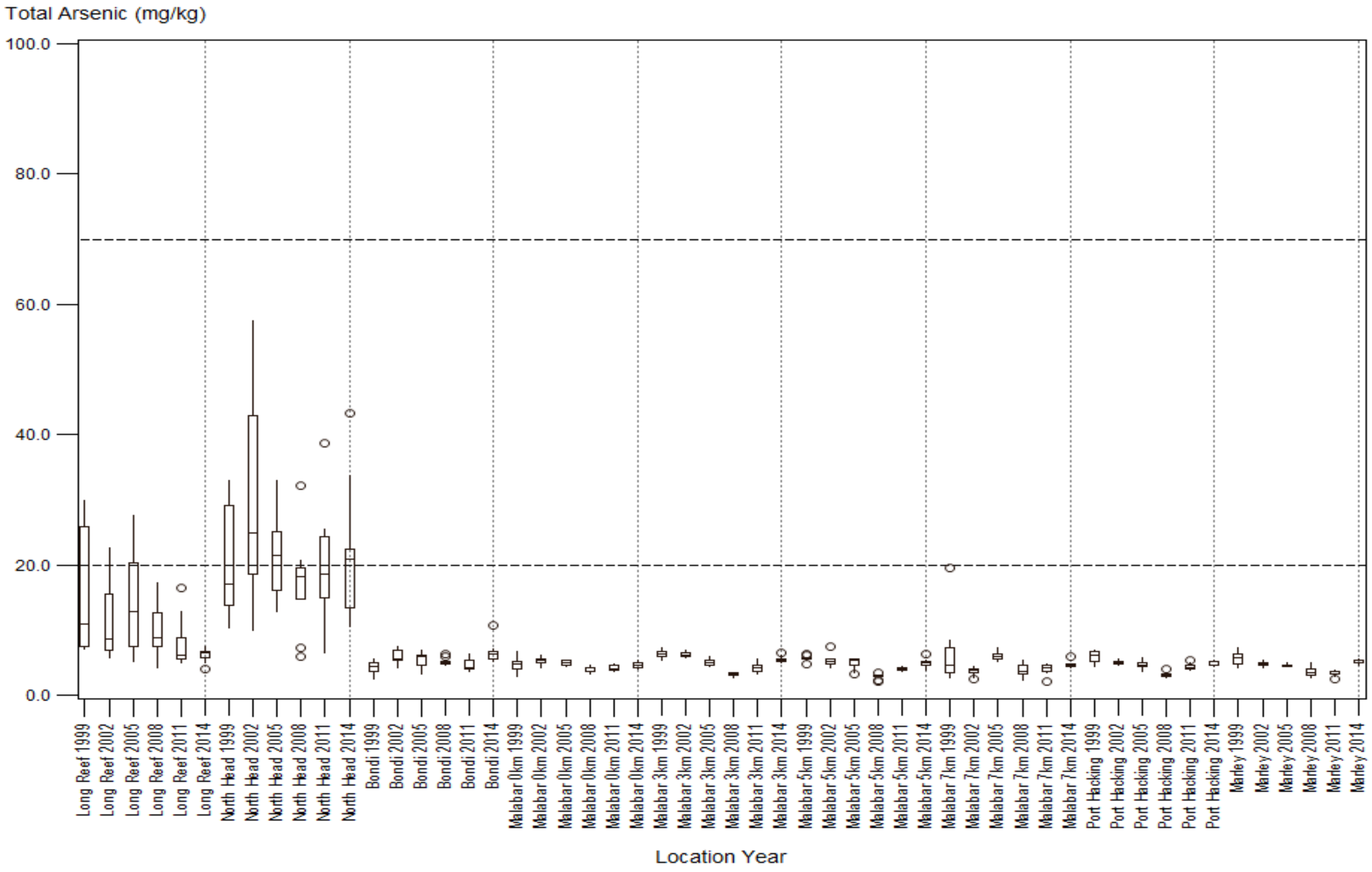

Figure 10-1 Total arsenic concentrations in sediments at each location by year

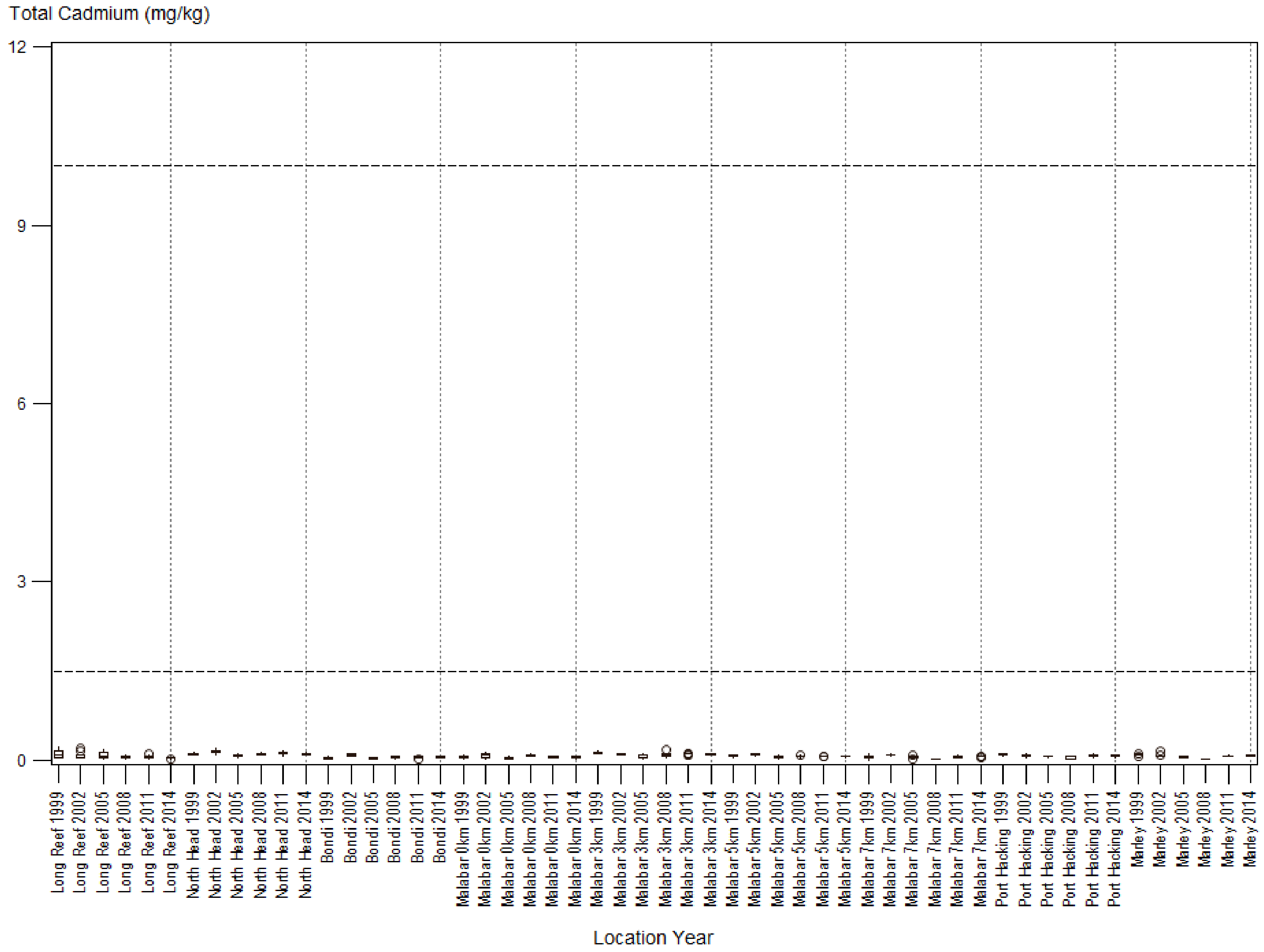

Figure 10-2 Total cadmium concentrations in sediments at each location by year

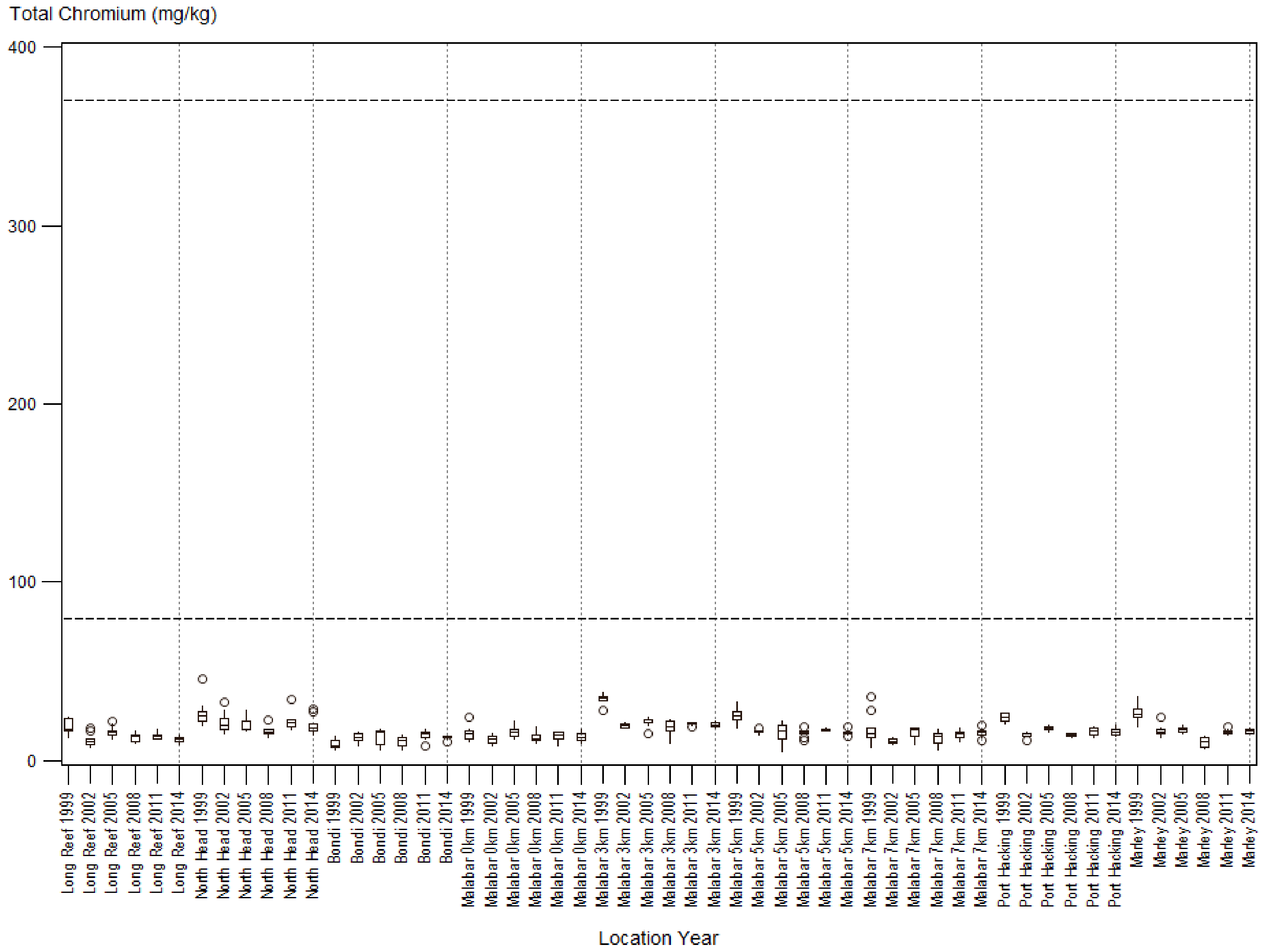

Figure 10-3 Total chromium concentrations in sediments at each location by year

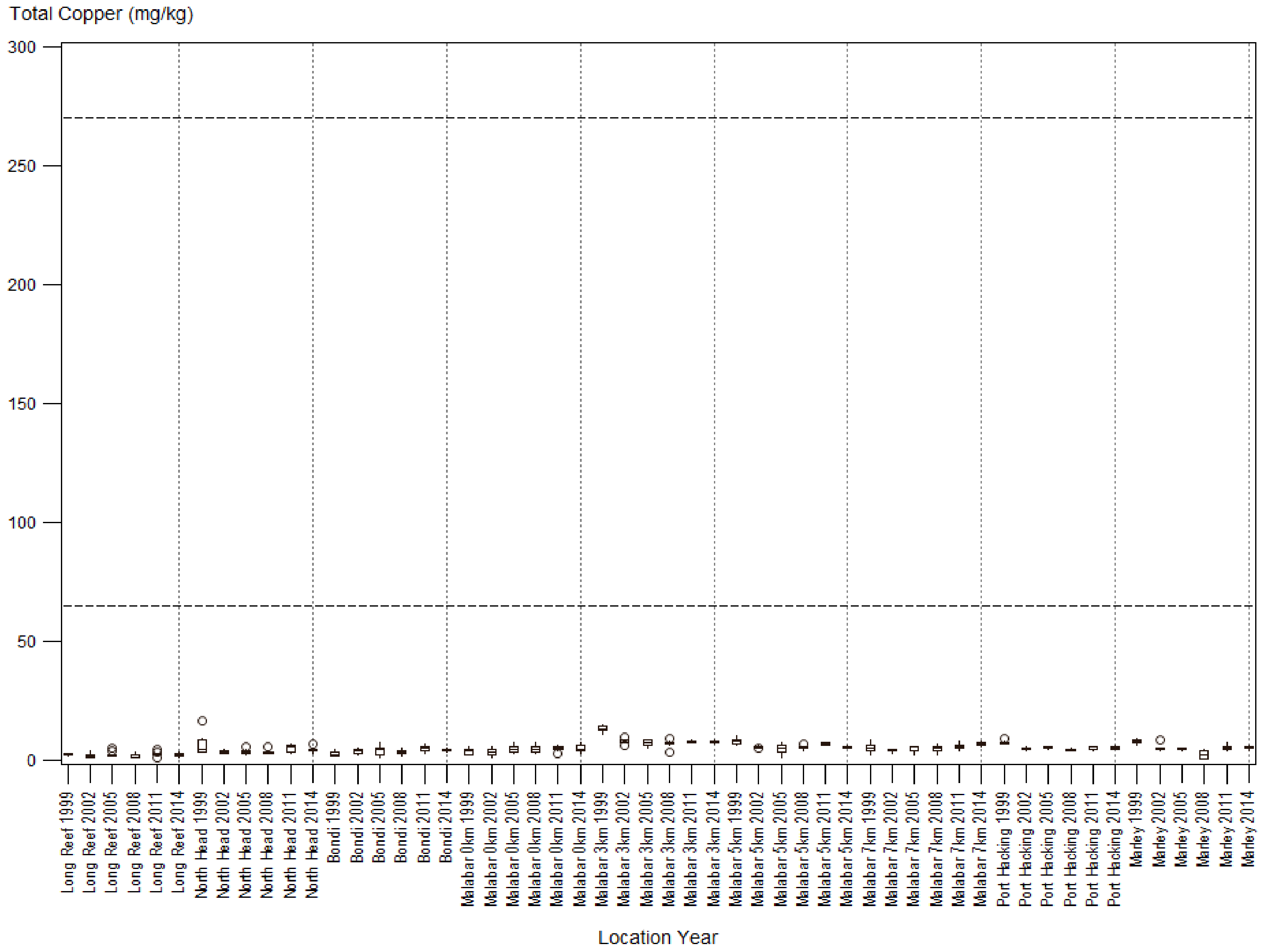

Figure 10-4 Total copper concentrations in sediments at each location by year

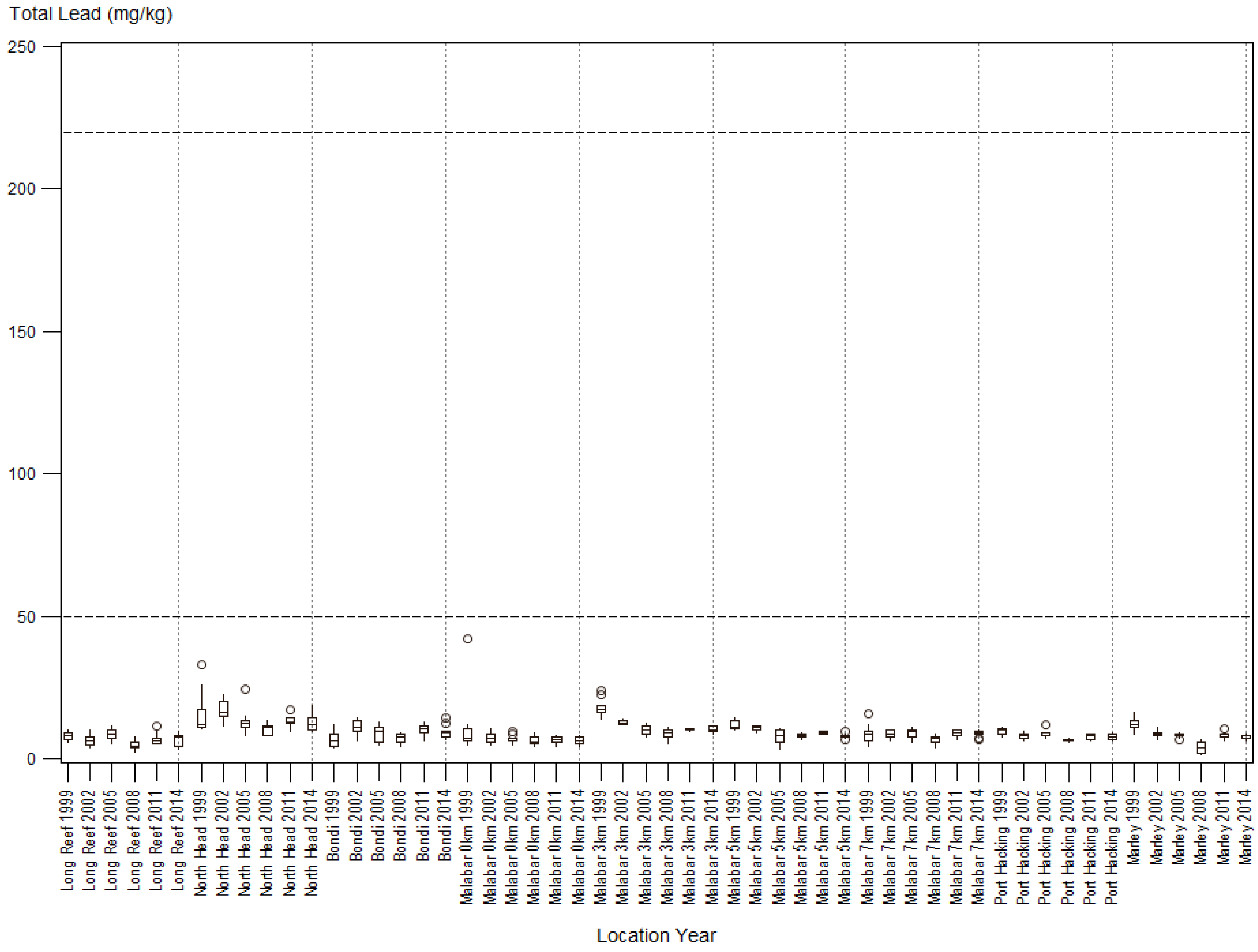

Figure 10-5 Total lead concentrations in sediments at each location by year

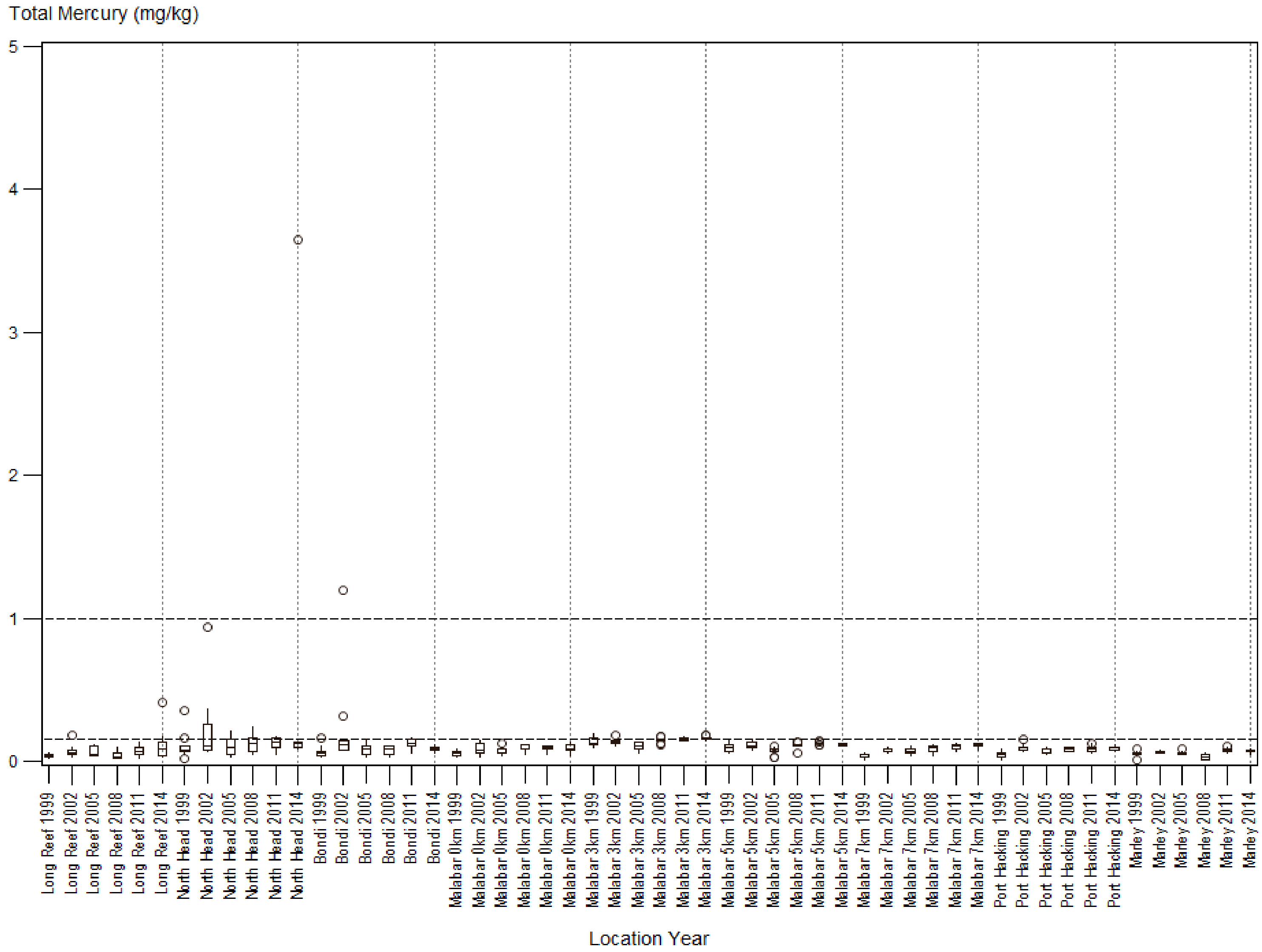

Figure 10-6 Total mercury concentrations in sediments at each location by year

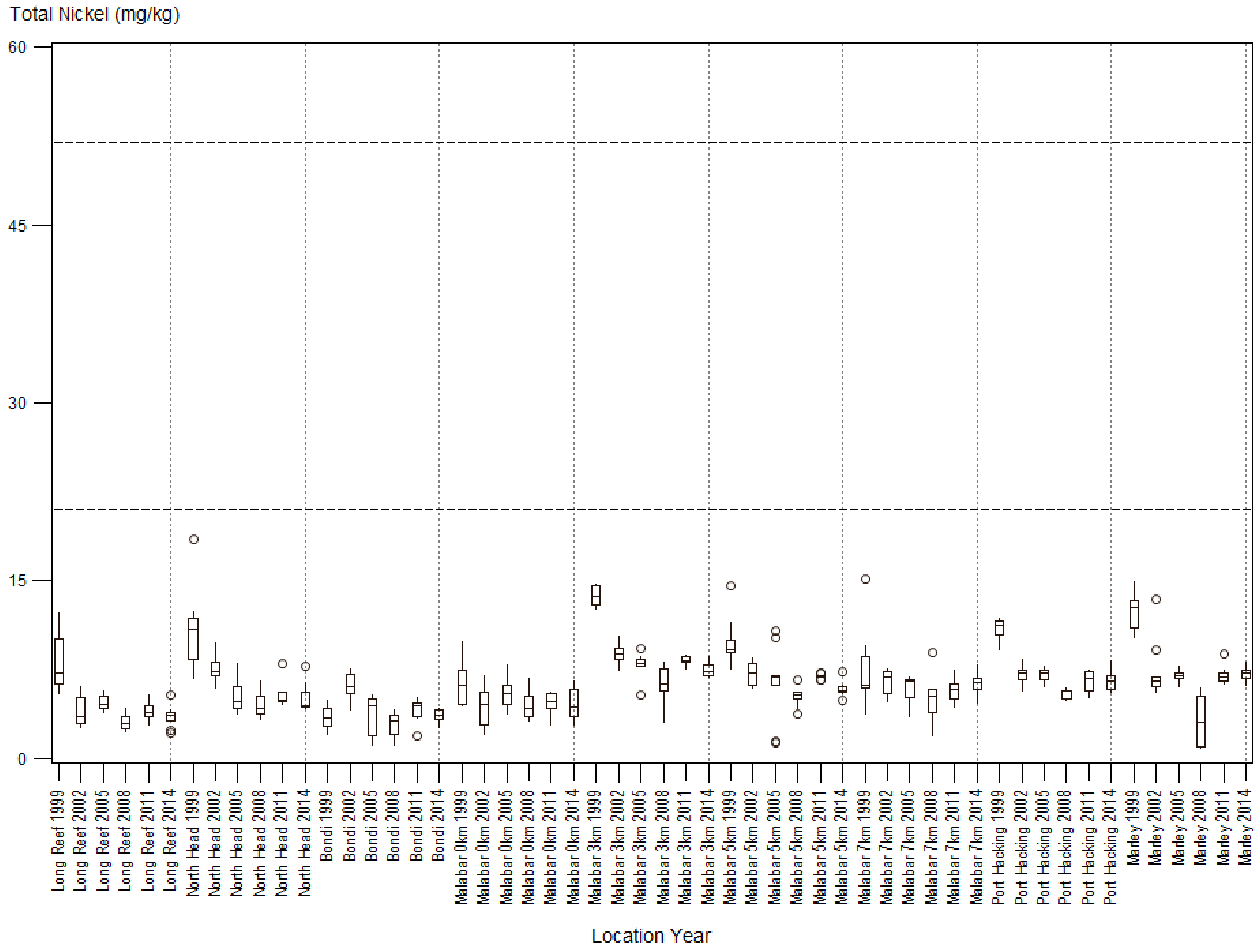

Figure 10-7 Total nickel concentrations in sediments at each location by year

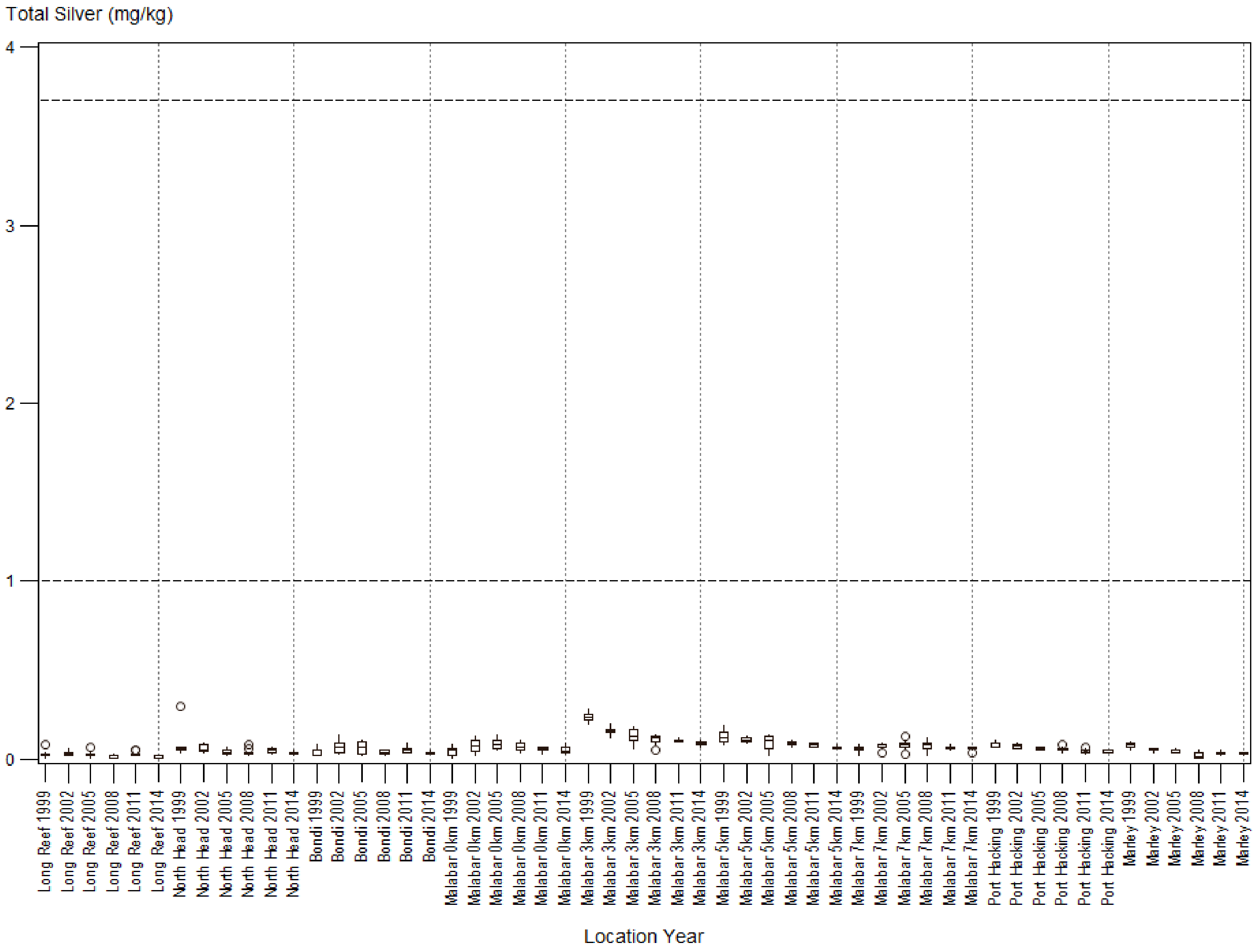

Figure 10-8 Total silver concentrations in sediments at each location by year

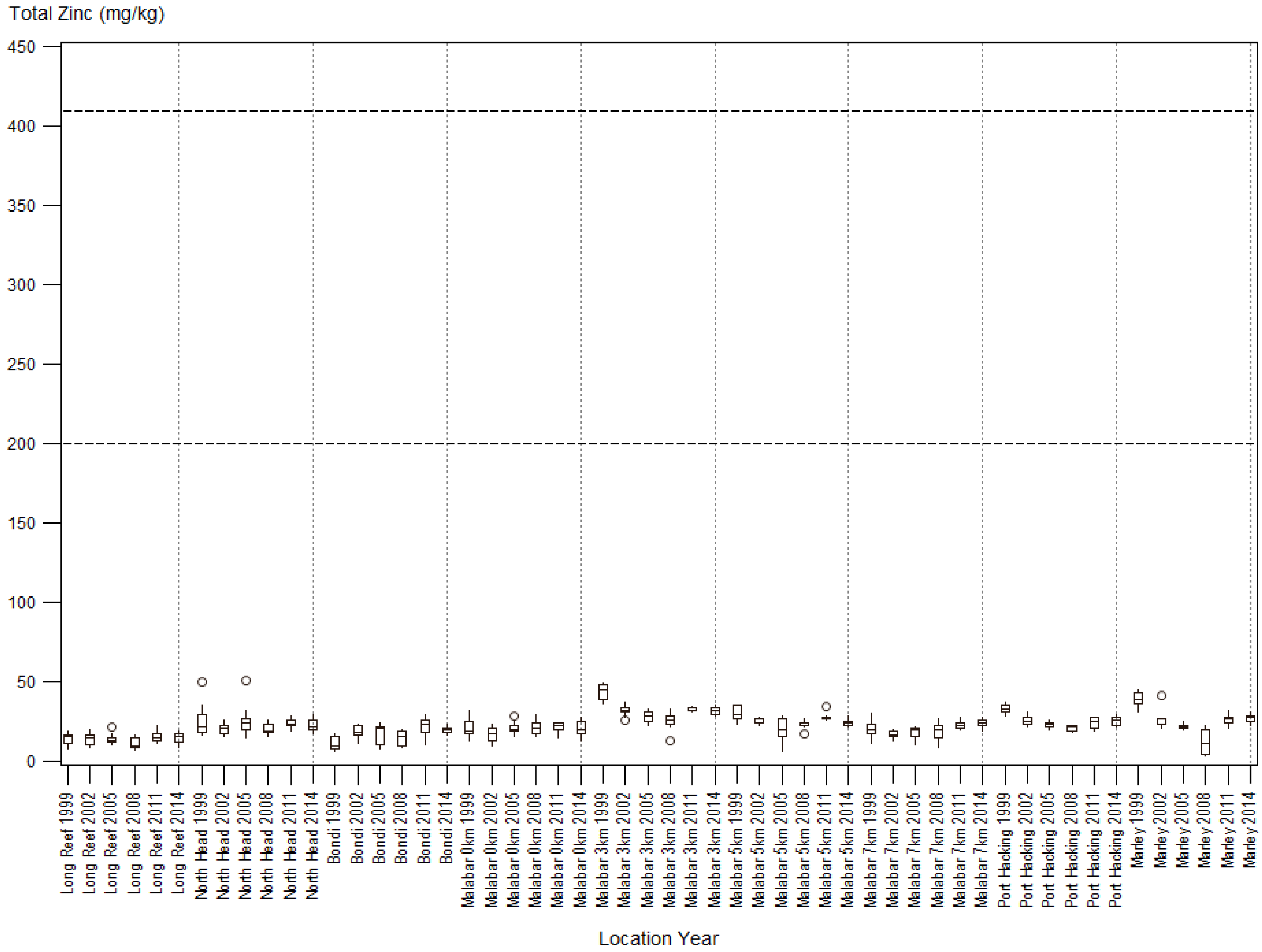

Figure 10-9 Total zinc concentrations in sediments at each location by year

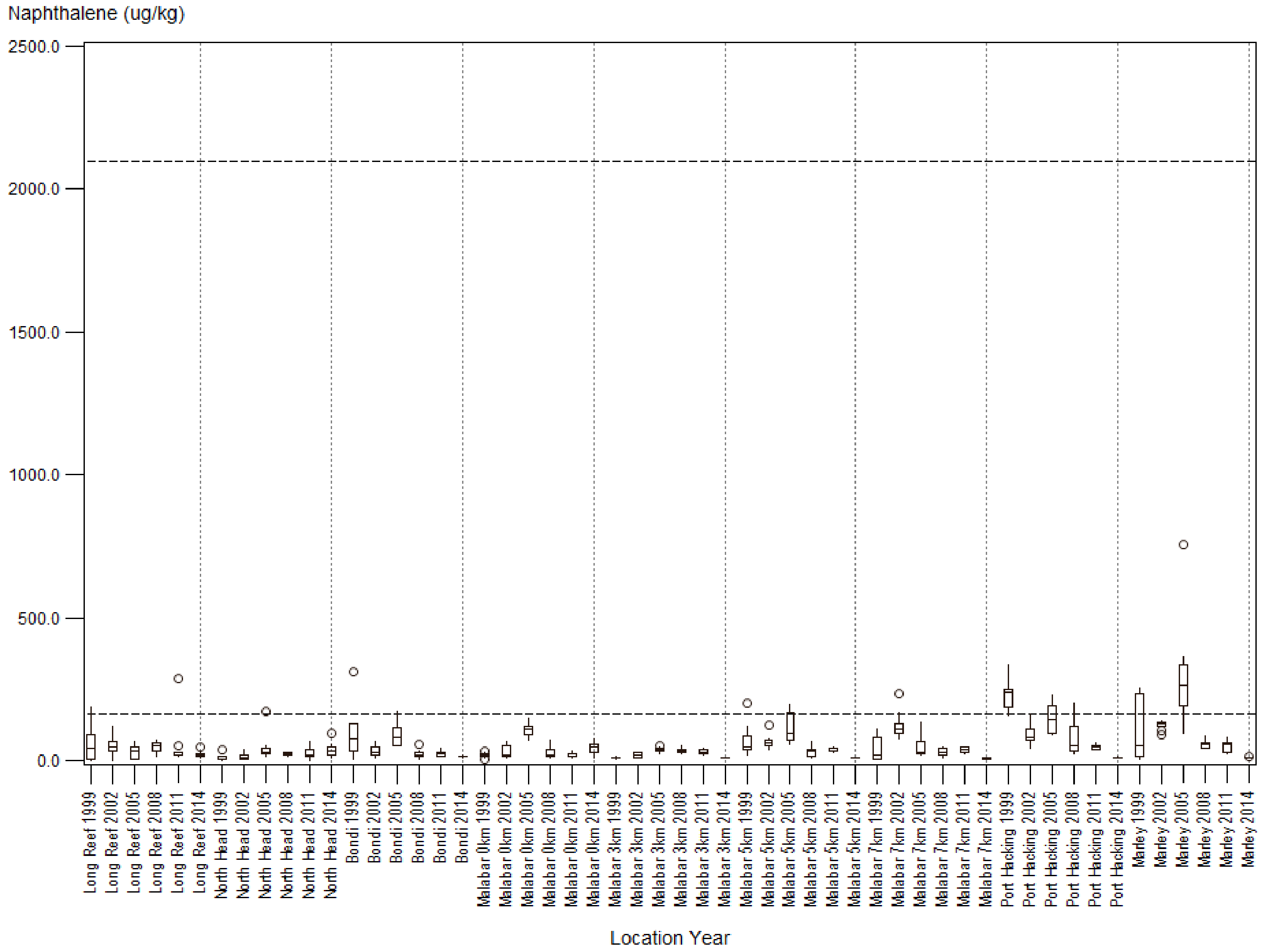

Figure 10-10 Naphthalene concentrations in sediments at each location by year

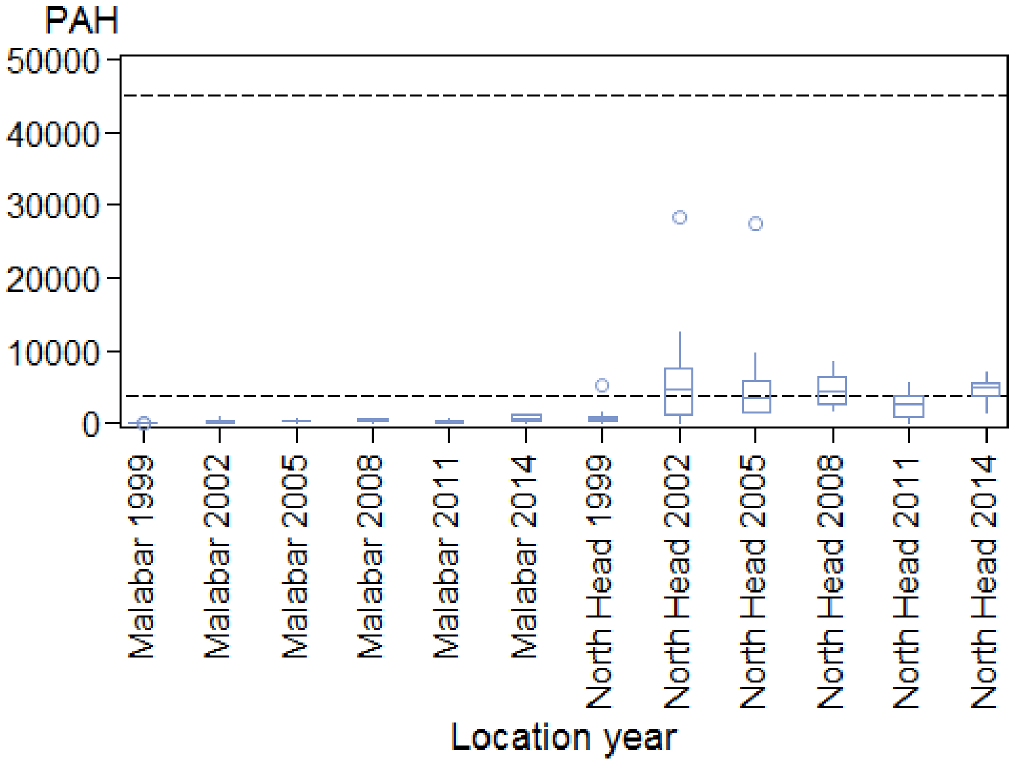

Figure 10-11 PAH concentrations in sediments at each location by year

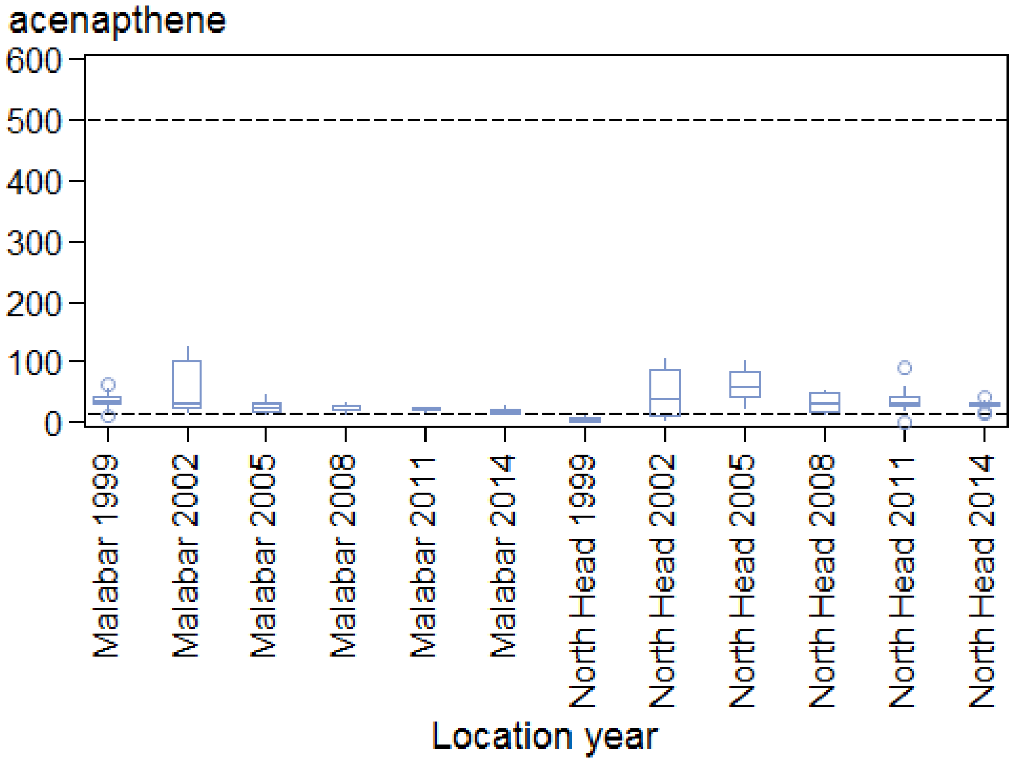

Figure 10-12 Acenapthene concentrations in sediments at each location by year

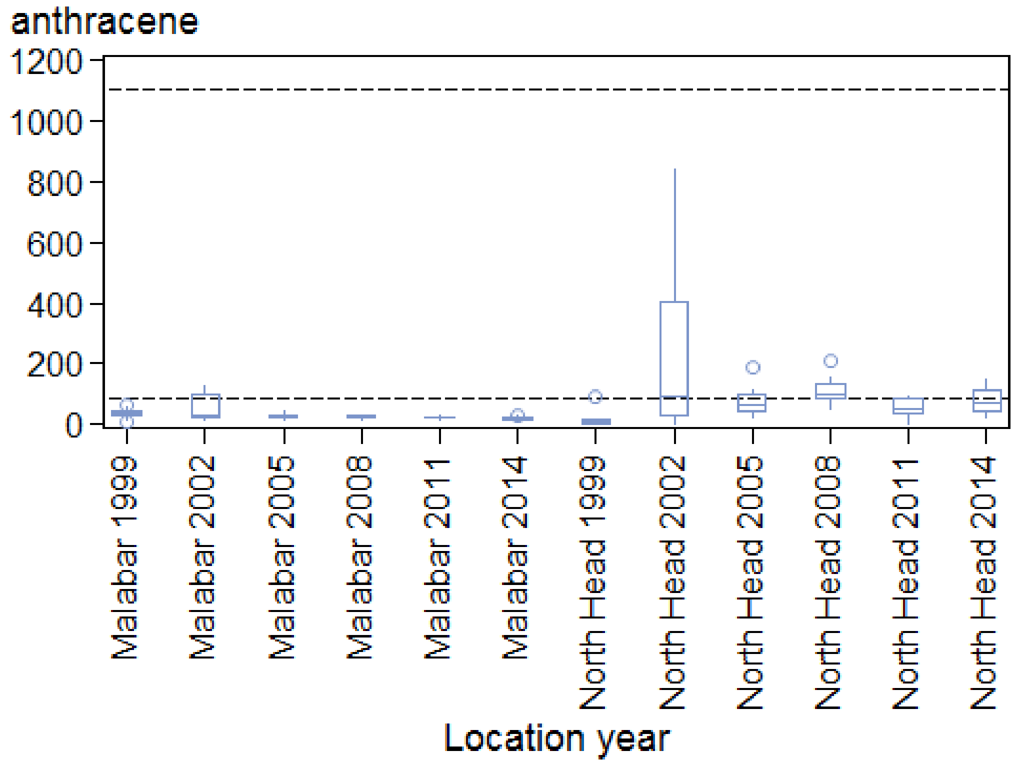

Figure 10-13 Anthracene concentrations in sediments at each location by year

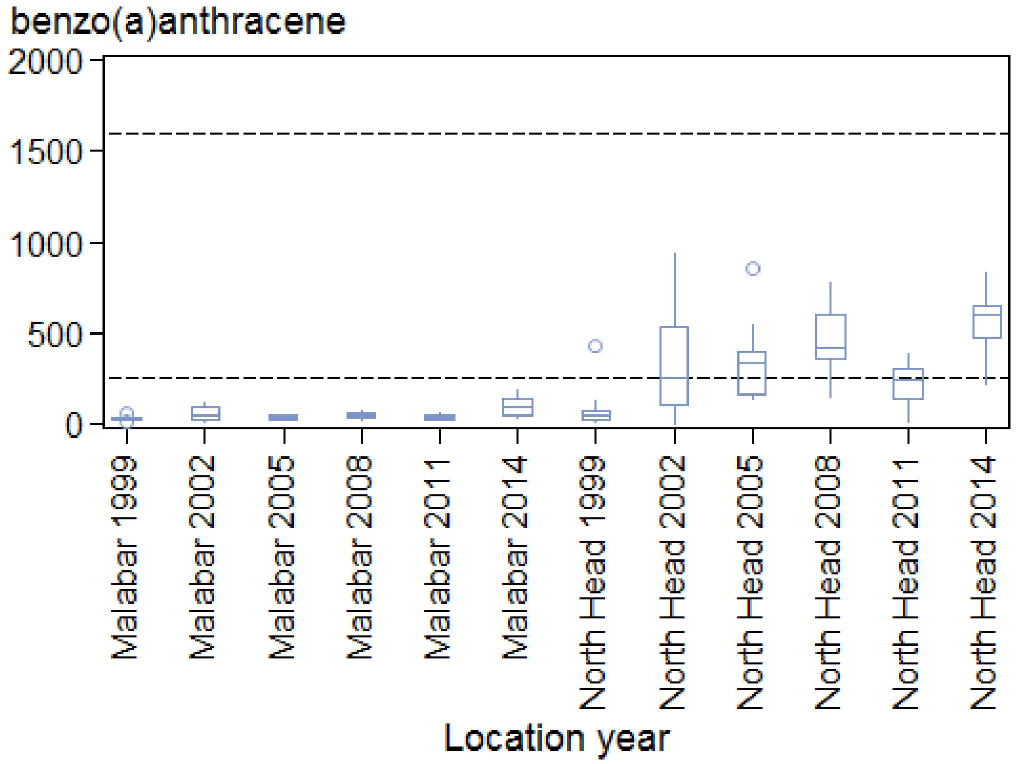

Figure 10-14 Benzo(a)anthracene concentrations in sediments at each location by year

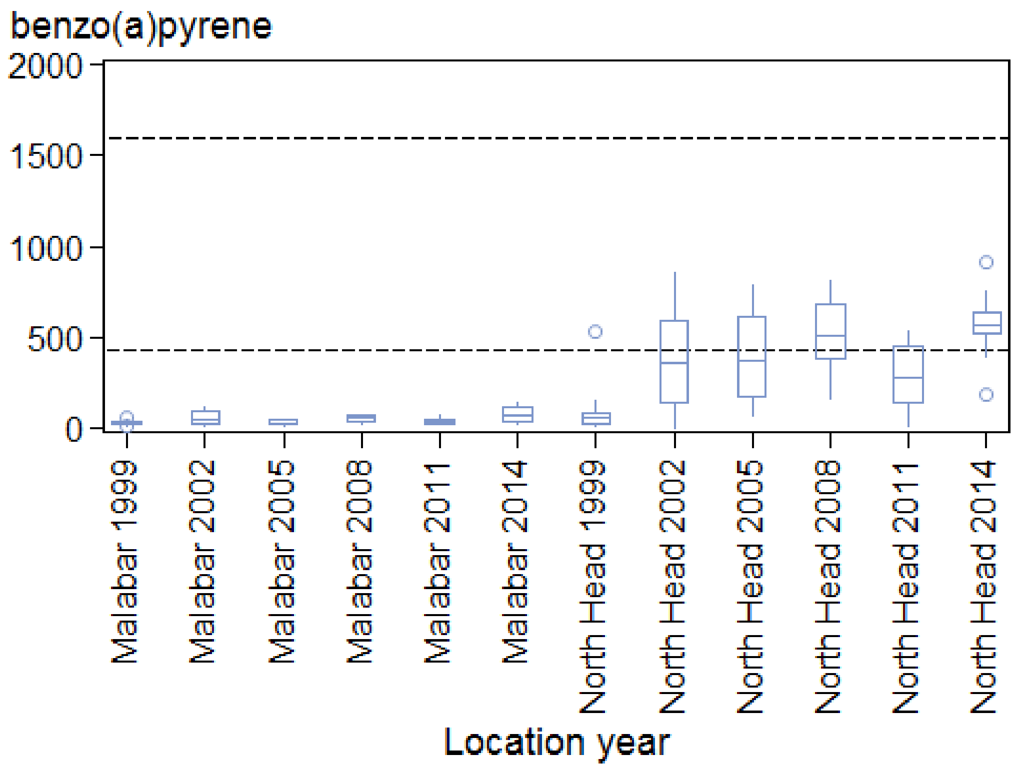

Figure 10-15 Benzo(a)pyrene concentrations in sediments at each location by year

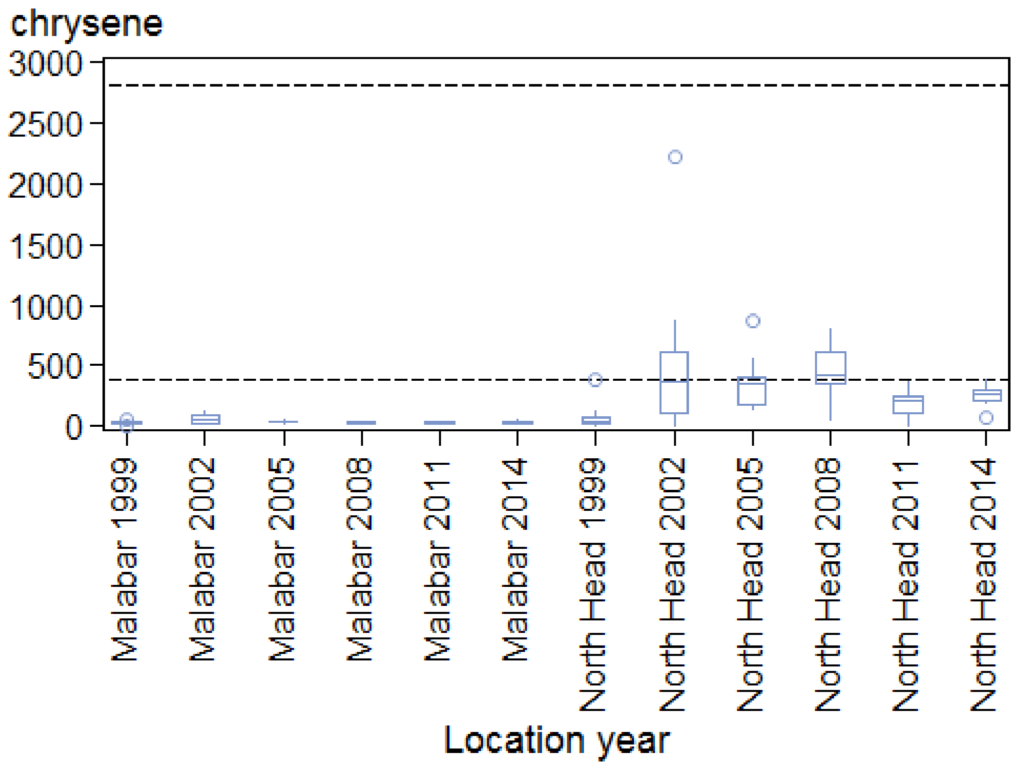

Figure 10-16 Chrysene concentrations in sediments at each location by year

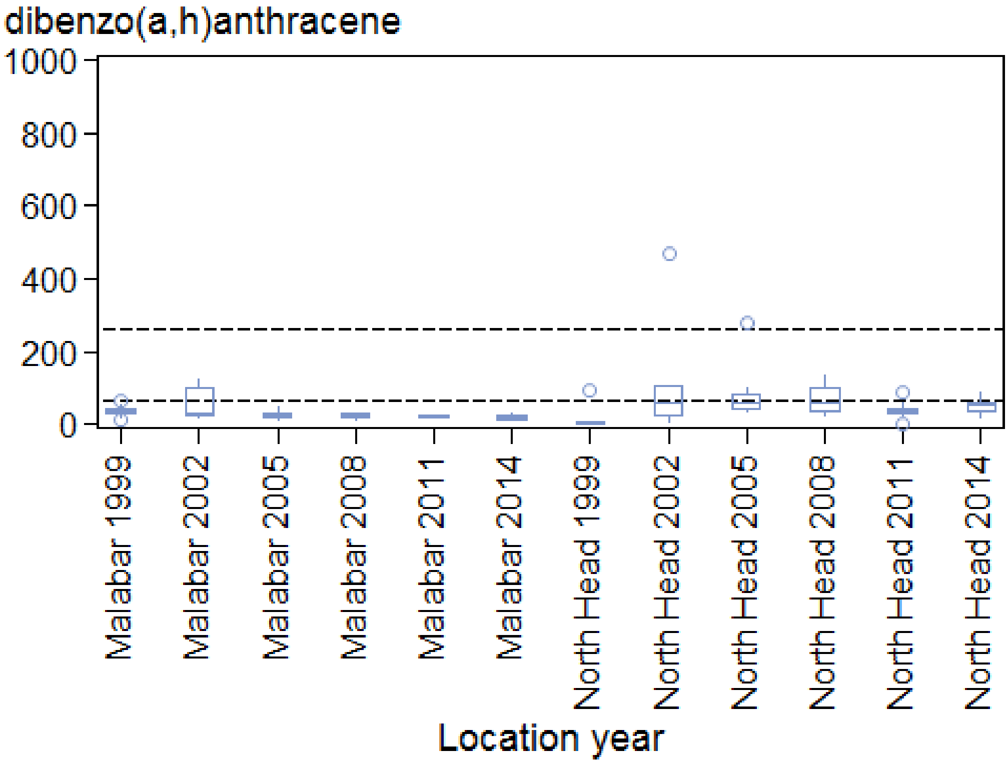

Figure 10-17 Dibenzo(a,h)anthracene concentrations in sediments at each location by year

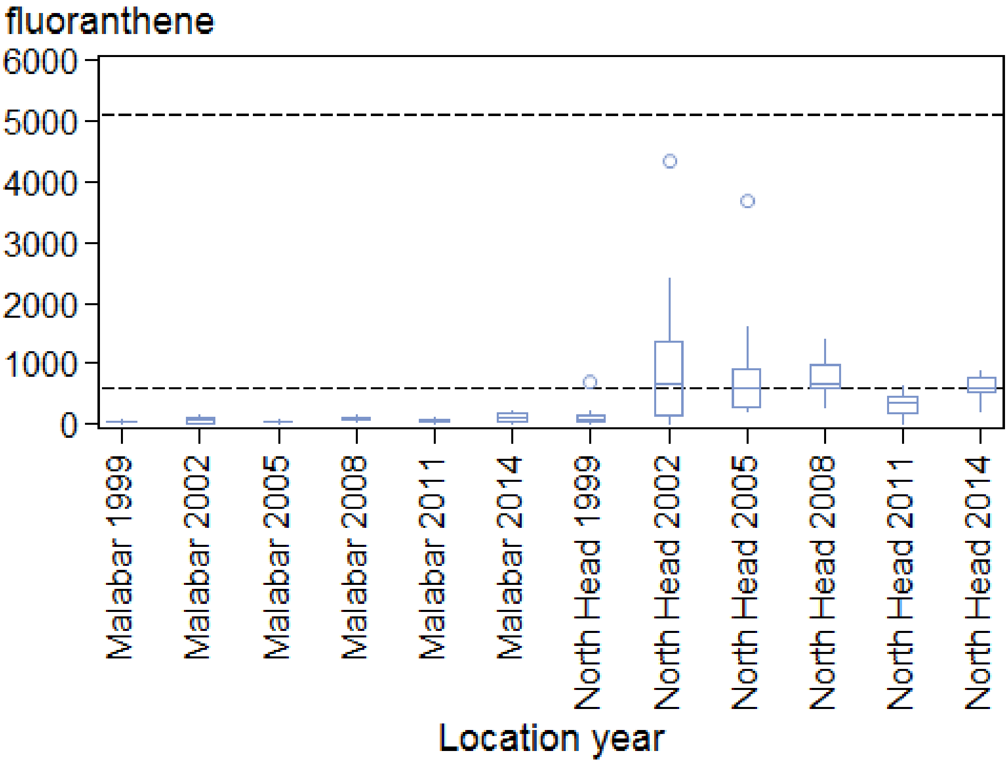

Figure 10-18 Fluoranthene concentrations in sediments at each location by year

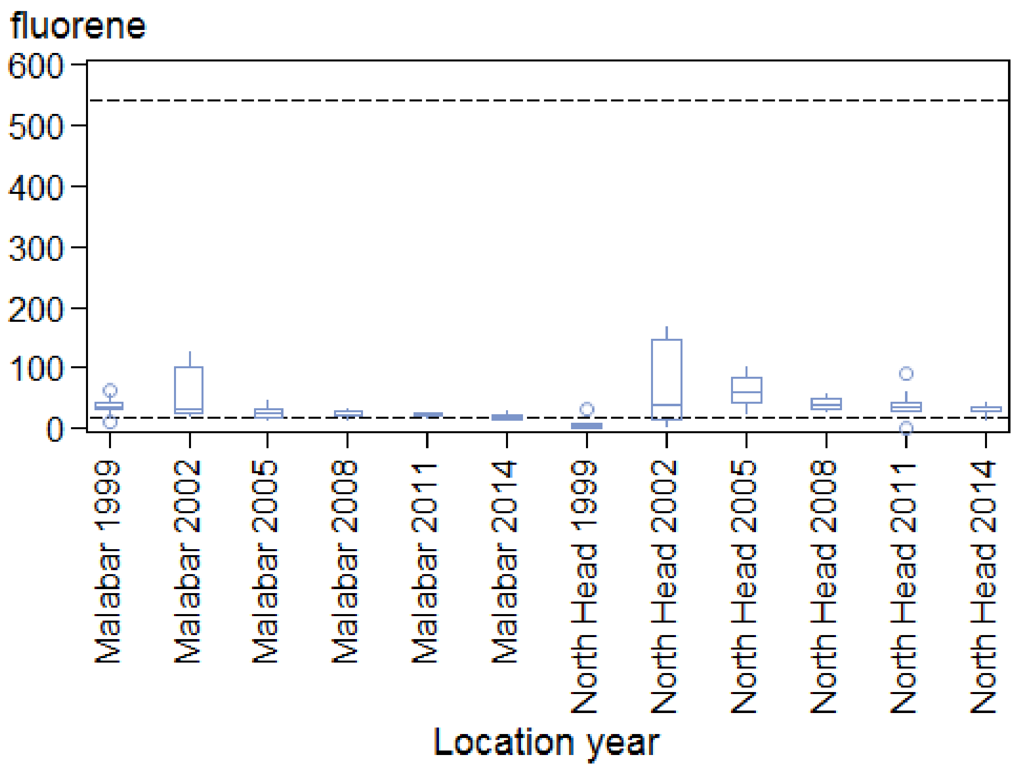

Figure 10-19 Fluorene concentrations in sediments at each location by year

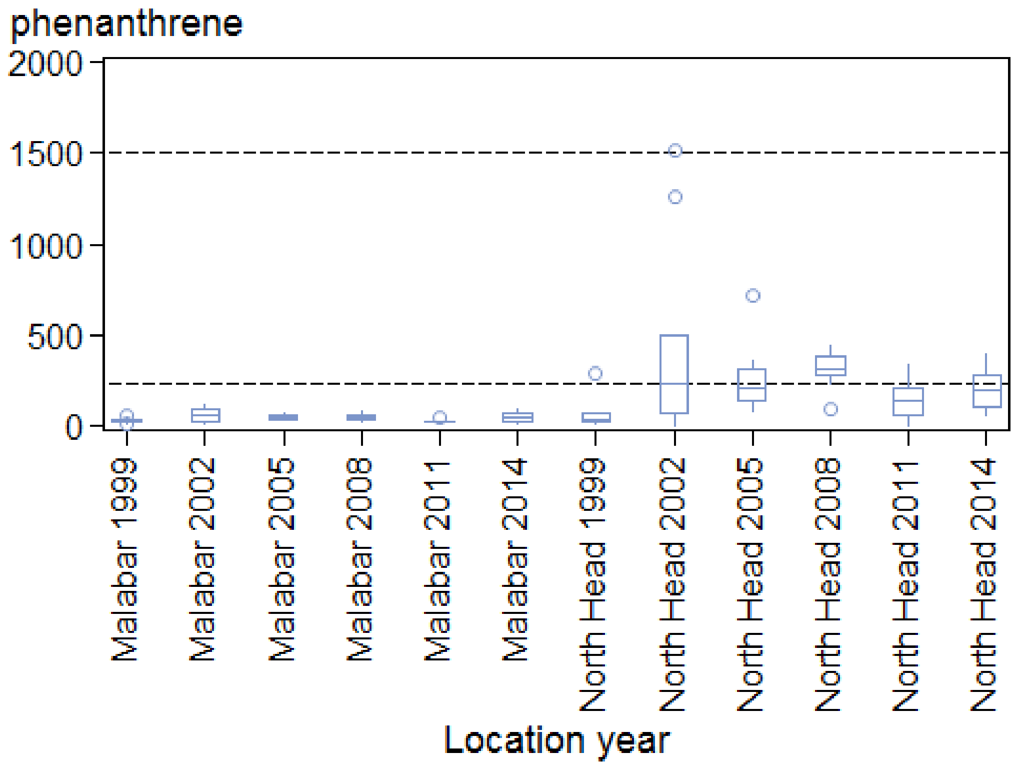

Figure 10-20 Phenanthrene concentrations in sediments at each location by year

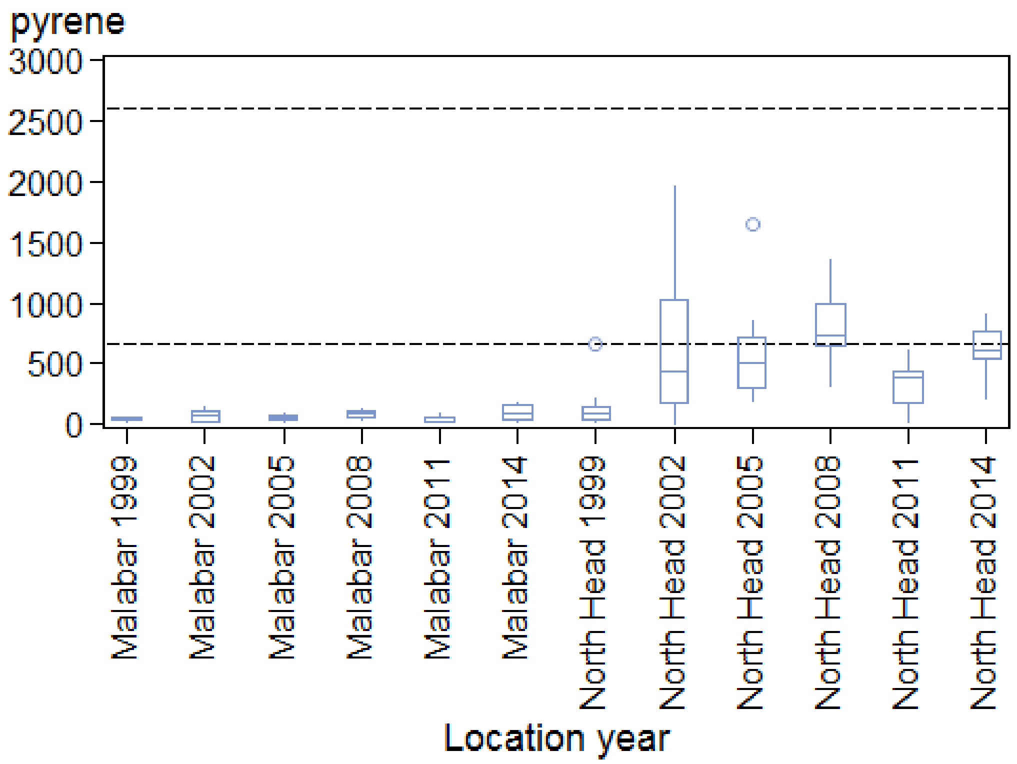

Figure 10-21 Pyrene concentrations in sediments at each location by year

10.2 Appendix C ANCOVA for 60m locations

PERMANOVA of aluminium

PERMANOVA table of results

```
                                                          Unique
Source          df        SS        MS  Pseudo-F  P(perm)  perms
Fines            1   2.108E6   2.108E6    13.209   0.0011   9820
Location         2 5.2601E6    2.63E6     16.48   0.0002   9954
FinesxLocation   2 1.7621E5     88106   0.55207   0.5757   9949
Res             24 3.8302E6 1.5959E5
Total           29 1.1375E7
```

PAIR-WISE TESTS

Term 'Location'

```
                             Unique
Groups        t  P(perm)   perms
B, NH   3.5089    0.002    9847
B, LR   1.9143   0.0715    9824
NH, LR  4.1592   0.0008    9844
```

Average Distance between/within groups

```
        B      NH      LR
B   334.44
NH   644.6  605.33
LR   592.6    1135  510.89
```

PERMANOVA of arsenic

PERMANOVA table of results

```
                                                      Unique
Source          df      SS      MS  Pseudo-F  P(perm)  perms
Fines            1  3.8901  3.8901   0.10146   0.7155   9782
Location         2  1603.6  801.81    20.912   0.0001   9948
FinesxLocation   2  8.1037  4.0518   0.10568   0.8649   9936
Res             24   920.2  38.342
Total           29  2535.8
```

PAIR-WISE TESTS

Term 'Location'

```
                              Unique
Groups         t  P(perm)   perms
B, NH    4.3911   0.0002    9816
B, LR   0.32185   0.7756    9852
NH, LR   4.0642   0.0004    9844
```

Average Distance between/within groups

```
        B      NH      LR
B   1.5884
NH  15.358  11.082
LR  1.3344  15.679  1.1993
```

PERMANOVA of cadmium

PERMANOVA table of results

```
                                                              Unique
Source          df         SS         MS  Pseudo-F  P(perm)    perms
Fines            1  9.7344E-4  9.7344E-4    6.1319   0.0183     9848
Location         2  2.1943E-2  1.0972E-2    69.113   0.0001     9960
FinesxLocation   2  1.0332E-4  5.1658E-5    0.3254   0.7382     9950
Res             24    3.81E-3  1.5875E-4
Total           29   2.683E-2
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups       t  P(perm)  perms
B, NH   7.9413   0.0001   9850
B, LR   2.0852   0.0536   9852
NH, LR  8.8325   0.0001   9835
```

Average Distance between/within groups

```
            B          NH          LR
B   1.0889E-2
NH       5E-2  1.9333E-2
LR    1.48E-2      6.4E-2  1.0889E-2
```

PERMANOVA of chromium

PERMANOVA table of results

```
                                                        Unique
Source          df      SS      MS  Pseudo-F  P(perm)    perms
Fines            1   2.969   2.969   0.31103   0.5403     9807
Location         2  388.01     194    20.324   0.0001     9967
FinesxLocation   2  2.9325  1.4663   0.15361   0.8299     9961
Res             24  229.09  9.5456
Total           29     623
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups       t  P(perm)  perms
B, NH    4.175   0.0002   9820
B, LR   1.2808   0.2222   9847
NH, LR  4.2354   0.0003   9833
```

Average Distance between/within groups

```
        B      NH      LR
B    1.04
NH    7.1  5.1911
LR  1.621   8.111  1.8976
```

PERMANOVA of copper

PERMANOVA table of results

```
                                                          Unique
Source          df      SS       MS  Pseudo-F  P(perm)   perms
Fines            1  16.233   16.233    33.821   0.0003    9816
Location         2  13.954    6.977    14.536   0.0002    9959
FinesxLocation   2  2.5831   1.2916    2.6909   0.1016    9960
Res             24  11.519  0.47997
Total           29   44.29
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups        t  P(perm)  perms
B, NH   0.61615   0.5633   9835
B, LR    5.5554   0.0001   9841
NH, LR   3.8418   0.0015   9837
```

Average Distance between/within groups

```
         B      NH       LR
B   0.70889
NH   0.8762   1.118
LR   1.9618  1.9728  0.83667
```

PERMANOVA of iron

PERMANOVA table of results

```
                                                             Unique
Source          df        SS         MS  Pseudo-F  P(perm)   perms
Fines            1  9.7155E5  9.7155E5   0.17253   0.6412    9804
Location         2  2.8405E8  1.4203E8     25.22   0.0001    9949
FinesxLocation   2  3.0953E6  1.5477E6   0.27483    0.684    9953
Res             24  1.3515E8  5.6314E6
Total           29  4.2327E8
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups        t  P(perm)  perms
B, NH    4.9043   0.0001   9875
B, LR   0.17952    0.862   9842
NH, LR   4.4563   0.0003   9849
```

Average Distance between/within groups

```
        B      NH      LR
B   1056.9
NH    6436  3775.6
LR    1126    6626  1315.6
```

PERMANOVA of lead

PERMANOVA table of results

```
                                                    Unique
Source          df     SS     MS  Pseudo-F P(perm)  perms
Fines            1 8.0372 8.0372    1.1853   0.2811   9827
Location         2 157.87 78.937    11.642   0.0003   9957
FinesxLocation   2 16.154 8.0772    1.1912   0.3219   9946
Res             24 162.73 6.7806
Total           29  344.8
```

PAIR-WISE TESTS

Term 'Location'

```
                       Unique
Groups      t  P(perm)  perms
B, NH  2.1514   0.0438   9825
B, LR   2.528   0.0239   9843
NH, LR 3.7778   0.0015   9832
```

Average Distance between/within groups

```
        B     NH      LR
B   2.618
NH 3.7482 3.3898
LR  3.208  5.757  2.6589
```

PERMANOVA of mercury

PERMANOVA table of results

```
                                                      Unique
Source          df      SS      MS  Pseudo-F P(perm)  perms
Fines            1 0.31148 0.31148   0.93736  0.2738   9790
Location         2  1.0363 0.51815    1.5593  0.2163   9951
FinesxLocation   2  2.9651  1.4826    4.4616  0.1172   9888
Res             24   7.975 0.33229
Total           29  12.288
```

PERMANOVA of nickel

PERMANOVA table of results

```
                                                               Unique
Source          df        SS        MS  Pseudo-F  P(perm)  perms
Fines            1 8.6422E-2 8.6422E-2 9.3997E-2   0.7446   9802
Location         2        16    7.9999    8.7011   0.0007   9957
FinesxLocation   2 2.6964E-2 1.3482E-2 1.4664E-2   0.9831   9945
Res             24    22.066   0.91941
Total           29    38.179
```

PAIR-WISE TESTS

Term 'Location'

```
                           Unique
Groups          t  P(perm)  perms
B, NH      3.3908   0.0013   9840
B, LR   9.8194E-2   0.9257   9843
NH, LR     2.7992   0.0114   9831
```

Average Distance between/within groups

```
         B      NH      LR
B  0.58978
NH   1.508  1.2342
LR  0.7604  1.7086  1.0182
```

PERMANOVA of selenium

PERMANOVA table of results

```
                                                              Unique
Source          df        SS        MS Pseudo-F  P(perm)  perms
Fines            1 1.4542E-2 1.4542E-2   35.997   0.0001   9834
Location         2 1.5308E-2  7.654E-3   18.947   0.0001   9930
FinesxLocation   2 2.4841E-3 1.2421E-3   3.0746   0.0716   9952
Res             24 9.6955E-3 4.0398E-4
Total           29  4.203E-2
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups       t  P(perm)  perms
B, NH   4.3912   0.0002   9856
B, LR   1.5754   0.1326   9830
NH, LR   3.891   0.0014   9827
```

Average Distance between/within groups

```
           B          NH          LR
B  2.3778E-2
NH      4E-2   4.1111E-2
LR    3.6E-2      6.5E-2   2.9556E-2
```

PERMANOVA of silver

PERMANOVA table of results

```
                                                                 Unique
Source           df          SS          MS  Pseudo-F  P(perm)   perms
Fines             1   1.087E-3   1.087E-3    28.561   0.0001    9828
Location          2 1.0916E-3 5.4579E-4     14.34   0.0001    9960
FinesxLocation    2 1.2466E-4 6.2329E-5    1.6377   0.2212    9950
Res              24 9.1343E-4   3.806E-5
Total            29 3.2167E-3
```

PAIR-WISE TESTS

Term 'Location'

```
                           Unique
Groups          t  P(perm)   perms
B, NH   4.9843E-2   0.9596    9829
B, LR      5.0019   0.0002    9827
NH, LR     4.4965   0.0004    9847
```

Average Distance between/within groups

```
            B         NH         LR
B   7.3333E-3
NH     7.4E-3  8.6667E-3
LR     1.8E-2     1.6E-2  4.6667E-3
```

PERMANOVA of zinc

PERMANOVA table of results

```
                                                           Unique
Source           df      SS      MS  Pseudo-F  P(perm)   perms
Fines             1  31.676  31.676    3.2097   0.0867    9846
Location          2  286.77  143.39    14.529   0.0001    9952
FinesxLocation    2    24.4    12.2    1.2362   0.3072    9965
Res              24  236.85  9.8689
Total            29   579.7
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups       t  P(perm)   perms
B, NH   1.7072    0.105    9856
B, LR   3.6996   0.0027    9845
NH, LR  3.9249   0.0016    9805
```

Average Distance between/within groups

```
         B      NH      LR
B   2.4356
NH   3.672  4.1667
LR   5.322   7.866  4.0467
```

10.3 Appendix D ANCOVA for 80m locations

PERMANOVA of Aluminium

PERMANOVA table of results

```
                                                                Unique
Source          df        SS        MS  Pseudo-F  P(perm)  perms
Fines            1   1.285E7   1.285E7    28.498   0.0001    9833
Location         2 3.7469E6 1.8734E6    4.1549   0.0243    9945
FinesxLocation   2 3.1303E6 1.5652E6    3.4712   0.0553    9957
Res             24 1.0822E7   4.509E5
Total           29 3.0548E7
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups        t  P(perm)  perms
MOK, PH  3.7631   0.0024    9838
MOK, MB  1.4075    0.172    9837
PH, MB   1.0148   0.3238    9818
```

Average Distance between/within groups

```
        MOK      PH      MB
MOK  1132.4
PH     1126  477.78
MB   1664.2   824.4  1004.9
```

PERMANOVA of Arsenic

PERMANOVA table of results

```
                                                             Unique
Source          df        SS        MS  Pseudo-F  P(perm)  perms
Fines            1   1.4944    1.4944    12.098   0.0017    9826
Location         2  0.34828   0.17414    1.4098   0.2555    9948
FinesxLocation   2  0.69542   0.34771     2.815    0.073    9956
Res             24   2.9645   0.12352
Total           29   5.5026
```

PERMANOVA of cadmium

PERMANOVA table of results

```
                                                         Unique
Source          df        SS         MS  Pseudo-F  P(perm)  perms
Fines            1  2.1629E-3  2.1629E-3   16.004   0.0007   9810
Location         2  1.6724E-3  8.3622E-4   6.1873   0.0063   9945
FinesxLocation   2  5.7654E-5  2.8827E-5  0.21329   0.8022   9941
Res             24  3.2436E-3  1.3515E-4
Total           29  7.1367E-3
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups       t  P(perm)   perms
MOK, PH 3.4242   0.0026    9824
MOK, MB 1.5917   0.1335    9831
PH, MB  1.2323   0.2287    9832
```

Average Distance between/within groups

```
          MOK         PH         MB
MOK 1.5556E-2
PH    2.16E-2  1.4222E-2
MB    2.38E-2    1.24E-2  1.2667E-2
```

PERMANOVA of chromium

PERMANOVA table of results

```
                                                  Unique
Source          df     SS     MS  Pseudo-F  P(perm)  perms
Fines            1 72.933 72.933    29.404   0.0001   9835
Location         2 34.811 17.406    7.0174   0.0048   9948
FinesxLocation   2 3.9854 1.9927   0.80338   0.4605   9941
Res             24 59.529 2.4804
Total           29 171.26
```

PAIR-WISE TESTS

Term 'Location'

```
                          Unique
Groups        t  P(perm)   perms
MOK, PH  3.0256   0.0082    9829
MOK, MB 0.38429   0.7065    9832
PH, MB   2.0603   0.0558    9850
```

Average Distance between/within groups

```
       MOK      PH      MB
MOK 3.1867
PH   3.492  2.2689
MB   3.524   1.788  1.3711
```

PERMANOVA of copper

PERMANOVA table of results

```
                                                      Unique
Source          df        SS        MS  Pseudo-F P(perm)   perms
Fines            1    9.7173    9.7173    19.953  0.0002    9829
Location         2    6.0599    3.0299    6.2216  0.0042    9953
FinesxLocation   2   0.92546   0.46273   0.95016  0.3863    9933
Res             24    11.688     0.487
Total           29    28.391
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups        t  P(perm)  perms
MOK, PH 0.22207   0.8263   9817
MOK, MB  2.8176   0.0109   9840
PH, MB   2.1367     0.05   9836
```

Average Distance between/within groups

```
       MOK     PH      MB
MOK 1.8233
PH  1.3246    0.71
MB  1.3486  0.6902 0.74622
```

PERMANOVA of iron

PERMANOVA table of results

```
                                                        Unique
Source          df       SS       MS  Pseudo-F P(perm)   perms
Fines            1 1.6915E7 1.6915E7    22.297  0.0001    9861
Location         2 9.7553E6 4.8776E6    6.4296  0.0044    9945
FinesxLocation   2 2.6572E6 1.3286E6    1.7514  0.2018    9958
Res             24 1.8207E7 7.5862E5
Total           29 4.7534E7
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups       t  P(perm)  perms
MOK, PH 3.5445    0.003   9846
MOK, MB 1.1175   0.2826   9835
PH, MB  1.5914   0.1298   9831
```

Average Distance between/within groups

```
       MOK     PH     MB
MOK   1396
PH  1760.2 1256.9
MB  1848.4   1084 1015.3
```

PERMANOVA of lead

PERMANOVA table of results

```
                                                    Unique
Source          df      SS       MS  Pseudo-F P(perm)  perms
Fines            1  16.031   16.031    23.414  0.0002   9831
Location         2  9.1075   4.5538     6.651  0.0068   9958
FinesxLocation   2  0.2882   0.1441   0.21046   0.823   9953
Res             24  16.432  0.68468
Total           29  41.859
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups        t  P(perm)  perms
MOK, PH  2.7464   0.0171   9837
MOK, MB 0.39294   0.7011   9851
PH, MB   2.7472   0.0137   9828
```

Average Distance between/within groups

```
       MOK     PH     MB
MOK 1.5253
PH   1.702   1.19
MB  1.6466 1.0262 0.952
```

PERMANOVA of Mercury

PERMANOVA table of results

```
                                                          Unique
Source          df        SS        MS  Pseudo-F P(perm)   perms
Fines            1  3.181E-4  3.181E-4    1.4813  0.2377    9841
Location         2 6.4125E-3 3.2062E-3    14.931  0.0002    9958
FinesxLocation   2 2.3279E-4 1.1639E-4   0.54202  0.5881    9947
Res             24 5.1538E-3 2.1474E-4
Total           29 1.2117E-2
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups        t  P(perm)  perms
MOK, PH 0.96332   0.3516   9838
MOK, MB  4.6665   0.0002   9847
PH, MB   4.5232   0.0004   9813
```

Average Distance between/within groups

```
          MOK        PH        MB
MOK 3.5044E-2
PH   2.574E-2 1.7044E-2
MB   2.726E-2  1.654E-2 9.7333E-3
```

PERMANOVA of Nickel

PERMANOVA table of results

```
                                                            Unique
Source          df      SS       MS  Pseudo-F  P(perm)   perms
Fines            1  33.094   33.094    63.884   0.0001    9831
Location         2  15.644   7.8222      15.1   0.0002    9940
FinesxLocation   2 0.91967  0.45983   0.88767   0.4256    9947
Res             24  12.433  0.51802
Total           29   62.09
```

PAIR-WISE TESTS

Term 'Location'

```
                               Unique
Groups         t  P(perm)   perms
M0K, PH   4.965   0.0001    9814
M0K, MB  2.1681   0.0428    9841
PH, MB   1.3901   0.1854    9829
```

Average Distance between/within groups

```
       M0K      PH       MB
M0K 1.5456
PH  2.0884 1.0873
MB  2.5694 1.0084 0.67067
```

PERMANOVA of selenium

PERMANOVA table of results

```
                                                                Unique
Source          df         SS          MS  Pseudo-F  P(perm)   perms
Fines            1   3.611E-2   3.611E-2    43.745   0.0001    9831
Location         2 1.8566E-3  9.2831E-4    1.1246   0.3415    9968
FinesxLocation   2 5.1693E-3  2.5847E-3    3.1312   0.0602    9956
Res             24 1.9811E-2  8.2546E-4
Total           29 6.2947E-2
```

PERMANOVA of silver

PERMANOVA table of results

```
                                                               Unique
Source          df          SS          MS  Pseudo-F  P(perm)   perms
Fines            1   4.617E-6   4.617E-6  5.1315E-2   0.8205    9829
Location         2 3.9666E-3  1.9833E-3     22.044   0.0001    9947
FinesxLocation   2 2.5605E-4  1.2802E-4     1.4229    0.265    9948
Res             24 2.1594E-3  8.9973E-5
Total           29 6.3867E-3
```

PAIR-WISE TESTS

Term 'Location'

```
                        Unique
Groups        t  P(perm)  perms
MOK, PH  2.3611   0.0265   9838
MOK, MB  5.5141   0.0001   9824
PH, MB   4.2026   0.0005   9844
```

Average Distance between/within groups

```
          MOK         PH         MB
MOK 2.3111E-2
PH     1.6E-2  5.3333E-3
MB    2.16E-2     1.2E-2  8.8889E-3
```

PERMANOVA of zinc

PERMANOVA table of results

```
                                                        Unique
Source          df      SS      MS  Pseudo-F  P(perm)   perms
Fines            1  267.78  267.78    31.862   0.0002    9831
Location         2  108.25  54.126    6.4403   0.0065    9962
FinesxLocation   2   4.258   2.129   0.25333   0.7786    9936
Res             24   201.7  8.4042
Total           29  581.99
```

PAIR-WISE TESTS

Term 'Location'

```
                          Unique
Groups         t  P(perm)  perms
MOK, PH   3.2404   0.0061   9841
MOK, MB  0.84893   0.4066   9828
PH, MB    1.3228   0.1968   9834
```

Average Distance between/within groups

```
       MOK      PH      MB
MOK 5.6378
PH   6.266  3.4844
MB    7.14   3.202  2.8333
```

10.4 Appendix E ANCOVA for 80m gradient study locations

PERMANOVA of aluminium

PERMANOVA table of results

```
                                                             Unique
Source          df        SS        MS  Pseudo-F  P(perm)   perms
Fines            1    1.46E7    1.46E7    26.905   0.0001    9851
Location         3 3.3078E6 1.1026E6    2.0319   0.1334    9962
FinesxLocation   3 1.6984E6 5.6612E5    1.0432   0.3799    9940
Res             32 1.7365E7 5.4265E5
Total           39 3.6971E7
```

PERMANOVA of arsenic

PERMANOVA table of results

```
                                                           Unique
Source          df       SS       MS  Pseudo-F  P(perm)   perms
Fines            1 0.89691 0.89691     3.396   0.0741    9827
Location         3   4.1585   1.3862    5.2485   0.0049    9960
FinesxLocation   3 0.73352 0.24451   0.92578   0.4355    9965
Res             32   8.4514 0.26411
Total           39    14.24
```

PAIR-WISE TESTS

Term 'Location'

```
                                  Unique
Groups            t  P(perm)   perms
M0K, M3K   2.6182   0.0198    9829
M0K, M5K   0.9838    0.344    9822
M0K, M7K   0.4817   0.6388    9824
M3K, M5K   1.8753     0.08    9862
M3K, M7K   3.9989   0.0001    9837
M5K, M7K  0.78918   0.4491    9847
```

Average Distance between/within groups

```
         M0K      M3K      M5K    M7K
M0K 0.47267
M3K   0.8954 0.50778
M5K   0.6382   0.7486 0.76956
M7K   0.4526   0.9066   0.6498 0.468
```

PERMANOVA of cadmium

PERMANOVA table of results

```
                                                          Unique
Source          df        SS        MS  Pseudo-F  P(perm)  perms
Fines            1 2.2671E-3 2.2671E-3    23.905   0.0001   9840
Location         3 7.4029E-3 2.4676E-3    26.021   0.0001   9965
FinesxLocation   3  2.953E-4 9.8435E-5     1.038   0.3856   9955
Res             32 3.0347E-3 9.4834E-5
Total           39    1.3E-2
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups         t P(perm)  perms
M0K, M3K 5.0246   0.0002   9863
M0K, M5K 1.6887   0.1103   9808
M0K, M7K 1.1737   0.2637   9834
M3K, M5K 6.2962   0.0001   9848
M3K, M7K 7.0306   0.0001   9835
M5K, M7K 0.3068    0.761   9824
```

Average Distance between/within groups

```
           M0K        M3K        M5K        M7K
M0K  1.5556E-2
M3K     4.2E-2  1.2889E-2
M5K    1.56E-2     2.9E-2  8.2222E-3
M7K    1.52E-2     2.9E-2     6.4E-3  5.5556E-3
```

PERMANOVA of chromium

PERMANOVA table of results

```
                                                     Unique
Source          df     SS      MS  Pseudo-F P(perm)   perms
Fines            1 131.99  131.99    48.641  0.0001    9825
Location         3 146.72  48.905    18.022  0.0001    9959
FinesxLocation   3 2.8131 0.93771   0.34555  0.7945    9959
Res             32 86.837  2.7137
Total           39 368.36
```

PAIR-WISE TESTS

Term 'Location'

```
                          Unique
Groups          t P(perm)  perms
M0K, M3K   4.7842  0.0004   9839
M0K, M5K  0.89648  0.3862   9842
M0K, M7K  0.56809  0.5823   9839
M3K, M5K   6.5873  0.0001   9843
M3K, M7K   6.8766  0.0001   9852
M5K, M7K   1.2971  0.2176   9836
```

Average Distance between/within groups

```
        M0K     M3K     M5K     M7K
M0K  3.1867
M3K    6.59  1.5533
M5K   3.068   4.184  1.4422
M7K   3.268   4.402   1.926  2.5822
```

PERMANOVA of coppper

PERMANOVA table of results

```
                                                     Unique
Source          df     SS      MS  Pseudo-F P(perm)   perms
Fines            1 37.844  37.844    82.924  0.0001    9842
Location         3 17.047  5.6823    12.451  0.0001    9961
FinesxLocation   3 2.6886 0.89621    1.9638  0.1435    9956
Res             32 14.604 0.45637
Total           39 72.184
```

PAIR-WISE TESTS

Term 'Location'

```
                          Unique
Groups          t P(perm)  perms
M0K, M3K   3.1462  0.0069   9849
M0K, M5K   1.0492  0.3148   9855
M0K, M7K  0.52241  0.6077   9848
M3K, M5K   8.5659  0.0001   9851
M3K, M7K   3.8074   0.002   9838
M5K, M7K   2.5873  0.0197   9819
```

Average Distance between/within groups

```
       M0K     M3K     M5K     M7K
M0K 1.8233
M3K 2.6962 0.67556
M5K 1.4228   1.984 0.60667
M7K 1.9966  1.0216  1.1688 0.86067
```

PERMANOVA of iron

PERMANOVA table of results

```
                                                        Unique
Source          df       SS       MS  Pseudo-F P(perm)   perms
Fines            1 1.7055E7 1.7055E7    29.949  0.0001    9823
Location         3 3.2736E7 1.0912E7    19.162  0.0001    9951
FinesxLocation   3 1.7785E6 5.9285E5    1.0411  0.3966    9950
Res             32 1.8223E7 5.6946E5
Total           39 6.9792E7
```

PAIR-WISE TESTS

Term 'Location'

```
                          Unique
Groups          t P(perm)  perms
M0K, M3K   4.1526  0.0012   9840
M0K, M5K  0.59026  0.5676   9832
M0K, M7K   1.1261  0.2706   9839
M3K, M5K   5.3849  0.0001   9859
M3K, M7K   9.3364  0.0001   9835
M5K, M7K   1.3078  0.2172   9820
```

Average Distance between/within groups

```
       M0K    M3K    M5K    M7K
M0K   1396
M3K   2756 797.33
M5K 1299.2 1977.2 928.44
M7K 1183.4   2165  811.4 803.33
```

PERMANOVA of lead

PERMANOVA table of results

```
                                                   Unique
Source         df      SS      MS Pseudo-F P(perm)  perms
Fines           1  62.574  62.574    85.03  0.0001   9817
Location        3  39.306  13.102   17.804  0.0001   9947
FinesxLocation  3 0.53497 0.17832  0.24232  0.8631   9951
Res            32  23.549 0.73591
Total          39  125.96
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups         t P(perm)  perms
M0K, M3K  5.6404  0.0001   9831
M0K, M5K  2.0725  0.0614   9853
M0K, M7K  1.9248  0.0729   9829
M3K, M5K  5.3673  0.0001   9827
M3K, M7K  5.0595  0.0003   9841
M5K, M7K 0.56601  0.5862   9847
```

Average Distance between/within groups

```
       M0K    M3K     M5K    M7K
M0K 1.5253
M3K  4.103 1.1896
M5K 1.9374 2.3396 0.89778
M7K 2.6406 1.6648  1.2436 1.0976
```

PERMANOVA of mercury

PERMANOVA table of results

```
                                                       Unique
Source         df        SS        MS Pseudo-F P(perm)  perms
Fines           1 1.3573E-2 1.3573E-2   72.736  0.0001   9834
Location        3 1.8642E-2  6.214E-3   33.301  0.0001   9954
FinesxLocation  3 1.2278E-3 4.0926E-4   2.1932   0.104   9943
Res            32 5.9713E-3  1.866E-4
Total          39 3.9414E-2
```

PAIR-WISE TESTS

Term 'Location'

```
                         Unique
Groups         t P(perm)  perms
M0K, M3K  5.3405  0.0002   9855
M0K, M5K  1.2663  0.2234   9837
M0K, M7K 0.81193  0.4318   9848
M3K, M5K  9.2895  0.0001   9838
M3K, M7K  10.701  0.0001   9817
M5K, M7K   3.166  0.0073   9830
```

Average Distance between/within groups

```
          M0K       M3K       M5K       M7K
M0K 3.5044E-2
M3K   7.28E-2 1.2244E-2
M5K  3.444E-2   4.38E-2 9.0889E-3
M7K  3.282E-2   4.89E-2  1.338E-2 1.7911E-2
```

PERMANOVA of nickel

PERMANOVA table of results

```
                                                         Unique
Source          df      SS       MS  Pseudo-F  P(perm)   perms
Fines            1  35.931   35.931    73.033   0.0001    9854
Location         3   17.48   5.8267    11.843   0.0002    9944
FinesxLocation   3  1.5251  0.50836    1.0333    0.381    9949
Res             32  15.743  0.49198
Total           39  70.679
```

PAIR-WISE TESTS

Term 'Location'

```
                           Unique
Groups          t  P(perm)  perms
M0K, M3K    4.357   0.0005   9833
M0K, M5K   1.1172   0.2716   9835
M0K, M7K   0.4128    0.686   9835
M3K, M5K   5.7878   0.0001   9832
M3K, M7K   4.9182   0.0002   9836
M5K, M7K  0.14175   0.8909   9850
```

Average Distance between/within groups

```
       M0K      M3K      M5K     M7K
M0K 1.5456
M3K   2.85  0.65622
M5K 1.5094   1.6192  0.63889
M7K 1.8818   1.2944   0.9314  1.1031
```

PERMANOVA of selenium

PERMANOVA table of results

```
                                                                Unique
Source          df         SS         MS  Pseudo-F  P(perm)    perms
Fines            1  5.8279E-2  5.8279E-2    46.143   0.0001     9826
Location         3  8.9454E-3  2.9818E-3    2.3609   0.0863     9958
FinesxLocation   3  6.7603E-3  2.2534E-3    1.7842   0.1728     9953
Res             32  4.0416E-2   1.263E-3
Total           39     0.1144
```

PERMANOVA of silver

PERMANOVA table of results

```
                                                              Unique
Source          df         SS         MS  Pseudo-F  P(perm)    perms
Fines            1  4.3323E-3  4.3323E-3    40.241   0.0001     9833
Location         3   6.096E-3   2.032E-3    18.875   0.0001     9957
FinesxLocation   3  4.0413E-4  1.3471E-4    1.2513   0.3072     9961
Res             32  3.4451E-3  1.0766E-4
Total           39  1.4278E-2
```

PAIR-WISE TESTS

Term 'Location'

```
                                 Unique
Groups             t  P(perm)     perms
M0K, M3K      2.8729   0.0112      9842
M0K, M5K     0.15125   0.8839      9869
M0K, M7K      1.2898   0.2194      9854
M3K, M5K      5.4138   0.0001      9831
M3K, M7K      6.7414   0.0001      9836
M5K, M7K      2.2765   0.0375      9841
```

Average Distance between/within groups

```
           M0K        M3K        M5K        M7K
M0K  2.3111E-2
M3K     3.9E-2  1.4667E-2
M5K    2.04E-2    2.52E-2  7.3333E-3
M7K    1.88E-2       3E-2     8.6E-3  1.0222E-2
```

PERMANOVA of zinc

PERMANOVA table of results

```
                                                       Unique
Source          df      SS      MS  Pseudo-F  P(perm)   perms
Fines            1  358.31  358.31    53.759   0.0001    9858
Location         3   478.4  159.47    23.925   0.0001    9956
FinesxLocation   3  19.767  6.5892   0.98859   0.4088    9959
Res             32  213.29  6.6652
Total           39  1069.8
```

PAIR-WISE TESTS

Term 'Location'

```
                                 Unique
Groups             t  P(perm)     perms
M0K, M3K       4.685   0.0001      9835
M0K, M5K      1.1033   0.2901      9860
M0K, M7K     0.50297   0.6233      9855
M3K, M5K      7.3661   0.0001      9843
M3K, M7K       9.066   0.0001      9840
M5K, M7K      1.4652   0.1584      9813
```

Average Distance between/within groups

```
        M0K      M3K      M5K      M7K
M0K  5.6378
M3K   11.65   2.8133
M5K    5.46      7.4   2.3067
M7K   5.414     7.81    2.644   3.3044
```

10.5 Appendix F SIMPER results for all outfall, positive-control and control locations 2002, 2005, 2008, 2011, 2014

```
Similarity Percentages - species contributions
One-Way Analysis
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 100.00%

Group LR-2002
Average similarity: 49.20
Species                                               Av.Abund     Av.Sim     Sim/SD   Contrib%   Cum.%
Crustacea Leptocheliidae                                  3.86       5.50       2.59      11.18   11.18
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae            3.10       3.65       2.78       7.41   18.59
Polychaeta Onuphidae                                      1.94       2.97       5.36       6.04   24.64
Polychaeta Sabellidae                                     2.12       2.53       1.72       5.14   29.77
Crustacea Phoxocephalidae                                 1.80       2.46       1.77       5.00   34.78
Polychaeta Spionidae                                      1.83       2.21       1.65       4.49   39.27
Crustacea Ampeliscidae                                    2.06       2.20       1.59       4.47   43.74
Crustacea Apseudidae                                      2.13       2.18       1.54       4.44   48.18
Polychaeta Syllidae                                       1.79       2.06       1.18       4.19   52.37
Polychaeta Maldanidae                                     2.77       1.87       0.95       3.80   56.17
Crustacea Ischyroceridae                                  1.83       1.86       1.74       3.79   59.96
Polychaeta Lumbrineridae                                  1.49       1.72       1.79       3.49   63.45
Polychaeta Cirratulidae                                   1.24       1.59       1.68       3.24   66.69
Polychaeta Paraonidae                                     1.33       1.45       1.10       2.95   69.63
Crustacea Cypridinidae/Rutidermatidae                     1.09       1.20       1.23       2.44   72.08
Mollusca Nuculanidae                                      1.04       1.13       1.22       2.30   74.37
Crustacea Lysianassidae                                   0.99       0.83       0.87       1.69   76.06
Crustacea Paratanaidae                                    0.77       0.82       0.91       1.66   77.72
Crustacea Synopiidae                                      0.96       0.73       0.68       1.47   79.20
Polychaeta Oweniidae                                      1.35       0.71       0.66       1.44   80.64
Crustacea Diastylidae/Gynodiastylidae                     0.81       0.62       0.66       1.26   81.90
Crustacea Leptanthuridae                                  1.35       0.62       0.69       1.25   83.15
Polychaeta Amphinomidae                                   0.61       0.42       0.52       0.86   84.01
Polychaeta Capitellidae                                   0.66       0.41       0.51       0.84   84.85
Crustacea Paguridae                                       0.66       0.40       0.52       0.81   85.66
Mollusca Galeommatidae                                    0.66       0.39       0.52       0.79   86.45
Crustacea Nebaliidae                                      0.69       0.39       0.51       0.79   87.24
Polychaeta Nephtyidae                                     0.62       0.38       0.52       0.77   88.01
Crustacea Anthuridae                                      0.54       0.35       0.52       0.72   88.73
Polychaeta Trichobranchidae                               0.60       0.35       0.52       0.71   89.44
Crustacea Pasiphaeidae                                    0.50       0.35       0.53       0.71   90.15
Polychaeta Opheliidae                                     0.57       0.34       0.52       0.69   90.84
Crustacea Cirolanidae                                     0.52       0.30       0.38       0.61   91.45
Polychaeta Chaetopteridae                                 0.40       0.24       0.38       0.49   91.94
Mollusca Marginellidae                                    0.44       0.23       0.38       0.47   92.41
Crustacea Atylidae                                        0.44       0.23       0.38       0.46   92.87
Mollusca Propeamussiidae                                  0.52       0.21       0.39       0.43   93.30
Polychaeta Ampharetidae                                   0.72       0.21       0.38       0.42   93.73
Crustacea Bodotriidae                                     0.40       0.20       0.39       0.40   94.12
Polychaeta Phyllodocidae                                  0.44       0.19       0.39       0.40   94.52
Crustacea Corophiidae                                     0.50       0.18       0.25       0.36   94.88
Polychaeta Glyceridae                                     0.34       0.15       0.26       0.31   95.19
Crustacea Pagurapseudidae                                 0.38       0.15       0.25       0.30   95.49
Polychaeta Dorvilleidae                                   0.34       0.13       0.26       0.27   95.76
Polychaeta Orbiniidae                                     0.30       0.13       0.26       0.27   96.03
Polychaeta Nereididae                                     0.34       0.13       0.26       0.27   96.30
Crustacea Sphaeromatidae                                  0.34       0.13       0.26       0.27   96.57
Polychaeta Goniadidae                                     0.41       0.13       0.26       0.26   96.82
Polychaeta Scalibregmatidae                               0.37       0.12       0.26       0.25   97.07
Polychaeta Oenonidae                                      0.30       0.12       0.26       0.24   97.31
Polychaeta Polynoidae                                     0.34       0.11       0.26       0.23   97.54
```

```
Crustacea Philomedidae                              0.37        0.11        0.26       0.22  97.76
Polychaeta Terebellidae                             0.40        0.11        0.26       0.22  97.98
Crustacea Diogenidae                                0.63        0.10        0.15       0.21  98.19
Mollusca Turridae                                   0.37        0.10        0.26       0.21  98.39
Mollusca Condylocardiidae                           0.30        0.10        0.26       0.20  98.59
Mollusca Veneridae                                  0.30        0.10        0.26       0.20  98.79
Crustacea Liljeborgiidae                            0.30        0.10        0.26       0.20  98.98
Crustacea Caprellidae                               0.31        0.05        0.15       0.11  99.09
Polychaeta Pectinariidae                            0.28        0.05        0.15       0.10  99.19
Mollusca Volutomitridae                             0.20        0.04        0.15       0.09  99.28
Crustacea Melitidae                                 0.20        0.04        0.15       0.09  99.36
Crustacea Platyischnopidae                          0.20        0.04        0.15       0.08  99.45
Crustacea Chaetiliidae                              0.24        0.04        0.15       0.08  99.53
Mollusca Chaetodermatidae                           0.31        0.04        0.15       0.08  99.61
Mollusca Rissoidae                                  0.24        0.04        0.15       0.07  99.68
Polychaeta Flabelligeridae                          0.20        0.04        0.15       0.07  99.75
Mollusca Acteonidae                                 0.20        0.03        0.15       0.07  99.82
Crustacea Serolidae                                 0.20        0.03        0.15       0.06  99.89
Crustacea Urothoidae                                0.20        0.03        0.15       0.06  99.94
Mollusca Olividae                                   0.20        0.03        0.15       0.06 100.00


Group LR-2005
Average similarity: 36.37
Species                                         Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Crustacea Phoxocephalidae                           1.80        3.93        2.35      10.81  10.81
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      3.24        3.44        1.12       9.46  20.27
Crustacea Ampeliscidae                              1.95        2.68        1.18       7.38  27.65
Crustacea Lysianassidae                             1.35        2.46        1.72       6.75  34.40
Crustacea Leptocheliidae                            1.87        2.32        1.61       6.37  40.78
Crustacea Oedicerotidae                             1.33        2.09        0.96       5.76  46.53
Crustacea Apseudidae                                1.18        1.78        0.75       4.90  51.43
Crustacea Ischyroceridae                            1.50        1.76        0.83       4.85  56.28
Crustacea Diastylidae/Gynodiastylidae               1.13        1.60        1.16       4.39  60.66
Mollusca Marginellidae                              0.70        1.31        0.87       3.60  64.26
Polychaeta Spionidae                                1.06        1.26        0.87       3.47  67.73
Crustacea Synopiidae                                0.76        0.99        0.48       2.72  70.45
Polychaeta Lumbrineridae                            0.78        0.97        0.66       2.67  73.12
Mollusca Veneridae                                  0.76        0.94        0.63       2.59  75.72
Polychaeta Syllidae                                 1.01        0.86        0.67       2.36  78.07
Polychaeta Maldanidae                               1.44        0.80        0.47       2.19  80.27
Polychaeta Amphinomidae                             1.08        0.64        0.27       1.75  82.02
Crustacea Leptanthuridae                            0.64        0.51        0.51       1.39  83.41
Polychaeta Cirratulidae                             0.50        0.50        0.51       1.38  84.79
Crustacea Pagurapseudidae                           0.77        0.44        0.36       1.20  85.99
Polychaeta Terebellidae                             0.50        0.39        0.53       1.07  87.06
Crustacea Cylindroleberidae                         0.44        0.37        0.37       1.02  88.08
Crustacea Anthuridae                                0.47        0.32        0.37       0.88  88.95
Crustacea Nebaliidae                                0.51        0.31        0.38       0.85  89.80
Crustacea Cypridinidae/Rutidermatidae               0.51        0.29        0.38       0.79  90.59
Polychaeta Trichobranchidae                         0.44        0.26        0.38       0.72  91.31
Polychaeta Onuphidae                                0.44        0.24        0.39       0.65  91.96
Polychaeta Glyceridae                               0.34        0.20        0.26       0.54  92.50
Polychaeta Oweniidae                                0.77        0.18        0.26       0.49  92.99
Mollusca Pectinidae                                 0.34        0.17        0.26       0.48  93.46
Mollusca Nuculanidae                                0.55        0.17        0.24       0.47  93.93
Polychaeta Phyllodocidae                            0.30        0.17        0.26       0.46  94.39
Mollusca Turritellidae                              0.30        0.16        0.26       0.44  94.83
Polychaeta Opheliidae                               0.51        0.16        0.26       0.44  95.26
Crustacea Pasiphaeidae                              0.44        0.15        0.26       0.42  95.69
Crustacea Urothoidae                                0.30        0.14        0.26       0.39  96.08
Crustacea Philomedidae                              0.54        0.13        0.26       0.36  96.44
Crustacea Nannastacidae                             0.34        0.13        0.26       0.35  96.79
Crustacea Urohaustoriidae                           0.34        0.07        0.15       0.19  96.99
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Polychaeta Fauveliopsidae                          0.24        0.06        0.15       0.18  97.16
Crustacea Bodotriidae                              0.37        0.06        0.15       0.16  97.32
Mollusca Olividae                                  0.24        0.06        0.15       0.16  97.48
Crustacea Stenothoidae                             0.20        0.06        0.15       0.15  97.63
Crustacea Cirolanidae                              0.20        0.05        0.15       0.15  97.78
Crustacea Atylidae                                 0.20        0.05        0.15       0.15  97.92
Crustacea Diogenidae                               0.20        0.05        0.15       0.15  98.07
Polychaeta Capitellidae                            0.24        0.05        0.15       0.14  98.21
Crustacea Antarcturidae                            0.27        0.05        0.15       0.14  98.36
Polychaeta Nephtyidae                              0.20        0.05        0.15       0.13  98.49
Crustacea Whiteleggiidae                           0.20        0.05        0.15       0.13  98.62
Mollusca Columbellidae                             0.20        0.05        0.15       0.13  98.75
Crustacea Podoceridae                              0.20        0.05        0.15       0.13  98.88
Mollusca Condylocardiidae                          0.20        0.05        0.15       0.13  99.01
Mollusca Laevidentaliidae                          0.20        0.04        0.15       0.11  99.12
Polychaeta Sigalionidae                            0.20        0.04        0.15       0.11  99.23
Mollusca Cuspidariidae                             0.20        0.04        0.15       0.11  99.34
Crustacea Paranthuridae                            0.24        0.04        0.15       0.10  99.44
Mollusca Chaetodermatidae                          0.20        0.03        0.15       0.09  99.54
Polychaeta Ampharetidae                            0.27        0.03        0.15       0.09  99.63
Crustacea Paratanaidae                             0.27        0.03        0.15       0.09  99.72
Crustacea Sarsiellidae                             0.24        0.03        0.15       0.09  99.82
Crustacea Liljeborgiidae                           0.27        0.03        0.15       0.09  99.91
Mollusca Volutomitridae                            0.24        0.03        0.15       0.09 100.00

Group LR-2008
Average similarity: 40.16
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Crustacea Apseudidae                               3.29        5.23        2.03      13.02  13.02
Crustacea Phoxocephalidae                          2.32        4.46        2.26      11.10  24.13
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     3.75        4.07        1.51      10.14  34.27
Crustacea Leptocheliidae                           3.35        3.55        1.38       8.84  43.10
Crustacea Ampeliscidae                             2.70        3.24        2.50       8.06  51.16
Crustacea Lysianassidae                            1.47        1.92        1.11       4.79  55.95
Polychaeta Onuphidae                               2.07        1.54        1.10       3.84  59.80
Crustacea Philomedidae                             1.09        1.31        1.04       3.25  63.05
Crustacea Paratanaidae                             1.71        1.23        0.84       3.06  66.10
Polychaeta Cirratulidae                            1.05        1.21        0.74       3.01  69.11
Polychaeta Sabellidae                              1.68        1.07        0.84       2.67  71.78
Crustacea Cypridinidae/Rutidermatidae              0.97        1.05        0.61       2.63  74.41
Mollusca Galeommatidae                             1.23        1.03        0.73       2.56  76.96
Crustacea Diastylidae/Gynodiastylidae              1.11        0.96        0.85       2.39  79.35
Mollusca Nuculanidae                               1.08        0.80        0.64       1.99  81.34
Polychaeta Lumbrineridae                           0.92        0.65        0.65       1.63  82.96
Polychaeta Terebellidae                            0.98        0.64        0.65       1.58  84.55
Polychaeta Orbiniidae                              0.72        0.53        0.66       1.32  85.86
Crustacea Oedicerotidae                            0.78        0.49        0.47       1.23  87.09
Crustacea Bodotriidae                              0.97        0.46        0.51       1.16  88.24
Crustacea Ischyroceridae                           1.08        0.44        0.46       1.11  89.35
Polychaeta Spionidae                               0.77        0.37        0.50       0.91  90.26
Crustacea Anthuridae                               0.69        0.34        0.52       0.84  91.10
Polychaeta Maldanidae                              2.01        0.28        0.23       0.69  91.79
Polychaeta Syllidae                                0.76        0.25        0.38       0.61  92.41
Crustacea Serolidae                                0.40        0.24        0.37       0.60  93.01
Crustacea Platyischnopidae                         0.30        0.24        0.26       0.59  93.60
Polychaeta Oweniidae                               0.56        0.18        0.38       0.45  94.05
Mollusca Veneridae                                 0.51        0.16        0.38       0.40  94.46
Polychaeta Scalibregmatidae                        0.44        0.15        0.39       0.38  94.83
Crustacea Urohaustoriidae                          0.55        0.13        0.26       0.32  95.15
Crustacea Cirolanidae                              0.50        0.12        0.25       0.31  95.46
Polychaeta Ampharetidae                            1.12        0.12        0.23       0.30  95.76
Mollusca Mytilidae                                 0.41        0.11        0.25       0.29  96.05
Mollusca Limidae                                   0.60        0.11        0.26       0.28  96.33
Crustacea Leptanthuridae                           0.65        0.10        0.25       0.26  96.58
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Polychaeta Sigalionidae                            0.34        0.10        0.25       0.25  96.84
Crustacea Melphidippidae                           0.30        0.10        0.26       0.25  97.09
Crustacea Chaetiliidae                             0.37        0.10        0.26       0.25  97.33
Polychaeta Paraonidae                              0.30        0.10        0.26       0.25  97.58
Mollusca Cuspidariidae                             0.41        0.10        0.26       0.25  97.83
Crustacea Sphaeromatidae                           0.30        0.10        0.26       0.24  98.07
Polychaeta Opheliidae                              0.34        0.09        0.26       0.23  98.30
Crustacea Paranthuridae                            0.40        0.09        0.26       0.23  98.53
Mollusca Propeamussiidae                           0.38        0.08        0.26       0.20  98.74
Polychaeta Eunicidae                               0.20        0.08        0.15       0.20  98.93
Crustacea Paguridae                                0.24        0.04        0.15       0.10  99.04
Crustacea Cylindroleberidae                        0.20        0.04        0.15       0.10  99.13
Polychaeta Polynoidae                              0.20        0.04        0.15       0.10  99.23
Crustacea Arcturididae                             0.20        0.04        0.15       0.10  99.32
Crustacea Sarsiellidae                             0.27        0.03        0.15       0.09  99.41
Polychaeta Nephtyidae                              0.20        0.03        0.15       0.08  99.50
Crustacea Arcturidae                               0.30        0.03        0.15       0.08  99.58
Polychaeta Amphinomidae                            0.20        0.03        0.15       0.07  99.65
Crustacea Nebaliidae                               0.24        0.03        0.15       0.07  99.72
Mollusca Marginellidae                             0.24        0.02        0.15       0.06  99.78
Mollusca Nassariidae                               0.24        0.02        0.15       0.06  99.83
Polychaeta Capitellidae                            0.24        0.02        0.15       0.06  99.89
Crustacea Podoceridae                              0.20        0.02        0.15       0.06  99.95
Mollusca Laevidentaliidae                          0.24        0.02        0.15       0.05 100.00

Group LR-2011
Average similarity: 50.07
Species                                        Av.Abund    Av.Sim     Sim/SD  Contrib%   Cum.%
Crustacea Ampeliscidae                             4.81      4.43       2.37      8.85    8.85
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     4.78      4.14       2.34      8.27   17.12
Crustacea Leptocheliidae                           5.08      3.08       2.06      6.14   23.27
Polychaeta Onuphidae                               4.43      2.62       2.11      5.22   28.49
Crustacea Ischyroceridae                           3.44      2.56       2.55      5.12   33.61
Crustacea Phoxocephalidae                          2.33      2.15       3.75      4.30   37.91
Polychaeta Maldanidae                              3.65      2.11       0.76      4.21   42.12
Crustacea Apseudidae                               2.58      2.09       2.49      4.17   46.29
Polychaeta Spionidae                               2.89      2.08       2.27      4.15   50.44
Polychaeta Sabellidae                              2.46      1.73       1.18      3.45   53.89
Polychaeta Cirratulidae                            1.85      1.67       3.17      3.33   57.22
Polychaeta Ampharetidae                            2.22      1.52       1.11      3.03   60.25
Crustacea Synopiidae                               1.79      1.48       4.29      2.96   63.21
Crustacea Lysianassidae                            1.42      1.26       1.59      2.52   65.73
Crustacea Diastylidae/Gynodiastylidae              1.80      1.20       1.66      2.39   68.12
Polychaeta Lumbrineridae                           1.28      1.12       1.71      2.23   70.35
Crustacea Paranthuridae                            1.47      1.06       1.10      2.12   72.47
Polychaeta Syllidae                                2.08      1.06       1.09      2.12   74.59
Crustacea Cirolanidae                              1.54      1.00       1.08      1.99   76.58
Crustacea Paratanaidae                             1.62      0.92       0.91      1.84   78.42
Crustacea Nebaliidae                               1.00      0.84       1.14      1.67   80.09
Crustacea Caprellidae                              1.33      0.83       0.84      1.65   81.74
Echinodermata Ophiuroidea                          1.08      0.70       0.82      1.40   83.14
Crustacea Paguridae                                1.03      0.57       0.88      1.14   84.28
Polychaeta Oweniidae                               1.32      0.53       0.61      1.06   85.34
Mollusca Chaetodermatidae                          0.86      0.45       0.66      0.91   86.25
Crustacea Arcturidae                               0.93      0.45       0.64      0.90   87.15
Polychaeta Paraonidae                              1.30      0.40       0.40      0.79   87.94
Mollusca Nuculidae                                 0.68      0.37       0.69      0.75   88.68
Polychaeta Amphinomidae                            1.39      0.37       0.50      0.74   89.43
Crustacea Melphidippidae                           0.62      0.33       0.52      0.66   90.08
Crustacea Serolidae                                0.72      0.30       0.52      0.59   90.68
Polychaeta Goniadidae                              0.58      0.29       0.52      0.58   91.26
Crustacea Anthuridae                               0.77      0.29       0.50      0.58   91.83
Mollusca Turridae                                  0.62      0.27       0.52      0.54   92.37
Polychaeta Nephtyidae                              0.64      0.25       0.52      0.49   92.86
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Crustacea Pasiphaeidae                              0.50     0.24        0.52      0.48   93.34
Mollusca Nuculanidae                                0.62     0.24        0.39      0.47   93.82
Mollusca Cuspidariidae                              0.48     0.18        0.38      0.37   94.18
Polychaeta Orbiniidae                               0.59     0.18        0.38      0.35   94.53
Mollusca Anabathridae                               0.48     0.17        0.39      0.35   94.88
Polychaeta Capitellidae                             0.51     0.17        0.38      0.33   95.21
Crustacea Cypridinidae/Rutidermatidae               0.59     0.16        0.38      0.33   95.54
Crustacea Paramunnidae                              0.54     0.16        0.39      0.32   95.86
Crustacea Bodotriidae                               0.54     0.15        0.38      0.31   96.17
Crustacea Atylidae                                  0.54     0.15        0.37      0.30   96.47
Polychaeta Sigalionidae                             0.48     0.15        0.38      0.30   96.77
Crustacea Philomedidae                              0.40     0.14        0.38      0.28   97.05
Polychaeta Chaetopteridae                           0.44     0.14        0.38      0.28   97.33
Mollusca Mytilidae                                  0.52     0.11        0.25      0.21   97.54
Crustacea Podoceridae                               0.34     0.10        0.26      0.19   97.74
Crustacea Urothoidae                                0.46     0.09        0.26      0.18   97.91
Echinodermata Echinoidea                            0.34     0.09        0.26      0.17   98.08
Crustacea Leptanthuridae                            0.30     0.08        0.26      0.17   98.25
Mollusca Marginellidae                              0.37     0.08        0.26      0.15   98.40
Crustacea Cylindroleberidae                         0.34     0.08        0.26      0.15   98.55
Polychaeta Opheliidae                               0.38     0.07        0.26      0.15   98.70
Crustacea Eusiridae                                 0.34     0.07        0.26      0.15   98.85
Polychaeta Flabelligeridae                          0.38     0.07        0.26      0.14   98.99
Crustacea Sphaeromatidae                            0.34     0.07        0.26      0.13   99.12
Polychaeta Pholoidae                                0.28     0.05        0.15      0.09   99.21
Polychaeta Terebellidae                             0.28     0.04        0.15      0.09   99.30
Crustacea Oedicerotidae                             0.28     0.04        0.15      0.08   99.38
Polychaeta Nereididae                               0.28     0.04        0.15      0.07   99.45
Crustacea Arcturididae                              0.34     0.04        0.15      0.07   99.52
Polychaeta Oenonidae                                0.24     0.03        0.15      0.07   99.58
Mollusca Acteonidae                                 0.27     0.03        0.15      0.06   99.64
Mollusca Rissoidae                                  0.20     0.03        0.15      0.05   99.70
Crustacea Whiteleggiidae                            0.49     0.03        0.15      0.05   99.75
Crustacea Chaetiliidae                              0.24     0.03        0.15      0.05   99.80
Polychaeta Trichobranchidae                         0.24     0.02        0.15      0.04   99.84
Polychaeta Scalibregmatidae                         0.20     0.02        0.15      0.04   99.88
Mollusca Galeommatidae                              0.27     0.02        0.15      0.04   99.92
Mollusca Condylocardiidae                           0.20     0.02        0.15      0.04   99.96
Crustacea Liljeborgiidae                            0.24     0.02        0.15      0.04  100.00
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Group LR-2014

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Average similarity: 57.83
Species                                         Av.Abund     Av.Sim      Sim/SD    Contrib%  Cum.%
Crustacea Leptocheliidae                           11.46       9.91        2.88       17.14  17.14
Mollusca Mytilidae                                  4.76       4.93        3.70        8.53  25.67
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      4.08       4.20        4.30        7.27  32.94
Crustacea Ampeliscidae                              3.09       3.17        3.44        5.49  38.43
Crustacea Apseudidae                                2.84       2.59        1.73        4.49  42.91
Polychaeta Onuphidae                                2.93       2.59        2.97        4.48  47.39
Crustacea Paratanaidae                              3.35       2.52        3.82        4.36  51.75
Crustacea Ischyroceridae                            3.06       2.28        2.52        3.95  55.70
Polychaeta Sabellidae                               2.26       2.28        3.77        3.95  59.65
Polychaeta Maldanidae                               2.89       2.07        1.32        3.58  63.23
Crustacea Phoxocephalidae                           1.74       1.85        3.03        3.21  66.43
Polychaeta Trichobranchidae                         1.62       1.48        1.85        2.57  69.00
Polychaeta Cirratulidae                             1.28       1.17        1.69        2.03  71.03
Polychaeta Lumbrineridae                            1.21       1.05        1.65        1.81  72.83
Crustacea Lysianassidae                             1.34       1.00        1.15        1.72  74.56
Polychaeta Spionidae                                1.30       0.89        1.21        1.54  76.10
Crustacea Urothoidae                                1.06       0.84        1.14        1.46  77.56
Mollusca Galeommatidae                              0.84       0.71        1.25        1.23  78.79
Crustacea Neotaniadae                               1.20       0.71        0.87        1.22  80.01
Polychaeta Nephtyidae                               1.06       0.70        0.84        1.22  81.23
Crustacea Paranthuridae                             1.08       0.68        0.87        1.17  82.40
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Crustacea Diastylidae/Gynodiastylidae               0.93       0.66        0.88        1.13  83.53
Mollusca Nuculanidae                                0.90       0.65        0.91        1.13  84.66
Crustacea Bodotriidae                               1.04       0.65        0.90        1.12  85.78
Polychaeta Oweniidae                                0.92       0.64        0.83        1.10  86.88
Crustacea Synopiidae                                1.11       0.61        0.89        1.06  87.94
Polychaeta Ampharetidae                             1.21       0.60        0.58        1.04  88.98
Echinodermata Ophiuroidea                           0.86       0.57        0.90        0.99  89.97
Polychaeta Pectinariidae                            0.78       0.54        0.91        0.93  90.90
Mollusca Nuculidae                                  0.76       0.41        0.69        0.70  91.60
Mollusca Chaetodermatidae                           0.61       0.33        0.52        0.57  92.18
Polychaeta Paraonidae                               0.86       0.32        0.50        0.56  92.74
Crustacea Cirolanidae                               0.76       0.31        0.51        0.54  93.28
Mollusca Cuspidariidae                              0.58       0.30        0.52        0.52  93.81
Polychaeta Opheliidae                               0.66       0.29        0.52        0.50  94.31
Polychaeta Syllidae                                 0.58       0.28        0.50        0.48  94.79
Mollusca Turridae                                   0.57       0.27        0.53        0.46  95.25
Mollusca Anabathridae                               0.61       0.24        0.52        0.42  95.67
Mollusca Propeamussiidae                            0.63       0.18        0.38        0.31  95.99
Mollusca Marginellidae                              0.44       0.17        0.39        0.30  96.28
Crustacea Sarsiellidae                              0.40       0.17        0.39        0.30  96.58
Crustacea Oedicerotidae                             0.40       0.17        0.39        0.29  96.87
Crustacea Atylidae                                  0.40       0.14        0.39        0.25  97.12
Polychaeta Goniadidae                               0.44       0.13        0.39        0.23  97.35
Crustacea Nebaliidae                                0.57       0.12        0.25        0.21  97.57
Echinodermata Echinoidea                            0.30       0.09        0.26        0.16  97.73
Crustacea Anthuridae                                0.37       0.09        0.26        0.15  97.87
Polychaeta Scalibregmatidae                         0.30       0.09        0.26        0.15  98.02
Crustacea Antarcturidae                             0.34       0.08        0.26        0.14  98.17
Crustacea Callianassidae                            0.34       0.08        0.26        0.14  98.31
Polychaeta Phyllodocidae                            0.30       0.08        0.26        0.14  98.44
Mollusca Lucinidae                                  0.30       0.08        0.26        0.13  98.58
Polychaeta Flabelligeridae                          0.30       0.08        0.26        0.13  98.71
Crustacea Whiteleggiidae                            0.37       0.07        0.26        0.13  98.83
Crustacea Chaetiliidae                              0.40       0.07        0.26        0.13  98.96
Crustacea Serolidae                                 0.30       0.07        0.26        0.12  99.08
Mollusca Limidae                                    0.30       0.07        0.26        0.12  99.20
Mollusca Condylocardiidae                           0.34       0.07        0.26        0.11  99.31
Crustacea Pagurapseudidae                           0.34       0.05        0.15        0.08  99.40
Polychaeta Chaetopteridae                           0.20       0.04        0.15        0.06  99.46
Crustacea Liljeborgiidae                            0.24       0.04        0.15        0.06  99.52
Crustacea Philomedidae                              0.20       0.03        0.15        0.05  99.57
Crustacea Lampropidae                               0.20       0.03        0.15        0.05  99.62
Polychaeta Terebellidae                             0.20       0.03        0.15        0.05  99.67
Echinodermata Holothuroidea                         0.24       0.03        0.15        0.04  99.71
Mollusca Epigridae                                  0.20       0.03        0.15        0.04  99.76
Crustacea Nannastacidae                             0.20       0.02        0.15        0.04  99.80
Crustacea Cypridinidae/Rutidermatidae               0.24       0.02        0.15        0.04  99.84
Polychaeta Amphinomidae                             0.20       0.02        0.15        0.04  99.88
Crustacea Paguridae                                 0.27       0.02        0.15        0.04  99.92
Crustacea Eusiridae                                 0.24       0.02        0.15        0.04  99.96
Polychaeta Capitellidae                             0.20       0.02        0.15        0.04 100.00

Group B-2002
Average similarity: 51.22
Species                                   Av.Abund Av.Sim     Sim/SD     Contrib%   Cum.%
Polychaeta Ampharetidae                       6.46   3.34       1.28         6.51    6.51
Crustacea Ampeliscidae                        3.20   3.29       3.53         6.43   12.95
Crustacea Apseudidae                          2.38   2.65       3.75         5.17   18.12
Polychaeta Cirratulidae                       2.63   2.59       2.47         5.06   23.18
Polychaeta Maldanidae                         3.77   2.55       1.58         4.98   28.16
Crustacea Lysianassidae                       2.45   2.47       5.02         4.82   32.98
Echinodermata Ophiuroidea                     2.71   2.34       2.22         4.56   37.55
Polychaeta Onuphidae                          1.94   2.04       2.80         3.99   41.54
Polychaeta Spionidae                          2.11   2.02       2.95         3.95   45.48
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Crustacea Aoridae/Isaeidae/Photidae/Unciolidae	1.85	1.75	1.58	3.41	48.89
Crustacea Leptocheliidae	2.67	1.74	1.25	3.41	52.30
Crustacea Nebaliidae	1.73	1.71	3.66	3.34	55.64
Crustacea Phoxocephalidae	1.76	1.58	1.75	3.08	58.72
Polychaeta Syllidae	1.86	1.51	1.63	2.94	61.66
Crustacea Ischyroceridae	1.39	1.47	4.13	2.86	64.53
Crustacea Leptanthuridae	1.85	1.42	1.57	2.78	67.31
Polychaeta Sabellidae	1.39	1.30	1.73	2.53	69.84
Crustacea Bodotriidae	1.47	1.28	1.58	2.51	72.34
Polychaeta Paraonidae	1.43	1.09	1.13	2.13	74.48
Polychaeta Oweniidae	1.94	0.76	0.75	1.49	75.96
Mollusca Chaetodermatidae	1.15	0.76	0.87	1.48	77.44
Crustacea Synopiidae	1.17	0.68	0.84	1.32	78.77
Mollusca Galeommatidae	0.89	0.58	0.68	1.13	79.89
Polychaeta Pectinariidae	0.86	0.56	0.63	1.10	80.99
Polychaeta Orbiniidae	1.13	0.54	0.67	1.06	82.06
Crustacea Diastylidae/Gynodiastylidae	0.76	0.49	0.66	0.95	83.01
Crustacea Paguridae	0.91	0.48	0.67	0.94	83.94
Crustacea Anthuridae	0.71	0.48	0.68	0.93	84.87
Polychaeta Terebellidae	0.81	0.44	0.64	0.86	85.74
Polychaeta Chaetopteridae	0.68	0.44	0.68	0.86	86.60
Mollusca Nuculanidae	0.65	0.38	0.49	0.74	87.34
Crustacea Philomedidae	0.50	0.33	0.52	0.64	87.98
Echinodermata Echinoidea	0.62	0.32	0.50	0.63	88.61
Crustacea Atylidae	0.67	0.31	0.52	0.60	89.21
Crustacea Oedicerotidae	0.66	0.31	0.50	0.60	89.81
Crustacea Melphidippidae	0.71	0.30	0.52	0.58	90.39
Mollusca Marginellidae	0.70	0.29	0.51	0.57	90.96
Polychaeta Lumbrineridae	0.66	0.29	0.51	0.56	91.52
Polychaeta Sigalionidae	0.54	0.29	0.51	0.56	92.08
Mollusca Rissoidae	0.71	0.27	0.52	0.52	92.60
Polychaeta Nephtyidae	0.57	0.26	0.52	0.51	93.11
Crustacea Arcturidae	1.13	0.25	0.38	0.48	93.59
Crustacea Pasiphaeidae	0.57	0.22	0.38	0.43	94.03
Polychaeta Trichobranchidae	0.48	0.20	0.38	0.38	94.41
Crustacea Cypridinidae/Rutidermatidae	0.58	0.19	0.38	0.37	94.78
Polychaeta Fauveliopsidae	0.47	0.18	0.38	0.35	95.13
Crustacea Eusiridae	0.40	0.17	0.38	0.34	95.47
Crustacea Cylindroleberidae	0.51	0.17	0.38	0.33	95.80
Polychaeta Flabelligeridae	0.56	0.17	0.38	0.33	96.12
Echinodermata Asteroidea	0.40	0.16	0.38	0.32	96.44
Polychaeta Opheliidae	0.40	0.14	0.39	0.28	96.72
Mollusca Propeamussiidae	0.51	0.14	0.38	0.28	97.00
Mollusca Capulidae	0.44	0.14	0.38	0.27	97.27
Mollusca Turridae	0.40	0.13	0.39	0.26	97.53
Polychaeta Oenonidae	0.38	0.10	0.26	0.19	97.72
Crustacea Whiteleggiidae	0.68	0.09	0.15	0.18	97.90
Polychaeta Phyllodocidae	0.38	0.08	0.26	0.17	98.07
Crustacea Urothoidae	0.34	0.08	0.26	0.16	98.23
Mollusca Olivellidae	0.34	0.08	0.26	0.16	98.39
Crustacea Leucosiidae	0.30	0.07	0.26	0.14	98.54
Mollusca Mytilidae	0.47	0.07	0.26	0.14	98.68
Mollusca Philobryidae	0.30	0.07	0.26	0.14	98.82
Polychaeta Polynoidae	0.30	0.07	0.26	0.14	98.95
Crustacea Paramunnidae	0.30	0.06	0.26	0.12	99.07
Mollusca Trochidae	0.30	0.06	0.26	0.12	99.19
Crustacea Callianassidae	0.24	0.04	0.15	0.07	99.26
Crustacea Sarsiellidae	0.20	0.04	0.15	0.07	99.33
Mollusca Lucinidae	0.27	0.03	0.15	0.06	99.39
Crustacea Arcturididae	0.20	0.03	0.15	0.06	99.45
Crustacea Grapsidae	0.20	0.03	0.15	0.06	99.51
Echinodermata Holothuroidea	0.20	0.03	0.15	0.05	99.56
Mollusca Columbellidae	0.20	0.03	0.15	0.05	99.61
Crustacea Serolidae	0.24	0.03	0.15	0.05	99.66

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Crustacea Paratanaidae                       0.27   0.02        0.15         0.05  99.70
Polychaeta Poecilochaetidae                  0.20   0.02        0.15         0.05  99.75
Crustacea Corophiidae                        0.24   0.02        0.15         0.05  99.80
Mollusca Cylichnidae                         0.20   0.02        0.15         0.05  99.84
Mollusca Anabathridae                        0.24   0.02        0.15         0.04  99.88
Crustacea Podoceridae                        0.27   0.02        0.15         0.04  99.92
Crustacea Caprellidae                        0.34   0.02        0.15         0.04  99.96
Mollusca Volutomitridae                      0.20   0.02        0.15         0.04 100.00

Group B-2005
Average similarity: 49.83
Species                                        Av.Abund    Av.Sim       Sim/SD  Contrib%   Cum.%
Polychaeta Oweniidae                               4.84      3.50         1.19      7.03    7.03
Polychaeta Spionidae                               2.99      3.47         3.13      6.97   13.99
Crustacea Lysianassidae                            2.99      3.20         2.75      6.41   20.41
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     2.95      3.09         1.91      6.20   26.60
Crustacea Ampeliscidae                             3.40      2.98         1.36      5.98   32.58
Crustacea Apseudidae                               2.98      2.70         1.70      5.42   38.00
Polychaeta Maldanidae                              3.89      2.52         0.94      5.05   43.06
Crustacea Phoxocephalidae                          2.16      2.11         2.20      4.24   47.30
Crustacea Leptocheliidae                           2.53      1.95         1.63      3.91   51.21
Polychaeta Cirratulidae                            2.18      1.93         1.60      3.88   55.09
Echinodermata Ophiuroidea                          1.73      1.73         1.59      3.46   58.55
Crustacea Synopiidae                               1.97      1.45         0.92      2.92   61.47
Polychaeta Syllidae                                1.37      1.20         1.17      2.41   63.88
Polychaeta Onuphidae                               1.78      1.20         0.77      2.40   66.28
Crustacea Bodotriidae                              1.15      1.12         1.23      2.25   68.54
Mollusca Nuculanidae                               1.15      1.03         0.85      2.07   70.61
Crustacea Paranthuridae                            1.32      0.97         1.18      1.95   72.56
Polychaeta Terebellidae                            1.29      0.93         0.87      1.87   74.43
Crustacea Diastylidae/Gynodiastylidae              0.91      0.88         1.21      1.77   76.20
Crustacea Philomedidae                             1.21      0.86         0.84      1.72   77.91
Polychaeta Ampharetidae                            1.90      0.81         0.61      1.63   79.55
Crustacea Urothoidae                               1.23      0.80         0.86      1.61   81.15
Crustacea Nebaliidae                               1.11      0.78         0.68      1.56   82.72
Polychaeta Sabellidae                              0.80      0.71         0.91      1.42   84.14
Crustacea Oedicerotidae                            0.97      0.71         0.89      1.42   85.56
Crustacea Ischyroceridae                           1.15      0.69         0.89      1.39   86.95
Crustacea Anthuridae                               0.86      0.65         0.90      1.31   88.26
Mollusca Marginellidae                             0.75      0.53         0.68      1.05   89.31
Crustacea Cylindroleberidae                        0.77      0.45         0.66      0.91   90.22
Crustacea Cypridinidae/Rutidermatidae              0.61      0.33         0.50      0.66   90.89
Mollusca Veneridae                                 0.64      0.32         0.50      0.64   91.53
Crustacea Arcturidae                               0.94      0.32         0.52      0.63   92.16
Crustacea Leptanthuridae                           0.50      0.30         0.51      0.61   92.77
Crustacea Melphidippidae                           0.58      0.29         0.52      0.58   93.35
Polychaeta Chaetopteridae                          0.50      0.28         0.52      0.56   93.91
Crustacea Atylidae                                 0.54      0.27         0.52      0.54   94.45
Mollusca Nassariidae                               0.51      0.21         0.38      0.42   94.87
Mollusca Propeamussiidae                           0.84      0.20         0.36      0.40   95.27
Mollusca Rissoidae                                 0.66      0.18         0.38      0.37   95.64
Polychaeta Pectinariidae                           0.47      0.17         0.38      0.35   95.99
Crustacea Caprellidae                              0.40      0.17         0.38      0.34   96.32
Mollusca Lucinidae                                 0.51      0.16         0.37      0.32   96.64
Polychaeta Orbiniidae                              0.48      0.16         0.38      0.32   96.96
Mollusca Mytilidae                                 0.51      0.12         0.26      0.24   97.21
Polychaeta Sigalionidae                            0.40      0.11         0.26      0.22   97.43
Crustacea Diogenidae                               0.30      0.11         0.26      0.21   97.64
Crustacea Pasiphaeidae                             0.34      0.10         0.26      0.21   97.85
Polychaeta Polynoidae                              0.30      0.10         0.26      0.20   98.05
Mollusca Myochamidae                               0.30      0.09         0.26      0.19   98.23
Polychaeta Lumbrineridae                           0.30      0.09         0.26      0.18   98.41
Echinodermata Echinoidea                           0.30      0.08         0.26      0.16   98.58
Mollusca Pyramidellidae                            0.30      0.08         0.26      0.16   98.73
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Polychaeta Glyceridae                                    0.30      0.08         0.26      0.15    98.88
Crustacea Cirolanidae                                    0.30      0.07         0.26      0.15    99.03
Polychaeta Fauveliopsidae                                0.42      0.06         0.15      0.13    99.16
Crustacea Paguridae                                      0.28      0.05         0.15      0.10    99.26
Crustacea Serolidae                                      0.20      0.04         0.15      0.08    99.34
Polychaeta Phyllodocidae                                 0.45      0.03         0.15      0.07    99.41
Mollusca Olivellidae                                     0.20      0.03         0.15      0.06    99.47
Mollusca Trochidae                                       0.20      0.03         0.15      0.06    99.53
Polychaeta Nephtyidae                                    0.27      0.03         0.15      0.06    99.59
Mollusca Cuspidariidae                                   0.24      0.03         0.15      0.06    99.65
Mollusca Chaetodermatidae                                0.24      0.03         0.15      0.06    99.70
Mollusca Laevidentaliidae                                0.20      0.03         0.15      0.05    99.76
Mollusca Turridae                                        0.20      0.03         0.15      0.05    99.81
Polychaeta Scalibregmatidae                              0.20      0.02         0.15      0.05    99.86
Mollusca Volutomitridae                                  0.27      0.02         0.15      0.05    99.91
Polychaeta Opheliidae                                    0.20      0.02         0.15      0.05    99.95
Crustacea Sphaeromatidae                                 0.24      0.02         0.15      0.05   100.00

Group B-2008
Average similarity: 51.02
Species                                              Av.Abund      Av.Sim      Sim/SD  Contrib%   Cum.%
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae           5.83        5.40        5.41     10.58   10.58
Polychaeta Ampharetidae                                  8.30        4.01        0.86      7.85   18.43
Crustacea Apseudidae                                     3.53        2.86        3.98      5.61   24.04
Polychaeta Maldanidae                                    4.67        2.81        1.00      5.51   29.55
Crustacea Leptocheliidae                                 3.65        2.56        1.31      5.01   34.56
Polychaeta Onuphidae                                     3.04        2.56        2.91      5.01   39.57
Crustacea Ampeliscidae                                   3.53        2.46        1.69      4.82   44.40
Polychaeta Spionidae                                     2.83        2.24        2.44      4.39   48.78
Polychaeta Cirratulidae                                  2.42        2.17        2.23      4.26   53.04
Crustacea Lysianassidae                                  2.36        2.14        3.38      4.20   57.24
Polychaeta Syllidae                                      2.20        2.12        5.14      4.15   61.39
Crustacea Synopiidae                                     2.87        1.83        1.29      3.58   64.97
Crustacea Phoxocephalidae                                1.81        1.60        3.42      3.14   68.11
Crustacea Atylidae                                       1.49        1.11        1.57      2.18   70.30
Crustacea Nebaliidae                                     1.52        1.06        1.19      2.07   72.36
Crustacea Bodotriidae                                    1.31        1.00        1.09      1.95   74.32
Polychaeta Sabellidae                                    1.59        0.99        1.03      1.95   76.26
Echinodermata Echinoidea                                 1.10        0.80        1.20      1.56   77.82
Echinodermata Ophiuroidea                                1.27        0.72        0.83      1.41   79.23
Crustacea Anthuridae                                     1.39        0.64        0.68      1.26   80.49
Crustacea Cypridinidae/Rutidermatidae                    1.19        0.59        0.62      1.15   81.65
Mollusca Veneridae                                       0.82        0.59        0.90      1.15   82.80
Crustacea Philomedidae                                   0.92        0.57        0.87      1.11   83.91
Crustacea Arcturidae                                     1.70        0.53        0.50      1.04   84.95
Crustacea Diastylidae/Gynodiastylidae                    0.81        0.52        0.91      1.01   85.96
Crustacea Ischyroceridae                                 1.06        0.50        0.66      0.98   86.94
Polychaeta Orbiniidae                                    0.89        0.49        0.67      0.95   87.89
Mollusca Limidae                                         0.97        0.45        0.68      0.88   88.78
Polychaeta Lumbrineridae                                 0.88        0.42        0.68      0.82   89.60
Mollusca Nuculanidae                                     0.70        0.41        0.69      0.80   90.40
Mollusca Propeamussiidae                                 0.83        0.37        0.68      0.73   91.13
Crustacea Caprellidae                                    0.83        0.29        0.51      0.57   91.70
Crustacea Oedicerotidae                                  0.73        0.29        0.51      0.56   92.26
Polychaeta Oweniidae                                     0.75        0.27        0.51      0.52   92.79
Crustacea Urohaustoriidae                                0.58        0.26        0.52      0.52   93.30
Crustacea Leptanthuridae                                 0.79        0.24        0.39      0.47   93.77
Crustacea Sphaeromatidae                                 0.68        0.23        0.38      0.45   94.22
Crustacea Whiteleggiidae                                 0.75        0.19        0.38      0.38   94.60
Polychaeta Paraonidae                                    0.79        0.19        0.37      0.38   94.98
Crustacea Amaryllididae                                  0.40        0.18        0.38      0.35   95.33
Mollusca Mytilidae                                       0.52        0.17        0.38      0.33   95.66
Polychaeta Sigalionidae                                  0.44        0.17        0.38      0.33   95.99
Crustacea Podoceridae                                    0.48        0.17        0.37      0.33   96.32
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Crustacea Pasiphaeidae                             0.40        0.15        0.38       0.29  96.61
Mollusca Galeommatidae                             0.54        0.14        0.38       0.27  96.88
Mollusca Lucinidae                                 0.40        0.13        0.39       0.26  97.14
Crustacea Paranthuridae                            0.51        0.10        0.26       0.20  97.34
Polychaeta Dorvilleidae                            0.37        0.09        0.26       0.18  97.52
Polychaeta Pectinariidae                           0.45        0.09        0.25       0.17  97.70
Polychaeta Amphinomidae                            0.64        0.08        0.26       0.17  97.86
Polychaeta Goniadidae                              0.30        0.08        0.26       0.16  98.03
Crustacea Chaetiliidae                             0.34        0.08        0.26       0.15  98.18
Polychaeta Terebellidae                            0.42        0.08        0.26       0.15  98.33
Mollusca Marginellidae                             0.49        0.07        0.26       0.14  98.47
Crustacea Gnathiidae                               0.34        0.07        0.26       0.14  98.61
Polychaeta Nephtyidae                              0.30        0.07        0.26       0.14  98.75
Crustacea Sarsiellidae                             0.30        0.07        0.26       0.13  98.89
Crustacea Liljeborgiidae                           0.34        0.07        0.26       0.13  99.01
Crustacea Platyischnopidae                         0.30        0.06        0.26       0.12  99.14
Crustacea Serolidae                                0.46        0.04        0.15       0.09  99.23
Polychaeta Phyllodocidae                           0.24        0.03        0.15       0.06  99.28
Crustacea Diogenidae                               0.38        0.03        0.15       0.06  99.34
Crustacea Cirolanidae                              0.32        0.03        0.15       0.06  99.39
Polychaeta Opheliidae                              0.27        0.03        0.15       0.05  99.44
Polychaeta Nereididae                              0.30        0.03        0.15       0.05  99.49
Polychaeta Oenonidae                               0.20        0.02        0.15       0.05  99.54
Mollusca Capulidae                                 0.27        0.02        0.15       0.05  99.59
Crustacea Paratanaidae                             0.20        0.02        0.15       0.05  99.64
Crustacea Arcturididae                             0.27        0.02        0.15       0.05  99.69
Mollusca Condylocardiidae                          0.27        0.02        0.15       0.05  99.74
Polychaeta Capitellidae                            0.20        0.02        0.15       0.05  99.78
Mollusca Turridae                                  0.20        0.02        0.15       0.04  99.83
Mollusca Olivellidae                               0.20        0.02        0.15       0.04  99.87
Mollusca Chaetodermatidae                          0.38        0.02        0.15       0.04  99.91
Crustacea Austrarcturellidae                       0.20        0.02        0.15       0.04  99.96
Crustacea Paguridae                                0.24        0.02        0.15       0.04 100.00

Group B-2011
Average similarity: 59.13
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     8.51        4.70        4.02       7.95   7.95
Polychaeta Oweniidae                              10.85        4.19        1.32       7.08  15.03
Polychaeta Ampharetidae                            9.12        3.73        1.48       6.31  21.34
Polychaeta Onuphidae                               8.56        3.59        1.93       6.07  27.41
Polychaeta Spionidae                               6.21        3.27        2.62       5.52  32.93
Crustacea Ampeliscidae                             5.25        2.75        1.77       4.65  37.59
Crustacea Apseudidae                               4.45        2.25        1.55       3.80  41.39
Polychaeta Maldanidae                              5.19        2.06        1.22       3.48  44.87
Crustacea Lysianassidae                            4.31        2.02        1.47       3.42  48.29
Polychaeta Syllidae                                3.67        2.02        1.74       3.42  51.71
Crustacea Ischyroceridae                           3.63        1.73        1.69       2.92  54.63
Echinodermata Ophiuroidea                          2.52        1.36        2.56       2.29  56.92
Crustacea Phoxocephalidae                          2.29        1.32        1.71       2.22  59.15
Polychaeta Orbiniidae                              2.25        1.25        3.44       2.12  61.27
Crustacea Synopiidae                               2.09        1.23        2.80       2.09  63.35
Polychaeta Cirratulidae                            2.64        1.15        1.32       1.94  65.30
Mollusca Marginellidae                             1.93        1.12        2.89       1.90  67.20
Mollusca Mytilidae                                 2.36        1.08        1.84       1.82  69.02
Crustacea Agathotanaidae                           3.43        0.95        0.74       1.60  70.62
Polychaeta Sabellidae                              2.48        0.91        1.25       1.54  72.16
Crustacea Urothoidae                               1.53        0.91        3.34       1.54  73.70
Crustacea Bodotriidae                              2.05        0.91        1.57       1.54  75.24
Crustacea Nebaliidae                               1.76        0.75        1.16       1.27  76.51
Crustacea Diastylidae/Gynodiastylidae              1.50        0.75        1.63       1.26  77.78
Polychaeta Lumbrineridae                           1.40        0.71        1.81       1.19  78.97
Polychaeta Opheliidae                              1.48        0.68        1.26       1.14  80.11
Crustacea Whiteleggiidae                           1.52        0.65        1.19       1.10  81.21
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Crustacea Caprellidae	1.67	0.56	1.06	0.94	82.15
Crustacea Liljeborgiidae	1.06	0.51	1.12	0.86	83.02
Crustacea Podoceridae	1.27	0.50	0.85	0.85	83.87
Crustacea Cylindroleberidae	1.16	0.50	1.17	0.85	84.72
Crustacea Melphidippidae	1.04	0.49	1.12	0.83	85.56
Polychaeta Paraonidae	1.26	0.48	1.10	0.82	86.37
Crustacea Atylidae	1.24	0.45	0.90	0.77	87.14
Polychaeta Sigalionidae	0.99	0.43	1.22	0.72	87.86
Crustacea Eusiridae	1.19	0.41	0.67	0.69	88.55
Mollusca Galeommatidae	1.10	0.40	0.66	0.68	89.23
Crustacea Anthuridae	1.25	0.37	0.69	0.62	89.85
Mollusca Rissoidae	0.93	0.36	0.87	0.61	90.46
Crustacea Pasiphaeidae	0.99	0.36	0.88	0.60	91.06
Crustacea Arcturidae	1.29	0.35	0.65	0.58	91.65
Mollusca Anabathridae	1.22	0.35	0.66	0.58	92.23
Mollusca Turridae	0.86	0.32	0.87	0.54	92.77
Crustacea Paramunnidae	0.90	0.26	0.69	0.45	93.22
Mollusca Nuculanidae	0.92	0.26	0.67	0.45	93.66
Echinodermata Echinoidea	0.94	0.26	0.67	0.44	94.10
Crustacea Paranthuridae	0.86	0.23	0.66	0.39	94.49
Mollusca Chaetodermatidae	0.79	0.23	0.67	0.39	94.88
Crustacea Oedicerotidae	0.78	0.22	0.68	0.37	95.25
Crustacea Cirolanidae	0.68	0.21	0.69	0.36	95.60
Crustacea Paguridae	0.80	0.19	0.49	0.32	95.93
Polychaeta Chaetopteridae	0.76	0.18	0.51	0.31	96.24
Polychaeta Pectinariidae	0.68	0.16	0.51	0.27	96.51
Polychaeta Phyllodocidae	0.58	0.16	0.50	0.27	96.78
Polychaeta Goniadidae	0.54	0.16	0.52	0.26	97.05
Mollusca Lucinidae	0.54	0.16	0.52	0.26	97.31
Mollusca Laevidentaliidae	0.58	0.15	0.50	0.26	97.57
Polychaeta Trichobranchidae	0.61	0.14	0.53	0.24	97.81
Crustacea Leptanthuridae	1.36	0.14	0.53	0.23	98.05
Crustacea Philomedidae	0.58	0.14	0.52	0.23	98.28
Crustacea Cypridinidae/Rutidermatidae	0.57	0.13	0.53	0.23	98.50
Polychaeta Capitellidae	0.56	0.10	0.38	0.17	98.67
Mollusca Nassariidae	0.40	0.10	0.38	0.17	98.84
Mollusca Limidae	0.44	0.09	0.39	0.15	98.99
Polychaeta Nephtyidae	0.47	0.08	0.39	0.14	99.12
Polychaeta Amphinomidae	0.77	0.06	0.26	0.10	99.22
Mollusca Propeamussiidae	0.38	0.06	0.26	0.09	99.31
Polychaeta Aphroditidae	0.37	0.05	0.26	0.08	99.40
Mollusca Skeneidae	0.30	0.05	0.26	0.08	99.47
Crustacea Arcturididae	0.54	0.04	0.15	0.07	99.55
Polychaeta Scalibregmatidae	0.34	0.04	0.26	0.07	99.61
Mollusca Epigridae	0.30	0.04	0.26	0.07	99.68
Mollusca Pyramidellidae	0.34	0.04	0.26	0.07	99.75
Crustacea Sphaeromatidae	0.34	0.04	0.26	0.06	99.81
Polychaeta Sphaerodoridae	0.31	0.02	0.15	0.03	99.84
Crustacea Iciliidae	0.20	0.02	0.15	0.03	99.87
Mollusca Naticidae	0.20	0.02	0.15	0.03	99.89
Crustacea Paratanaidae	0.47	0.01	0.15	0.02	99.92
Polychaeta Flabelligeridae	0.20	0.01	0.15	0.02	99.94
Crustacea Goneplacidae	0.20	0.01	0.15	0.02	99.96
Crustacea Serolidae	0.24	0.01	0.15	0.02	99.98
Mollusca Veneridae	0.24	0.01	0.15	0.02	100.00

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Group B-2014
Average similarity: 60.88
Species                                         Av.Abund     Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Ampharetidae                            14.41       7.06        1.74      11.60  11.60
Crustacea Leptocheliidae                            9.31       5.01        4.39       8.24  19.83
Polychaeta Onuphidae                                7.46       4.36        3.50       7.17  27.00
Polychaeta Maldanidae                               7.86       3.77        1.72       6.19  33.19
Crustacea Ischyroceridae                            5.40       3.54        4.07       5.81  39.00
Mollusca Mytilidae                                  4.55       2.83        3.07       4.65  43.65
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      4.41       2.62        3.67       4.30  47.95
Crustacea Apseudidae                                3.50       2.24        4.80       3.68  51.63
Crustacea Lysianassidae                             3.66       2.16        3.12       3.54  55.17
Polychaeta Sabellidae                               3.59       1.77        1.62       2.91  58.08
Crustacea Ampeliscidae                              2.48       1.56        5.11       2.56  60.64
Polychaeta Cirratulidae                             2.34       1.56        3.50       2.55  63.19
Polychaeta Syllidae                                 2.49       1.34        1.53       2.19  65.38
Crustacea Phoxocephalidae                           1.92       1.20        4.35       1.97  67.36
Crustacea Synopiidae                                2.20       1.18        1.63       1.94  69.29
Polychaeta Spionidae                                1.80       1.10        3.64       1.81  71.10
Crustacea Paranthuridae                             2.34       1.09        1.79       1.78  72.89
Polychaeta Oweniidae                                2.46       1.01        1.13       1.67  74.55
Crustacea Nebaliidae                                2.00       0.97        1.32       1.59  76.14
Crustacea Anthuridae                                1.34       0.89        7.40       1.46  77.60
Mollusca Nuculanidae                                1.33       0.88        3.73       1.44  79.04
Echinodermata Ophiuroidea                           1.60       0.85        1.61       1.40  80.44
Mollusca Propeamussiidae                            1.87       0.76        1.05       1.25  81.69
Mollusca Anabathridae                               1.36       0.73        1.75       1.20  82.89
Crustacea Urothoidae                                1.27       0.70        1.79       1.16  84.05
Crustacea Arcturidae                                1.72       0.67        0.85       1.10  85.14
Crustacea Eusiridae                                 1.29       0.62        1.17       1.01  86.16
Crustacea Bodotriidae                               1.31       0.60        0.87       0.99  87.15
Mollusca Marginellidae                              1.20       0.59        1.21       0.98  88.12
Polychaeta Opheliidae                               1.20       0.56        1.23       0.92  89.04
Crustacea Diastylidae/Gynodiastylidae               1.16       0.53        0.89       0.87  89.91
Mollusca Rissoidae                                  1.24       0.47        0.89       0.77  90.69
Polychaeta Trichobranchidae                         1.09       0.46        0.89       0.76  91.45
Crustacea Cirolanidae                               1.09       0.41        0.86       0.67  92.11
Polychaeta Lumbrineridae                            0.89       0.29        0.65       0.48  92.60
Polychaeta Paraonidae                               0.81       0.25        0.68       0.42  93.01
Crustacea Whiteleggiidae                            0.97       0.24        0.51       0.39  93.40
Crustacea Podoceridae                               0.82       0.24        0.47       0.39  93.80
Polychaeta Orbiniidae                               0.79       0.23        0.51       0.37  94.17
Crustacea Neotaniadae                               0.77       0.20        0.52       0.33  94.50
Mollusca Chaetodermatidae                           0.66       0.19        0.51       0.32  94.81
Crustacea Atylidae                                  0.69       0.18        0.51       0.30  95.11
Crustacea Cylindroleberidae                         0.66       0.17        0.51       0.28  95.39
Crustacea Leptanthuridae                            0.61       0.17        0.52       0.28  95.67
Mollusca Skeneidae                                  0.58       0.17        0.52       0.27  95.95
Echinodermata Echinoidea                            0.61       0.16        0.53       0.26  96.21
Polychaeta Nephtyidae                               0.54       0.16        0.52       0.26  96.46
Crustacea Cypridinidae/Rutidermatidae               0.71       0.14        0.37       0.22  96.69
Mollusca Galeommatidae                              0.59       0.13        0.37       0.21  96.90
Crustacea Maeridae                                  0.47       0.12        0.38       0.19  97.09
Polychaeta Pectinariidae                            0.52       0.11        0.38       0.19  97.28
Crustacea Paguridae                                 0.48       0.11        0.37       0.19  97.46
Crustacea Oedicerotidae                             0.55       0.11        0.37       0.18  97.65
Crustacea Sarsiellidae                              0.40       0.11        0.38       0.17  97.82
Mollusca Turridae                                   0.44       0.11        0.39       0.17  97.99
Crustacea Liljeborgiidae                            0.44       0.10        0.39       0.17  98.16
Polychaeta Phyllodocidae                            0.47       0.10        0.38       0.16  98.32
Mollusca Volutomitridae                             0.40       0.09        0.39       0.14  98.47
Mollusca Trapeziidae                                0.44       0.08        0.39       0.14  98.61
Polychaeta Chaetopteridae                           0.38       0.07        0.25       0.12  98.72
Crustacea Philomedidae                              0.52       0.07        0.24       0.11  98.84
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Crustacea Gnathiidae                                   0.30        0.06        0.26        0.09   98.93
Polychaeta Goniadidae                                  0.34        0.06        0.26        0.09   99.02
Crustacea Paratanaidae                                 0.47        0.05        0.26        0.09   99.11
Mollusca Lucinidae                                     0.30        0.05        0.26        0.09   99.19
Crustacea Caprellidae                                  0.34        0.05        0.26        0.08   99.27
Crustacea Ochlesidae                                   0.34        0.05        0.26        0.08   99.35
Crustacea Platyischnopidae                             0.30        0.05        0.26        0.08   99.43
Mollusca Philobryidae                                  0.34        0.04        0.26        0.07   99.50
Crustacea Chaetiliidae                                 0.39        0.02        0.15        0.04   99.54
Polychaeta Oenonidae                                   0.20        0.02        0.15        0.03   99.57
Mollusca Haminoeidae                                   0.20        0.02        0.15        0.03   99.60
Crustacea Melphidippidae                               0.20        0.02        0.15        0.03   99.63
Crustacea Crangonidae                                  0.20        0.02        0.15        0.03   99.66
Crustacea Paramunnidae                                 0.20        0.02        0.15        0.03   99.69
Crustacea Rectarcturidae                               0.27        0.02        0.15        0.03   99.72
Crustacea Cyproideidae                                 0.20        0.02        0.15        0.03   99.75
Crustacea Leucosiidae                                  0.20        0.02        0.15        0.03   99.78
Polychaeta Nereididae                                  0.24        0.02        0.15        0.03   99.81
Polychaeta Sigalionidae                                0.20        0.02        0.15        0.03   99.84
Polychaeta Capitellidae                                0.20        0.02        0.15        0.03   99.86
Polychaeta Scalibregmatidae                            0.24        0.02        0.15        0.02   99.89
Mollusca Columbellidae                                 0.20        0.01        0.15        0.02   99.91
Crustacea Munnopsidae                                  0.27        0.01        0.15        0.02   99.94
Mollusca Veneridae                                     0.24        0.01        0.15        0.02   99.96
Mollusca Epigridae                                     0.20        0.01        0.15        0.02   99.98
Crustacea Amaryllididae                                0.24        0.01        0.15        0.02  100.00

Group NH-2002
Average similarity: 49.80
Species                                            Av.Abund      Av.Sim     Sim/SD   Contrib%     Cum.%
Polychaeta Onuphidae                                   3.17        3.62       3.18       7.26      7.26
Crustacea Whiteleggiidae                               3.71        3.09       1.26       6.20     13.46
Echinodermata Ophiuroidea                              2.87        3.07       3.21       6.16     19.63
Polychaeta Syllidae                                    3.65        3.02       2.05       6.07     25.70
Crustacea Leptocheliidae                               4.27        2.81       1.40       5.65     31.35
Crustacea Phoxocephalidae                              2.22        2.62       3.52       5.27     36.62
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae         2.44        2.11       2.45       4.23     40.85
Crustacea Ampeliscidae                                 1.78        1.94       1.64       3.89     44.74
Polychaeta Paraonidae                                  1.70        1.92       4.01       3.86     48.61
Crustacea Apseudidae                                   2.11        1.86       1.37       3.73     52.34
Crustacea Leptanthuridae                               1.46        1.67       4.82       3.36     55.70
Polychaeta Cirratulidae                                1.70        1.58       1.16       3.17     58.88
Crustacea Synopiidae                                   1.54        1.57       1.70       3.14     62.02
Polychaeta Spionidae                                   1.55        1.54       1.21       3.09     65.11
Polychaeta Maldanidae                                  1.47        1.26       1.14       2.53     67.64
Crustacea Lysianassidae                                1.71        1.23       0.83       2.47     70.11
Polychaeta Dorvilleidae                                1.24        1.17       1.18       2.35     72.46
Crustacea Ischyroceridae                               1.59        1.15       0.79       2.31     74.77
Polychaeta Lumbrineridae                               1.16        1.00       1.13       2.01     76.78
Polychaeta Orbiniidae                                  1.00        0.91       1.21       1.84     78.61
Crustacea Cirolanidae                                  1.14        0.81       0.90       1.62     80.24
Polychaeta Trichobranchidae                            1.10        0.71       0.89       1.43     81.66
Polychaeta Sabellidae                                  1.08        0.68       0.87       1.37     83.03
Polychaeta Pectinariidae                               0.97        0.66       0.90       1.33     84.36
Mollusca Galeommatidae                                 0.90        0.65       0.90       1.31     85.67
Polychaeta Chaetopteridae                              0.86        0.48       0.68       0.96     86.63
Crustacea Cypridinidae/Rutidermatidae                  0.81        0.36       0.51       0.73     87.36
Crustacea Melitidae                                    0.66        0.32       0.51       0.65     88.01
Polychaeta Amphinomidae                                0.81        0.32       0.52       0.65     88.65
Crustacea Urothoidae                                   0.54        0.32       0.52       0.64     89.29
Crustacea Oedicerotidae                                0.54        0.28       0.52       0.56     89.85
Mollusca Condylocardiidae                              0.61        0.24       0.37       0.49     90.34
Crustacea Paratanaidae                                 0.67        0.22       0.37       0.44     90.78
Polychaeta Ampharetidae                                0.58        0.21       0.38       0.43     91.21
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Mollusca Propeamussiidae                            0.44        0.21     0.39      0.43   91.64
Crustacea Melphidippidae                            0.56        0.20     0.38      0.41   92.05
Crustacea Platyischnopidae                          0.56        0.20     0.39      0.40   92.45
Polychaeta Phyllodocidae                            0.57        0.19     0.38      0.39   92.83
Crustacea Corophiidae                               0.51        0.19     0.38      0.38   93.21
Crustacea Philomedidae                              0.54        0.19     0.37      0.37   93.59
Polychaeta Nereididae                               0.48        0.18     0.38      0.37   93.96
Mollusca Nuculanidae                                0.51        0.18     0.37      0.37   94.32
Crustacea Sphaeromatidae                            0.48        0.18     0.37      0.36   94.68
Crustacea Chaetiliidae                              0.40        0.18     0.38      0.36   95.04
Polychaeta Chrysopetalidae                          0.69        0.16     0.26      0.32   95.36
Mollusca Rissoidae                                  0.50        0.15     0.38      0.31   95.67
Crustacea Paguridae                                 0.61        0.12     0.25      0.24   95.91
Mollusca Marginellidae                              0.41        0.11     0.26      0.23   96.14
Polychaeta Opheliidae                               0.34        0.11     0.26      0.22   96.35
Crustacea Anthuridae                                0.30        0.10     0.26      0.21   96.56
Polychaeta Oweniidae                                0.61        0.10     0.25      0.20   96.76
Polychaeta Oenonidae                                0.34        0.10     0.26      0.20   96.96
Crustacea Bodotriidae                               0.38        0.10     0.26      0.20   97.16
Crustacea Diastylidae/Gynodiastylidae               0.48        0.10     0.26      0.20   97.36
Crustacea Eusiridae                                 0.34        0.10     0.26      0.19   97.55
Polychaeta Polynoidae                               0.42        0.09     0.26      0.19   97.74
Polychaeta Glyceridae                               0.34        0.09     0.26      0.18   97.92
Polychaeta Terebellidae                             0.37        0.09     0.26      0.18   98.10
Mollusca Capulidae                                  0.30        0.09     0.26      0.17   98.27
Crustacea Kalliapseudidae                           0.34        0.08     0.26      0.16   98.44
Mollusca Pyramidellidae                             0.38        0.08     0.26      0.16   98.59
Mollusca Naticidae                                  0.30        0.08     0.26      0.15   98.75
Mollusca Crassatellidae                             0.34        0.07     0.26      0.15   98.89
Polychaeta Capitellidae                             0.34        0.07     0.26      0.14   99.04
Echinodermata Holothuroidea                         0.49        0.05     0.15      0.10   99.13
Echinodermata Echinoidea                            0.20        0.04     0.15      0.07   99.21
Crustacea Nebaliidae                                0.36        0.04     0.15      0.07   99.28
Polychaeta Goniadidae                               0.27        0.03     0.15      0.06   99.34
Polychaeta Nephtyidae                               0.24        0.03     0.15      0.06   99.40
Crustacea Atylidae                                  0.20        0.03     0.15      0.06   99.46
Mollusca Carditidae                                 0.20        0.03     0.15      0.06   99.53
Mollusca Nuculidae                                  0.27        0.03     0.15      0.06   99.58
Mollusca Lucinidae                                  0.24        0.03     0.15      0.06   99.64
Mollusca Olivellidae                                0.20        0.03     0.15      0.06   99.70
Mollusca Cylichnidae                                0.20        0.03     0.15      0.06   99.76
Crustacea Podoceridae                               0.24        0.03     0.15      0.05   99.81
Mollusca Columbellidae                              0.20        0.03     0.15      0.05   99.86
Polychaeta Aphroditidae                             0.20        0.02     0.15      0.05   99.91
Mollusca Veneridae                                  0.20        0.02     0.15      0.05   99.96
Crustacea Sarsiellidae                              0.20        0.02     0.15      0.04  100.00

Group NH-2005
Average similarity: 36.18
Species                                         Av.Abund      Av.Sim   Sim/SD  Contrib%   Cum.%
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      2.59        5.15     2.49     14.22   14.22
Polychaeta Syllidae                                 1.82        3.12     1.17      8.63   22.85
Polychaeta Onuphidae                                1.82        3.08     1.39      8.52   31.37
Crustacea Phoxocephalidae                           1.67        2.83     1.08      7.82   39.19
Echinodermata Ophiuroidea                           1.78        2.79     0.86      7.71   46.90
Crustacea Apseudidae                                1.54        2.23     1.16      6.17   53.07
Crustacea Ampeliscidae                              1.65        1.87     0.78      5.17   58.23
Crustacea Synopiidae                                1.34        1.60     0.84      4.42   62.65
Crustacea Leptocheliidae                            1.31        1.53     0.85      4.22   66.88
Crustacea Whiteleggiidae                            1.37        1.19     0.50      3.28   70.16
Crustacea Ischyroceridae                            0.89        1.14     0.67      3.15   73.31
Crustacea Lysianassidae                             0.87        0.87     0.64      2.40   75.71
Polychaeta Lumbrineridae                            0.88        0.77     0.51      2.12   77.83
Crustacea Anthuridae                                0.57        0.67     0.51      1.84   79.67
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Crustacea Cirolanidae                               0.72       0.66      0.50      1.82   81.48
Polychaeta Amphinomidae                             0.91       0.62      0.48      1.72   83.20
Polychaeta Cirratulidae                             0.66       0.56      0.49      1.55   84.75
Mollusca Marginellidae                              0.61       0.56      0.51      1.54   86.29
Crustacea Oedicerotidae                             0.67       0.53      0.52      1.46   87.75
Crustacea Cypridinidae/Rutidermatidae               0.54       0.46      0.52      1.26   89.01
Crustacea Sarsiellidae                              0.40       0.41      0.37      1.14   90.15
Crustacea Paranthuridae                             0.48       0.35      0.36      0.98   91.13
Mollusca Nuculanidae                                0.54       0.33      0.38      0.91   92.03
Polychaeta Spionidae                                0.48       0.28      0.38      0.77   92.80
Crustacea Bodotriidae                               0.41       0.22      0.26      0.61   93.41
Mollusca Columbellidae                              0.30       0.17      0.26      0.48   93.89
Polychaeta Oweniidae                                0.34       0.17      0.26      0.46   94.35
Mollusca Fissurellidae                              0.41       0.17      0.26      0.46   94.81
Polychaeta Pectinariidae                            0.34       0.15      0.26      0.40   95.21
Polychaeta Terebellidae                             0.34       0.14      0.26      0.39   95.61
Polychaeta Oenonidae                                0.37       0.14      0.26      0.39   96.00
Crustacea Urothoidae                                0.30       0.14      0.26      0.38   96.38
Crustacea Calliopiidae                              0.47       0.13      0.26      0.36   96.74
Polychaeta Sabellidae                               0.30       0.13      0.26      0.36   97.10
Crustacea Liljeborgiidae                            0.40       0.13      0.26      0.36   97.46
Crustacea Pagurapseudidae                           0.37       0.09      0.15      0.25   97.71
Crustacea Nebaliidae                                0.28       0.08      0.15      0.23   97.94
Polychaeta Fauveliopsidae                           0.20       0.08      0.15      0.22   98.15
Crustacea Pasiphaeidae                              0.28       0.07      0.15      0.19   98.34
Crustacea Amaryllididae                             0.27       0.07      0.15      0.18   98.52
Echinodermata Echinoidea                            0.24       0.06      0.15      0.18   98.70
Mollusca Turridae                                   0.20       0.06      0.15      0.17   98.86
Mollusca Turritellidae                              0.20       0.06      0.15      0.16   99.03
Polychaeta Opheliidae                               0.20       0.06      0.15      0.15   99.18
Polychaeta Paraonidae                               0.41       0.05      0.15      0.14   99.32
Polychaeta Orbiniidae                               0.20       0.05      0.15      0.14   99.46
Mollusca Nassariidae                                0.20       0.05      0.15      0.13   99.59
Mollusca Trigonidae                                 0.20       0.04      0.15      0.11   99.70
Polychaeta Ampharetidae                             0.57       0.04      0.15      0.10   99.80
Polychaeta Phyllodocidae                            0.24       0.04      0.15      0.10   99.90
Crustacea Serolidae                                 0.24       0.04      0.15      0.10  100.00


Group NH-2008
Average similarity: 53.02
Species                                         Av.Abund  Av.Sim     Sim/SD    Contrib%   Cum.%
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      5.60    4.83       1.91        9.12    9.12
Crustacea Leptocheliidae                            4.89    4.73       2.74        8.92   18.04
Crustacea Ampeliscidae                              3.60    3.67       3.24        6.92   24.96
Crustacea Apseudidae                                3.51    3.61       2.40        6.81   31.78
Polychaeta Onuphidae                                2.97    2.83       2.08        5.34   37.12
Polychaeta Spionidae                                2.62    2.71       4.46        5.11   42.23
Crustacea Phoxocephalidae                           2.48    2.62       3.09        4.95   47.18
Polychaeta Sabellidae                               2.07    1.64       1.39        3.10   50.28
Crustacea Synopiidae                                2.06    1.62       1.37        3.05   53.33
Crustacea Lysianassidae                             1.86    1.62       1.63        3.05   56.37
Echinodermata Ophiuroidea                           1.92    1.59       1.51        2.99   59.36
Crustacea Cypridinidae/Rutidermatidae               1.73    1.57       1.48        2.96   62.32
Crustacea Whiteleggiidae                            2.63    1.57       0.90        2.96   65.28
Polychaeta Lumbrineridae                            1.53    1.39       1.78        2.63   67.90
Polychaeta Amphinomidae                             1.54    1.22       1.54        2.30   70.20
Mollusca Limidae                                    1.02    1.06       1.87        1.99   72.19
Polychaeta Maldanidae                               1.91    1.04       1.08        1.97   74.16
Polychaeta Syllidae                                 1.25    1.00       1.18        1.89   76.05
Polychaeta Cirratulidae                             1.25    1.00       1.19        1.89   77.94
Crustacea Paratanaidae                              1.23    0.91       1.19        1.72   79.66
Crustacea Anthuridae                                1.06    0.73       0.89        1.37   81.03
Polychaeta Terebellidae                             1.03    0.69       0.85        1.31   82.34
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Crustacea Urohaustoriidae                          0.95     0.64       0.90       1.21    83.55
Crustacea Podoceridae                              0.99     0.57       0.67       1.08    84.63
Polychaeta Paraonidae                              0.95     0.56       0.66       1.06    85.69
Crustacea Ischyroceridae                           3.69     0.55       0.65       1.05    86.74
Crustacea Amaryllididae                            0.83     0.53       0.67       1.00    87.74
Crustacea Sphaeromatidae                           0.79     0.48       0.67       0.91    88.65
Crustacea Cirolanidae                              1.02     0.45       0.50       0.86    89.50
Crustacea Bodotriidae                              0.84     0.44       0.68       0.83    90.34
Mollusca Galeommatidae                             0.64     0.42       0.70       0.79    91.13
Polychaeta Orbiniidae                              0.64     0.40       0.70       0.75    91.88
Crustacea Oedicerotidae                            0.62     0.33       0.52       0.63    92.51
Crustacea Nebaliidae                               0.61     0.30       0.53       0.57    93.08
Polychaeta Nephtyidae                              0.54     0.29       0.53       0.55    93.63
Crustacea Atylidae                                 0.50     0.29       0.53       0.54    94.17
Crustacea Arcturididae                             0.58     0.22       0.38       0.41    94.58
Crustacea Platyischnopidae                         0.52     0.21       0.38       0.40    94.98
Crustacea Caprellidae                              0.71     0.19       0.38       0.35    95.33
Crustacea Chaetiliidae                             0.40     0.18       0.39       0.34    95.67
Polychaeta Capitellidae                            0.44     0.18       0.39       0.33    96.00
Echinodermata Echinoidea                           0.44     0.17       0.39       0.31    96.32
Polychaeta Sigalionidae                            0.40     0.17       0.39       0.31    96.63
Polychaeta Oweniidae                               0.44     0.16       0.39       0.30    96.93
Crustacea Diastylidae/Gynodiastylidae              0.55     0.12       0.25       0.23    97.16
Mollusca Nuculanidae                               0.47     0.12       0.25       0.22    97.38
Polychaeta Dorvilleidae                            0.45     0.11       0.26       0.20    97.59
Polychaeta Opheliidae                              0.41     0.10       0.26       0.19    97.78
Crustacea Corophiidae                              0.47     0.09       0.26       0.17    97.96
Polychaeta Phyllodocidae                           0.30     0.09       0.26       0.17    98.13
Polychaeta Ampharetidae                            0.47     0.09       0.26       0.17    98.30
Mollusca Propeamussiidae                           0.34     0.09       0.26       0.17    98.47
Crustacea Liljeborgiidae                           0.42     0.08       0.26       0.15    98.62
Polychaeta Eunicidae                               0.30     0.08       0.26       0.15    98.77
Crustacea Cylindroleberidae                        0.30     0.08       0.26       0.15    98.93
Crustacea Serolidae                                0.34     0.08       0.26       0.15    99.07
Polychaeta Nereididae                              0.37     0.08       0.26       0.14    99.22
Crustacea Melphidippidae                           0.31     0.04       0.15       0.07    99.29
Mollusca Condylocardiidae                          0.24     0.03       0.15       0.05    99.34
Mollusca Tellinidae                                0.24     0.03       0.15       0.05    99.40
Polychaeta Scalibregmatidae                        0.20     0.03       0.15       0.05    99.45
Mollusca Marginellidae                             0.24     0.03       0.15       0.05    99.50
Crustacea Paranthuridae                            0.24     0.03       0.15       0.05    99.55
Mollusca Skeneidae                                 0.20     0.03       0.15       0.05    99.61
Polychaeta Glyceridae                              0.20     0.03       0.15       0.05    99.66
Mollusca Bullinidae                                0.20     0.03       0.15       0.05    99.71
Crustacea Nannastacidae                            0.20     0.03       0.15       0.05    99.76
Crustacea Portunidae                               0.20     0.03       0.15       0.05    99.81
Crustacea Leptanthuridae                           0.36     0.03       0.15       0.05    99.86
Mollusca Lucinidae                                 0.30     0.03       0.15       0.05    99.91
Crustacea Gnathiidae                               0.24     0.02       0.15       0.05    99.96
Mollusca Mytilidae                                 0.20     0.02       0.15       0.04   100.00

Group NH-2011
Average similarity: 47.81
Species                                        Av.Abund   Av.Sim    Sim/SD   Contrib%   Cum.%
Polychaeta Onuphidae                               6.00     5.75      2.21     12.04   12.04
Polychaeta Spionidae                               4.97     4.32      1.82      9.03   21.06
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     3.40     2.70      1.43      5.65   26.71
Echinodermata Ophiuroidea                          2.32     2.41      2.78      5.05   31.76
Crustacea Ampeliscidae                             2.46     2.38      2.69      4.98   36.74
Polychaeta Syllidae                                3.50     2.30      1.00      4.81   41.55
Polychaeta Amphinomidae                            2.83     2.28      1.95      4.77   46.31
Polychaeta Sabellidae                              3.13     2.08      1.21      4.34   50.66
Crustacea Apseudidae                               2.89     1.99      1.17      4.17   54.83
Crustacea Ischyroceridae                           2.17     1.88      2.28      3.93   58.75
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Polychaeta Cirratulidae	2.05	1.84	1.37	3.84	62.60
Crustacea Phoxocephalidae	2.16	1.76	1.64	3.68	66.27
Polychaeta Paraonidae	2.53	1.61	0.91	3.37	69.64
Crustacea Synopiidae	2.13	1.43	1.01	2.99	72.63
Crustacea Leptocheliidae	2.82	1.28	0.74	2.68	75.31
Polychaeta Dorvilleidae	1.51	1.16	1.15	2.42	77.73
Polychaeta Lumbrineridae	1.63	1.11	1.11	2.32	80.05
Crustacea Cirolanidae	1.96	0.94	0.78	1.96	82.02
Crustacea Anthuridae	1.08	0.87	0.91	1.82	83.84
Crustacea Oedicerotidae	1.23	0.82	0.86	1.71	85.55
Crustacea Lysianassidae	1.18	0.73	0.68	1.54	87.09
Crustacea Whiteleggiidae	1.27	0.53	0.50	1.11	88.20
Polychaeta Trichobranchidae	1.01	0.42	0.47	0.88	89.07
Crustacea Melphidippidae	0.87	0.41	0.53	0.87	89.94
Crustacea Paranthuridae	0.80	0.40	0.52	0.83	90.77
Mollusca Turridae	0.72	0.38	0.53	0.79	91.56
Polychaeta Maldanidae	0.93	0.34	0.49	0.71	92.27
Crustacea Eusiridae	0.76	0.32	0.52	0.67	92.94
Polychaeta Phyllodocidae	0.70	0.32	0.51	0.66	93.60
Crustacea Bodotriidae	0.71	0.25	0.38	0.52	94.12
Crustacea Urothoidae	0.67	0.21	0.38	0.44	94.56
Crustacea Diastylidae/Gynodiastylidae	0.52	0.18	0.37	0.38	94.95
Crustacea Sphaeromatidae	0.48	0.16	0.37	0.34	95.28
Polychaeta Opheliidae	0.62	0.15	0.38	0.32	95.60
Crustacea Podoceridae	0.51	0.12	0.26	0.24	95.85
Polychaeta Scalibregmatidae	0.54	0.11	0.26	0.23	96.07
Polychaeta Orbiniidae	0.44	0.11	0.26	0.22	96.30
Crustacea Paguridae	0.57	0.11	0.26	0.22	96.52
Polychaeta Capitellidae	0.48	0.11	0.26	0.22	96.74
Crustacea Paratanaidae	0.47	0.10	0.24	0.20	96.94
Crustacea Leptanthuridae	0.38	0.10	0.26	0.20	97.14
Crustacea Joeropsididae	0.42	0.09	0.26	0.20	97.33
Crustacea Platyischnopidae	0.38	0.09	0.25	0.19	97.53
Mollusca Mytilidae	0.47	0.09	0.25	0.18	97.71
Polychaeta Goniadidae	0.38	0.08	0.25	0.17	97.88
Polychaeta Oenonidae	0.38	0.08	0.25	0.17	98.06
Polychaeta Chaetopteridae	0.38	0.08	0.25	0.17	98.23
Mollusca Nassariidae	0.44	0.07	0.26	0.15	98.38
Mollusca Rissoidae	0.34	0.07	0.26	0.14	98.52
Crustacea Nebaliidae	0.28	0.05	0.15	0.11	98.63
Polychaeta Nereididae	0.40	0.05	0.15	0.11	98.74
Mollusca Nuculanidae	0.28	0.05	0.15	0.10	98.84
Mollusca Skeneidae	0.28	0.05	0.15	0.10	98.94
Crustacea Serolidae	0.28	0.05	0.15	0.10	99.04
Polychaeta Eunicidae	0.28	0.04	0.15	0.09	99.13
Crustacea Atylidae	0.28	0.04	0.15	0.08	99.21
Polychaeta Pholoidae	0.28	0.04	0.15	0.08	99.30
Crustacea Arcturidae	0.34	0.04	0.15	0.08	99.38
Crustacea Cylindroleberidae	0.37	0.04	0.15	0.08	99.46
Crustacea Amaryllididae	0.37	0.04	0.15	0.07	99.53
Mollusca Marginellidae	0.28	0.04	0.15	0.07	99.60
Crustacea Cypridinidae/Rutidermatidae	0.42	0.03	0.15	0.07	99.67
Polychaeta Nephtyidae	0.28	0.03	0.15	0.06	99.73
Crustacea Liljeborgiidae	0.31	0.03	0.15	0.06	99.79
Polychaeta Sigalionidae	0.24	0.03	0.15	0.06	99.85
Mollusca Anabathridae	0.24	0.03	0.15	0.05	99.90
Crustacea Pagurapseudidae	0.20	0.03	0.15	0.05	99.96
Crustacea Pasiphaeidae	0.20	0.02	0.15	0.04	100.00

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Group NH-2014
Average similarity: 53.11
Species                                          Av.Abund    Av.Sim    Sim/SD  Contrib%     Cum.%
Crustacea Leptocheliidae                             9.07      7.51      2.76     14.14     14.14
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae       4.53      4.14      3.58      7.80     21.94
Polychaeta Onuphidae                                 5.76      3.69      1.59      6.95     28.89
Crustacea Ischyroceridae                             2.85      2.80      3.36      5.28     34.17
Crustacea Apseudidae                                 3.27      2.70      1.74      5.08     39.25
Crustacea Synopiidae                                 3.07      2.30      2.64      4.33     43.59
Crustacea Whiteleggiidae                             3.36      2.18      1.01      4.11     47.69
Polychaeta Syllidae                                  2.79      2.13      1.99      4.01     51.71
Polychaeta Sabellidae                                3.15      2.10      1.49      3.96     55.66
Crustacea Phoxocephalidae                            2.33      2.05      2.89      3.86     59.52
Polychaeta Paraonidae                                2.64      2.02      1.80      3.80     63.32
Polychaeta Spionidae                                 2.14      1.43      1.09      2.70     66.02
Mollusca Mytilidae                                   2.37      1.37      0.98      2.58     68.59
Crustacea Cirolanidae                                1.70      1.34      1.70      2.52     71.12
Polychaeta Cirratulidae                              1.75      1.23      1.73      2.31     73.43
Polychaeta Amphinomidae                              2.27      1.21      0.87      2.28     75.71
Echinodermata Ophiuroidea                            1.43      1.20      1.44      2.27     77.98
Crustacea Ampeliscidae                               1.72      1.17      1.13      2.21     80.19
Crustacea Paranthuridae                              1.36      0.88      1.11      1.65     81.84
Crustacea Paratanaidae                               1.36      0.72      0.66      1.35     83.19
Crustacea Lysianassidae                              1.28      0.71      0.86      1.34     84.52
Polychaeta Lumbrineridae                             1.31      0.62      0.63      1.17     85.69
Polychaeta Oweniidae                                 1.52      0.58      0.59      1.09     86.78
Crustacea Cypridinidae/Rutidermatidae                0.82      0.56      0.89      1.05     87.84
Crustacea Maeridae                                   1.14      0.54      0.65      1.02     88.85
Polychaeta Maldanidae                                1.22      0.50      0.67      0.93     89.79
Crustacea Urothoidae                                 0.92      0.48      0.67      0.90     90.69
Mollusca Nuculanidae                                 0.71      0.38      0.68      0.71     91.40
Polychaeta Phyllodocidae                             0.71      0.36      0.69      0.67     92.07
Crustacea Bodotriidae                                0.74      0.31      0.51      0.58     92.65
Crustacea Paguridae                                  0.66      0.27      0.52      0.51     93.16
Crustacea Diastylidae/Gynodiastylidae                0.50      0.27      0.52      0.51     93.67
Mollusca Propeamussiidae                             0.54      0.23      0.52      0.44     94.11
Polychaeta Ampharetidae                              0.68      0.22      0.38      0.41     94.52
Crustacea Rectarcturidae                             0.60      0.21      0.53      0.40     94.92
Polychaeta Dorvilleidae                              0.81      0.17      0.35      0.33     95.25
Polychaeta Orbiniidae                                0.57      0.17      0.37      0.32     95.57
Crustacea Cylindroleberidae                          0.44      0.15      0.38      0.29     95.86
Mollusca Anabathridae                                0.44      0.15      0.38      0.28     96.14
Polychaeta Chrysopetalidae                           0.50      0.14      0.38      0.27     96.41
Polychaeta Capitellidae                              0.52      0.14      0.38      0.26     96.67
Crustacea Podoceridae                                0.40      0.14      0.38      0.26     96.93
Crustacea Neotaniadae                                0.50      0.14      0.38      0.26     97.19
Crustacea Anthuridae                                 0.47      0.13      0.39      0.24     97.43
Crustacea Chaetiliidae                               0.34      0.10      0.26      0.19     97.62
Crustacea Leptanthuridae                             0.34      0.09      0.26      0.17     97.79
Mollusca Galeommatidae                               0.30      0.08      0.26      0.16     97.95
Polychaeta Nephtyidae                                0.34      0.07      0.26      0.14     98.09
Crustacea Eusiridae                                  0.37      0.07      0.26      0.14     98.23
Crustacea Hexapodidae                                0.34      0.07      0.26      0.14     98.37
Polychaeta Pectinariidae                             0.30      0.07      0.26      0.13     98.50
Crustacea Sphaeromatidae                             0.47      0.07      0.26      0.13     98.63
Crustacea Amaryllididae                              0.34      0.07      0.26      0.12     98.76
Polychaeta Trichobranchidae                          0.30      0.06      0.26      0.12     98.88
Polychaeta Oenonidae                                 0.37      0.06      0.26      0.12     99.00
Crustacea Serolidae                                  0.30      0.06      0.26      0.12     99.12
Crustacea Atylidae                                   0.34      0.06      0.26      0.11     99.23
Crustacea Nannastacidae                              0.30      0.06      0.26      0.11     99.34
Polychaeta Opheliidae                                0.31      0.03      0.15      0.06     99.40
Crustacea Diogenidae                                 0.24      0.03      0.15      0.06     99.47
Polychaeta Sigalionidae                              0.20      0.03      0.15      0.06     99.52
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Mollusca Lucinidae                                 0.20      0.03      0.15      0.05   99.57
Mollusca Trapeziidae                               0.24      0.02      0.15      0.05   99.62
Crustacea Oedicerotidae                            0.24      0.02      0.15      0.05   99.67
Crustacea Paramunnidae                             0.20      0.02      0.15      0.05   99.71
Crustacea Platyischnopidae                         0.20      0.02      0.15      0.04   99.76
Mollusca Marginellidae                             0.20      0.02      0.15      0.04   99.80
Polychaeta Flabelligeridae                         0.20      0.02      0.15      0.04   99.84
Polychaeta Nereididae                              0.20      0.02      0.15      0.04   99.89
Crustacea Cyproideidae                             0.20      0.02      0.15      0.04   99.93
Polychaeta Goniadidae                              0.24      0.02      0.15      0.04   99.97
Mollusca Turridae                                  0.20      0.02      0.15      0.03  100.00

Group M0-2002
Average similarity: 53.90
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Maldanidae                              5.88        4.97        1.86       9.22   9.22
Crustacea Apseudidae                               4.30        4.01        1.97       7.44  16.66
Polychaeta Syllidae                                3.60        3.70        3.07       6.87  23.53
Crustacea Leptocheliidae                           3.70        3.13        3.30       5.80  29.32
Polychaeta Spionidae                               3.05        2.80        3.69       5.20  34.52
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     2.55        2.47        3.91       4.59  39.11
Echinodermata Ophiuroidea                          2.60        2.10        1.74       3.89  43.01
Crustacea Ischyroceridae                           2.41        2.05        1.59       3.80  46.80
Crustacea Lysianassidae                            1.89        1.96        3.69       3.64  50.45
Crustacea Phoxocephalidae                          1.94        1.93        3.54       3.58  54.03
Polychaeta Oweniidae                               3.55        1.87        1.82       3.47  57.49
Crustacea Ampeliscidae                             2.51        1.83        1.20       3.39  60.89
Crustacea Anthuridae                               1.78        1.80        3.43       3.35  64.23
Polychaeta Cirratulidae                            1.73        1.24        1.21       2.31  66.54
Crustacea Leptanthuridae                           1.51        1.19        1.18       2.20  68.74
Crustacea Nebaliidae                               1.67        1.09        1.11       2.02  70.76
Polychaeta Orbiniidae                              1.43        1.05        1.14       1.95  72.71
Crustacea Oedicerotidae                            1.13        0.95        1.13       1.76  74.48
Polychaeta Sabellidae                              2.01        0.92        0.62       1.70  76.18
Mollusca Lucinidae                                 0.97        0.91        1.22       1.69  77.86
Mollusca Chaetodermatidae                          1.46        0.77        0.89       1.43  79.30
Crustacea Atylidae                                 1.24        0.71        0.82       1.32  80.62
Polychaeta Opheliidae                              0.97        0.70        0.91       1.30  81.91
Crustacea Callianassidae                           1.08        0.67        0.90       1.25  83.16
Polychaeta Lumbrineridae                           1.00        0.66        0.88       1.23  84.39
Crustacea Pasiphaeidae                             0.84        0.64        0.90       1.19  85.58
Polychaeta Paraonidae                              0.86        0.64        0.90       1.19  86.77
Polychaeta Chaetopteridae                          0.85        0.63        0.89       1.17  87.94
Polychaeta Pectinariidae                           0.99        0.59        0.67       1.10  89.04
Crustacea Paguridae                                0.90        0.50        0.64       0.92  89.97
Crustacea Goneplacidae                             0.72        0.43        0.68       0.80  90.77
Polychaeta Apistobranchidae                        0.64        0.41        0.70       0.76  91.53
Polychaeta Onuphidae                               1.22        0.38        0.38       0.71  92.24
Echinodermata Echinoidea                           0.84        0.34        0.51       0.62  92.86
Polychaeta Ampharetidae                            0.79        0.33        0.51       0.62  93.48
Crustacea Synopiidae                               0.61        0.33        0.50       0.61  94.09
Crustacea Urothoidae                               0.58        0.28        0.52       0.52  94.61
Crustacea Cylindroleberidae                        0.54        0.26        0.53       0.48  95.08
Mollusca Nassariidae                               0.61        0.25        0.52       0.46  95.54
Polychaeta Nereididae                              0.47        0.20        0.38       0.37  95.91
Crustacea Cypridinidae/Rutidermatidae              0.54        0.19        0.38       0.35  96.26
Mollusca Galeommatidae                             0.40        0.19        0.39       0.34  96.60
Crustacea Bodotriidae                              0.59        0.18        0.38       0.34  96.94
Crustacea Eusiridae                                0.40        0.18        0.38       0.33  97.27
Crustacea Diastylidae/Gynodiastylidae              0.44        0.17        0.38       0.32  97.59
Mollusca Pyramidellidae                            0.40        0.16        0.39       0.29  97.88
Crustacea Cirolanidae                              0.38        0.11        0.25       0.20  98.07
Polychaeta Goniadidae                              0.34        0.10        0.26       0.18  98.25
Crustacea Melitidae                                0.47        0.09        0.26       0.17  98.43
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Polychaeta Oenonidae                               0.30        0.09        0.26       0.17  98.60
Polychaeta Polynoidae                              0.34        0.09        0.26       0.17  98.76
Polychaeta Fauveliopsidae                          0.30        0.09        0.26       0.16  98.93
Polychaeta Scalibregmatidae                        0.37        0.07        0.26       0.12  99.05
Polychaeta Trichobranchidae                        0.20        0.05        0.15       0.09  99.13
Crustacea Whiteleggiidae                           0.46        0.04        0.15       0.07  99.20
Mollusca Skeneidae                                 0.20        0.03        0.15       0.06  99.27
Mollusca Nuculanidae                               0.24        0.03        0.15       0.06  99.33
Crustacea Caprellidae                              0.20        0.03        0.15       0.06  99.40
Mollusca Nuculidae                                 0.24        0.03        0.15       0.06  99.46
Crustacea Corophiidae                              0.20        0.03        0.15       0.06  99.51
Polychaeta Nephtyidae                              0.24        0.03        0.15       0.06  99.57
Crustacea Melphidippidae                           0.20        0.03        0.15       0.05  99.62
Crustacea Paratanaidae                             0.27        0.03        0.15       0.05  99.67
Crustacea Sarsiellidae                             0.20        0.03        0.15       0.05  99.72
Polychaeta Phyllodocidae                           0.20        0.03        0.15       0.05  99.77
Mollusca Rissoidae                                 0.24        0.03        0.15       0.05  99.81
Echinodermata Holothuroidea                        0.24        0.03        0.15       0.05  99.86
Crustacea Liljeborgiidae                           0.24        0.03        0.15       0.05  99.91
Mollusca Columbellidae                             0.20        0.03        0.15       0.05  99.95
Polychaeta Sigalionidae                            0.20        0.02        0.15       0.05 100.00

Group M0-2005
Average similarity: 56.34
Species                                           Av.Abund  Av.Sim    Sim/SD  Contrib%  Cum.%
Polychaeta Maldanidae                                 9.06    6.79      2.13     12.05  12.05
Polychaeta Spionidae                                  3.79    3.23      3.76      5.73  17.78
Crustacea Apseudidae                                  3.32    2.87      3.60      5.09  22.87
Polychaeta Syllidae                                   3.45    2.53      2.79      4.49  27.36
Crustacea Leptocheliidae                              4.42    2.53      1.26      4.48  31.84
Crustacea Phoxocephalidae                             2.97    2.41      5.48      4.28  36.12
Polychaeta Oweniidae                                  4.39    2.34      1.64      4.16  40.28
Crustacea Ischyroceridae                              2.61    2.07      2.22      3.67  43.94
Crustacea Anthuridae                                  2.69    2.06      3.55      3.65  47.59
Echinodermata Ophiuroidea                             3.22    1.92      1.40      3.40  51.00
Polychaeta Cirratulidae                               2.24    1.81      1.81      3.21  54.20
Crustacea Lysianassidae                               2.08    1.75      3.68      3.11  57.32
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae        2.15    1.66      1.65      2.95  60.26
Crustacea Bodotriidae                                 1.91    1.64      2.91      2.92  63.18
Polychaeta Sabellidae                                 2.59    1.50      1.46      2.66  65.84
Polychaeta Lumbrineridae                              1.78    1.49      4.10      2.65  68.49
Crustacea Philomedidae                                1.35    1.23      1.80      2.18  70.67
Crustacea Leptanthuridae                              1.66    1.16      1.46      2.05  72.73
Crustacea Oedicerotidae                               1.46    1.15      1.58      2.04  74.77
Polychaeta Terebellidae                               1.50    1.09      1.14      1.93  76.69
Polychaeta Orbiniidae                                 1.67    1.07      1.20      1.89  78.59
Crustacea Ampeliscidae                                1.32    1.04      1.68      1.85  80.44
Crustacea Paranthuridae                               1.31    0.88      1.03      1.56  82.00
Mollusca Rissoidae                                    1.14    0.79      1.16      1.41  83.41
Echinodermata Echinoidea                              1.42    0.67      0.84      1.18  84.59
Polychaeta Chaetopteridae                             0.94    0.64      0.90      1.13  85.72
Polychaeta Opheliidae                                 1.01    0.59      0.87      1.04  86.76
Polychaeta Sigalionidae                               0.78    0.58      0.89      1.04  87.80
Mollusca Anabathridae                                 0.96    0.57      0.86      1.02  88.82
Mollusca Chaetodermatidae                             0.91    0.43      0.65      0.76  89.58
Polychaeta Paraonidae                                 0.90    0.41      0.65      0.73  90.31
Crustacea Goneplacidae                                0.71    0.39      0.69      0.69  91.00
Crustacea Callianassidae                              0.64    0.32      0.69      0.56  91.56
Crustacea Sarsiellidae                                0.67    0.31      0.52      0.56  92.12
Polychaeta Trichobranchidae                           0.71    0.29      0.51      0.52  92.64
Polychaeta Fauveliopsidae                             0.54    0.29      0.53      0.52  93.16
Crustacea Cypridinidae/Rutidermatidae                 0.69    0.29      0.49      0.51  93.67
Polychaeta Nephtyidae                                 0.61    0.27      0.52      0.48  94.14
Polychaeta Phyllodocidae                              0.60    0.26      0.51      0.46  94.60
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Polychaeta Scalibregmatidae                           0.58     0.25      0.52     0.45  95.05
Polychaeta Onuphidae                                  0.54     0.25      0.52     0.45  95.50
Mollusca Nuculidae                                    0.54     0.21      0.52     0.38  95.88
Crustacea Diastylidae/Gynodiastylidae                 0.57     0.20      0.38     0.36  96.24
Crustacea Sphaeromatidae                              0.66     0.20      0.38     0.35  96.59
Mollusca Marginellidae                                0.51     0.18      0.38     0.31  96.90
Crustacea Urothoidae                                  0.44     0.15      0.38     0.27  97.17
Crustacea Nebaliidae                                  0.48     0.15      0.38     0.27  97.44
Crustacea Cylindroleberidae                           0.47     0.14      0.39     0.24  97.68
Crustacea Antarcturidae                               0.44     0.13      0.38     0.24  97.92
Polychaeta Nereididae                                 0.51     0.13      0.37     0.24  98.16
Crustacea Paratanaidae                                0.44     0.13      0.38     0.23  98.38
Polychaeta Glyceridae                                 0.38     0.09      0.26     0.16  98.54
Crustacea Gnathiidae                                  0.34     0.09      0.26     0.15  98.70
Crustacea Cirolanidae                                 0.41     0.08      0.25     0.15  98.84
Mollusca Laevidentaliidae                             0.30     0.06      0.26     0.11  98.96
Polychaeta Flabelligeridae                            0.37     0.06      0.26     0.11  99.07
Crustacea Nannastacidae                               0.34     0.06      0.26     0.11  99.18
Crustacea Amaryllididae                               0.37     0.06      0.26     0.10  99.28
Crustacea Arcturidae                                  0.30     0.06      0.26     0.10  99.38
Crustacea Caprellidae                                 0.44     0.06      0.26     0.10  99.49
Mollusca Skeneidae                                    0.28     0.03      0.15     0.06  99.54
Polychaeta Apistobranchidae                           0.24     0.03      0.15     0.06  99.60
Crustacea Urohaustoriidae                             0.24     0.03      0.15     0.05  99.65
Crustacea Calliopiidae                                0.24     0.03      0.15     0.05  99.69
Mollusca Turridae                                     0.20     0.03      0.15     0.05  99.74
Polychaeta Polynoidae                                 0.27     0.02      0.15     0.04  99.78
Mollusca Nassariidae                                  0.24     0.02      0.15     0.04  99.82
Polychaeta Ampharetidae                               0.20     0.02      0.15     0.04  99.86
Crustacea Paramunnidae                                0.20     0.02      0.15     0.04  99.90
Crustacea Pasiphaeidae                                0.20     0.02      0.15     0.03  99.94
Mollusca Propeamussiidae                              0.24     0.02      0.15     0.03  99.97
Mollusca Lucinidae                                    0.20     0.02      0.15     0.03 100.00

Group M0-2008
Average similarity: 56.37
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Maldanidae                              9.13        6.55        2.31      11.63  11.63
Polychaeta Ampharetidae                            5.28        4.69        2.21       8.32  19.94
Crustacea Ampeliscidae                             3.49        3.50        4.32       6.21  26.15
Polychaeta Spionidae                               4.29        3.12        1.98       5.54  31.69
Polychaeta Cirratulidae                            3.40        2.97        4.22       5.27  36.96
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     3.20        2.81        3.09       4.98  41.94
Crustacea Leptocheliidae                           2.99        2.28        1.49       4.05  45.99
Crustacea Phoxocephalidae                          2.55        2.21        3.03       3.93  49.92
Polychaeta Lumbrineridae                           2.28        2.10        6.03       3.72  53.64
Crustacea Apseudidae                               2.54        1.98        1.79       3.52  57.16
Crustacea Lysianassidae                            2.06        1.65        1.87       2.92  60.08
Echinodermata Ophiuroidea                          3.46        1.63        1.06       2.89  62.97
Polychaeta Sabellidae                              1.82        1.57        3.46       2.78  65.75
Crustacea Philomedidae                             1.85        1.38        1.66       2.45  68.20
Mollusca Chaetodermatidae                          1.54        1.29        1.76       2.28  70.48
Polychaeta Syllidae                                1.79        1.26        1.64       2.24  72.72
Echinodermata Echinoidea                           1.88        1.09        1.06       1.94  74.66
Crustacea Anthuridae                               1.35        1.08        1.73       1.91  76.57
Crustacea Oedicerotidae                            1.32        1.00        1.60       1.77  78.34
Crustacea Nebaliidae                               1.50        0.99        1.17       1.75  80.09
Crustacea Diastylidae/Gynodiastylidae              1.24        0.95        1.13       1.69  81.78
Polychaeta Orbiniidae                              1.17        0.80        1.24       1.42  83.21
Polychaeta Opheliidae                              1.07        0.71        0.80       1.26  84.47
Crustacea Bodotriidae                              1.15        0.71        0.86       1.26  85.73
Mollusca Nassariidae                               1.24        0.70        0.81       1.24  86.96
Crustacea Cypridinidae/Rutidermatidae              0.98        0.54        0.90       0.97  87.93
Polychaeta Paraonidae                              0.76        0.43        0.68       0.76  88.69
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Mollusca Nuculidae	0.82	0.43	0.66	0.76	89.45
Crustacea Cylindroleberidae	1.04	0.42	0.52	0.74	90.19
Crustacea Sphaeromatidae	0.76	0.34	0.68	0.61	90.80
Crustacea Ischyroceridae	1.11	0.31	0.35	0.54	91.34
Polychaeta Scalibregmatidae	0.54	0.26	0.52	0.47	91.81
Mollusca Skeneidae	0.57	0.25	0.52	0.44	92.25
Crustacea Paratanaidae	0.74	0.23	0.52	0.42	92.67
Crustacea Arcturidae	0.54	0.22	0.52	0.39	93.06
Mollusca Solemyidae	0.54	0.21	0.52	0.38	93.44
Mollusca Anabathridae	0.97	0.20	0.37	0.36	93.80
Crustacea Callianassidae	0.52	0.20	0.36	0.35	94.15
Crustacea Atylidae	0.65	0.19	0.37	0.33	94.48
Polychaeta Terebellidae	0.51	0.17	0.38	0.31	94.79
Mollusca Propeamussiidae	0.67	0.17	0.38	0.31	95.10
Crustacea Leptanthuridae	0.56	0.17	0.38	0.30	95.40
Mollusca Mytilidae	0.44	0.17	0.38	0.29	95.70
Mollusca Rissoidae	0.47	0.16	0.38	0.29	95.98
Polychaeta Onuphidae	0.44	0.16	0.38	0.29	96.27
Polychaeta Nephtyidae	0.44	0.16	0.38	0.29	96.56
Crustacea Liljeborgiidae	0.58	0.16	0.38	0.28	96.84
Crustacea Gnathiidae	0.51	0.15	0.38	0.27	97.11
Crustacea Cirolanidae	0.40	0.15	0.39	0.26	97.37
Crustacea Goneplacidae	0.40	0.14	0.38	0.25	97.62
Polychaeta Phyllodocidae	0.46	0.12	0.26	0.22	97.84
Mollusca Capulidae	0.30	0.10	0.26	0.18	98.02
Mollusca Galeommatidae	0.30	0.09	0.26	0.15	98.18
Crustacea Sarsiellidae	0.41	0.09	0.26	0.15	98.33
Crustacea Urohaustoriidae	0.37	0.08	0.26	0.15	98.48
Crustacea Melitidae	0.30	0.08	0.26	0.14	98.62
Crustacea Pasiphaeidae	0.41	0.07	0.26	0.13	98.75
Mollusca Turridae	0.30	0.07	0.26	0.13	98.88
Polychaeta Sigalionidae	0.30	0.07	0.26	0.12	99.00
Mollusca Marginellidae	0.34	0.07	0.26	0.12	99.12
Crustacea Caprellidae	0.37	0.07	0.26	0.12	99.24
Crustacea Munnopsidae	0.30	0.06	0.26	0.11	99.35
Crustacea Amaryllididae	0.30	0.06	0.26	0.11	99.46
Polychaeta Goniadidae	0.30	0.06	0.26	0.10	99.56
Mollusca Laevidentaliidae	0.24	0.03	0.15	0.05	99.61
Mollusca Limidae	0.24	0.03	0.15	0.05	99.66
Echinodermata Holothuroidea	0.20	0.02	0.15	0.04	99.71
Crustacea Raninidae	0.27	0.02	0.15	0.04	99.75
Polychaeta Pectinariidae	0.24	0.02	0.15	0.04	99.79
Polychaeta Oweniidae	0.30	0.02	0.15	0.04	99.83
Crustacea Paguridae	0.24	0.02	0.15	0.04	99.86
Crustacea Paranthuridae	0.27	0.02	0.15	0.04	99.90
Mollusca Lucinidae	0.27	0.02	0.15	0.03	99.93
Polychaeta Capitellidae	0.43	0.02	0.15	0.03	99.97
Crustacea Cyproideidae	0.20	0.02	0.15	0.03	100.00

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Group M0-2011
Average similarity: 60.89
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Maldanidae                             10.72        6.43        3.47      10.56  10.56
Polychaeta Spionidae                               7.77        5.04        2.71       8.27  18.83
Polychaeta Sabellidae                              6.28        3.78        1.96       6.21  25.04
Crustacea Leptocheliidae                           5.05        2.44        1.51       4.00  29.04
Polychaeta Cirratulidae                            3.14        2.28        5.03       3.75  32.80
Crustacea Apseudidae                               3.96        2.21        2.20       3.62  36.42
Crustacea Ampeliscidae                             3.57        2.04        1.60       3.35  39.77
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     4.07        2.03        1.69       3.34  43.11
Polychaeta Syllidae                                3.65        1.97        1.86       3.24  46.35
Crustacea Phoxocephalidae                          2.93        1.94        2.95       3.18  49.53
Crustacea Ischyroceridae                           2.98        1.79        2.35       2.93  52.46
Polychaeta Lumbrineridae                           3.28        1.73        1.40       2.84  55.31
Echinodermata Echinoidea                           2.41        1.56        2.78       2.56  57.87
Crustacea Oedicerotidae                            2.61        1.55        3.27       2.55  60.42
Crustacea Bodotriidae                              2.63        1.52        2.41       2.50  62.92
Crustacea Paranthuridae                            2.26        1.52        3.18       2.49  65.41
Polychaeta Oweniidae                               3.39        1.37        1.41       2.26  67.66
Polychaeta Ampharetidae                            2.26        1.07        1.30       1.75  69.41
Crustacea Lysianassidae                            2.16        1.05        1.39       1.73  71.14
Crustacea Cylindroleberidae                        1.66        1.00        4.43       1.65  72.79
Echinodermata Ophiuroidea                          1.83        0.97        1.53       1.59  74.38
Polychaeta Opheliidae                              1.66        0.96        1.75       1.58  75.96
Crustacea Paratanaidae                             1.57        0.91        1.54       1.49  77.46
Polychaeta Paraonidae                              1.74        0.83        1.06       1.37  78.82
Polychaeta Orbiniidae                              1.44        0.83        1.75       1.36  80.18
Mollusca Chaetodermatidae                          1.41        0.78        1.21       1.28  81.46
Crustacea Anthuridae                               1.63        0.78        1.07       1.28  82.74
Polychaeta Chaetopteridae                          1.16        0.69        1.84       1.13  83.87
Crustacea Pasiphaeidae                             1.06        0.66        1.88       1.08  84.95
Crustacea Paguridae                                1.06        0.55        1.22       0.90  85.86
Crustacea Atylidae                                 1.60        0.55        0.80       0.90  86.76
Crustacea Nebaliidae                               1.24        0.52        0.85       0.85  87.61
Crustacea Cirolanidae                              1.07        0.49        0.89       0.80  88.41
Mollusca Nuculidae                                 0.88        0.40        0.90       0.66  89.07
Crustacea Callianassidae                           0.90        0.39        0.86       0.65  89.72
Crustacea Philomedidae                             0.86        0.38        0.90       0.62  90.34
Crustacea Caprellidae                              0.88        0.37        0.89       0.61  90.95
Crustacea Sarsiellidae                             1.11        0.35        0.67       0.58  91.53
Mollusca Nassariidae                               0.89        0.33        0.67       0.54  92.07
Crustacea Liljeborgiidae                           0.82        0.30        0.65       0.49  92.57
Polychaeta Phyllodocidae                           0.64        0.30        0.70       0.49  93.05
Mollusca Anabathridae                              0.91        0.29        0.66       0.48  93.53
Crustacea Stegocephalidae                          1.65        0.29        0.65       0.48  94.01
Polychaeta Onuphidae                               0.93        0.29        0.66       0.48  94.49
Crustacea Synopiidae                               0.75        0.29        0.68       0.47  94.96
Polychaeta Sigalionidae                            0.74        0.21        0.51       0.35  95.30
Mollusca Rissoidae                                 0.74        0.20        0.51       0.33  95.63
Mollusca Lucinidae                                 0.66        0.20        0.51       0.32  95.95
Crustacea Cypridinidae/Rutidermatidae              0.76        0.19        0.51       0.32  96.27
Crustacea Goneplacidae                             0.64        0.19        0.51       0.31  96.57
Crustacea Munnopsidae                              0.64        0.17        0.52       0.29  96.86
Crustacea Arcturidae                               0.60        0.11        0.38       0.19  97.05
Polychaeta Amphinomidae                            0.48        0.11        0.38       0.18  97.23
Crustacea Antarcturidae                            0.47        0.11        0.39       0.18  97.41
Mollusca Solemyidae                                0.44        0.11        0.39       0.18  97.58
Crustacea Urothoidae                               0.48        0.11        0.38       0.17  97.75
Crustacea Leptanthuridae                           0.44        0.11        0.39       0.17  97.93
Mollusca Marginellidae                             0.44        0.10        0.39       0.16  98.09
Crustacea Agathotanaidae                           0.50        0.07        0.25       0.11  98.20
Mollusca Turridae                                  0.38        0.07        0.26       0.11  98.31
Polychaeta Sphaerodoridae                          0.50        0.06        0.26       0.10  98.41
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Crustacea Melitidae                                 0.30       0.06        0.26        0.10   98.51
Crustacea Gnathiidae                                0.30       0.06        0.26        0.10   98.60
Polychaeta Trichobranchidae                         0.46       0.06        0.26        0.10   98.70
Polychaeta Nereididae                               0.45       0.06        0.25        0.09   98.79
Mollusca Skeneidae                                  0.30       0.06        0.26        0.09   98.88
Polychaeta Goniadidae                               0.38       0.05        0.26        0.09   98.97
Crustacea Amaryllididae                             0.44       0.05        0.26        0.09   99.06
Polychaeta Scalibregmatidae                         0.30       0.05        0.26        0.08   99.14
Mollusca Acteonidae                                 0.34       0.05        0.26        0.08   99.23
Polychaeta Flabelligeridae                          0.34       0.05        0.26        0.08   99.30
Polychaeta Glyceridae                               0.30       0.05        0.26        0.08   99.38
Crustacea Diastylidae/Gynodiastylidae               0.30       0.05        0.26        0.08   99.46
Crustacea Leucosiidae                               0.30       0.05        0.26        0.08   99.54
Crustacea Calliopiidae                              0.31       0.03        0.15        0.04   99.58
Crustacea Serolidae                                 0.20       0.02        0.15        0.04   99.62
Polychaeta Oenonidae                                0.20       0.02        0.15        0.03   99.65
Mollusca Laevidentaliidae                           0.20       0.02        0.15        0.03   99.68
Mollusca Pyramidellidae                             0.20       0.02        0.15        0.03   99.71
Mollusca Noetiidae                                  0.20       0.02        0.15        0.03   99.75
Polychaeta Terebellidae                             0.24       0.02        0.15        0.03   99.78
Mollusca Turritellidae                              0.20       0.02        0.15        0.03   99.81
Crustacea Crangonidae                               0.27       0.02        0.15        0.03   99.84
Polychaeta Capitellidae                             0.24       0.02        0.15        0.03   99.87
Crustacea Podoceridae                               0.20       0.02        0.15        0.03   99.89
Crustacea Sphaeromatidae                            0.30       0.02        0.15        0.03   99.92
Crustacea Melphidippidae                            0.20       0.02        0.15        0.03   99.95
Crustacea Ochlesidae                                0.27       0.02        0.15        0.03   99.98
Crustacea Cyproideidae                              0.24       0.01        0.15        0.02  100.00
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Group M0-2014

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Average similarity: 63.36
Species                                         Av.Abund     Av.Sim      Sim/SD    Contrib%   Cum.%
Polychaeta Maldanidae                              10.22       7.74        4.19       12.22   12.22
Polychaeta Sabellidae                               7.98       5.91        2.34        9.33   21.55
Polychaeta Ampharetidae                             9.02       5.33        2.45        8.41   29.96
Polychaeta Spionidae                                4.31       3.65        4.13        5.76   35.72
Polychaeta Lumbrineridae                            4.08       3.64        3.76        5.75   41.47
Polychaeta Syllidae                                 4.22       3.34        4.56        5.28   46.75
Crustacea Apseudidae                                3.68       3.09        3.83        4.87   51.62
Echinodermata Ophiuroidea                           4.40       2.95        1.96        4.66   56.28
Crustacea Leptocheliidae                            4.96       2.87        2.42        4.54   60.82
Crustacea Phoxocephalidae                           3.27       2.70        5.16        4.26   65.08
Crustacea Anthuridae                                2.00       1.57        3.32        2.47   67.55
Crustacea Ampeliscidae                              1.90       1.51        3.18        2.38   69.93
Polychaeta Cirratulidae                             1.88       1.43        1.86        2.25   72.18
Crustacea Lysianassidae                             1.64       1.23        3.39        1.94   74.12
Crustacea Oedicerotidae                             1.69       1.21        1.85        1.90   76.02
Crustacea Paranthuridae                             1.75       1.15        1.79        1.81   77.83
Echinodermata Echinoidea                            1.63       1.09        1.56        1.73   79.56
Polychaeta Opheliidae                               1.51       1.00        1.52        1.58   81.14
Polychaeta Orbiniidae                               1.34       0.98        1.19        1.55   82.69
Polychaeta Paraonidae                               1.37       0.89        1.18        1.41   84.09
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      1.55       0.87        1.14        1.37   85.47
Crustacea Callianassidae                            1.23       0.76        1.15        1.20   86.67
Crustacea Paratanaidae                              1.47       0.74        0.88        1.16   87.83
Mollusca Anabathridae                               1.23       0.58        0.69        0.91   88.74
Crustacea Ischyroceridae                            1.22       0.58        0.85        0.91   89.65
Polychaeta Trichobranchidae                         0.91       0.50        0.89        0.79   90.44
Polychaeta Nereididae                               0.84       0.48        0.91        0.75   91.19
Polychaeta Nephtyidae                               0.78       0.45        0.90        0.71   91.90
Crustacea Cylindroleberidae                         0.72       0.38        0.68        0.60   92.51
Crustacea Bodotriidae                               0.78       0.38        0.69        0.59   93.10
Polychaeta Scalibregmatidae                         0.76       0.37        0.67        0.58   93.68
Polychaeta Onuphidae                                1.23       0.36        0.68        0.56   94.24
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Mollusca Chaetodermatidae                           0.68        0.34        0.69       0.53  94.78
Crustacea Leptanthuridae                            0.76        0.33        0.66       0.52  95.30
Mollusca Nuculidae                                  0.64        0.32        0.69       0.50  95.80
Polychaeta Oweniidae                                0.89        0.30        0.51       0.48  96.27
Crustacea Hexapodidae                               0.58        0.24        0.52       0.38  96.65
Crustacea Liljeborgiidae                            0.57        0.23        0.53       0.36  97.01
Polychaeta Oenonidae                                0.67        0.20        0.52       0.32  97.33
Crustacea Cirolanidae                               0.60        0.19        0.38       0.29  97.62
Mollusca Rissoidae                                  0.48        0.14        0.38       0.23  97.85
Mollusca Marginellidae                              0.44        0.14        0.39       0.22  98.07
Crustacea Gnathiidae                                0.47        0.13        0.39       0.21  98.28
Polychaeta Phyllodocidae                            0.44        0.13        0.39       0.20  98.48
Polychaeta Chaetopteridae                           0.44        0.12        0.38       0.19  98.67
Mollusca Mytilidae                                  0.54        0.11        0.39       0.18  98.85
Crustacea Sphaeromatidae                            0.44        0.08        0.26       0.12  98.97
Crustacea Leptognathiidae                           0.34        0.07        0.26       0.11  99.08
Crustacea Diastylidae/Gynodiastylidae              0.34        0.07        0.26       0.11  99.18
Crustacea Raninidae                                 0.34        0.07        0.26       0.11  99.29
Mollusca Solemyidae                                 0.30        0.07        0.26       0.11  99.39
Polychaeta Amphinomidae                             0.30        0.06        0.26       0.09  99.48
Crustacea Paguridae                                 0.40        0.04        0.15       0.06  99.54
Mollusca Skeneidae                                  0.20        0.03        0.15       0.04  99.58
Polychaeta Pectinariidae                            0.20        0.03        0.15       0.04  99.62
Crustacea Crangonidae                               0.20        0.02        0.15       0.04  99.66
Crustacea Lampropidae                               0.20        0.02        0.15       0.04  99.70
Crustacea Caprellidae                               0.24        0.02        0.15       0.04  99.74
Crustacea Melitidae                                 0.24        0.02        0.15       0.03  99.77
Polychaeta Capitellidae                             0.24        0.02        0.15       0.03  99.81
Crustacea Pasiphaeidae                              0.24        0.02        0.15       0.03  99.84
Mollusca Philobryidae                               0.20        0.02        0.15       0.03  99.87
Crustacea Eusiridae                                 0.20        0.02        0.15       0.03  99.91
Mollusca Lucinidae                                  0.32        0.02        0.15       0.03  99.94
Polychaeta Flabelligeridae                          0.27        0.02        0.15       0.03  99.97
Crustacea Urothoidae                                0.20        0.02        0.15       0.03 100.00

Group M3-2002
Average similarity: 57.50
Species                                         Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Oweniidae                                7.46        6.21        1.44      10.80  10.80
Polychaeta Cirratulidae                             4.28        5.73        2.46       9.97  20.77
Polychaeta Spionidae                                3.50        4.35        2.67       7.56  28.33
Polychaeta Maldanidae                               3.67        4.07        2.16       7.08  35.42
Crustacea Phoxocephalidae                           2.29        3.37        5.02       5.86  41.28
Echinodermata Ophiuroidea                           2.16        3.21        4.00       5.59  46.87
Polychaeta Syllidae                                 2.57        3.02        3.49       5.26  52.13
Crustacea Apseudidae                                2.02        2.82        3.81       4.90  57.03
Crustacea Anthuridae                                1.81        2.32        1.65       4.04  61.07
Crustacea Leptanthuridae                            1.85        2.06        1.38       3.58  64.65
Crustacea Melitidae                                 1.24        1.82        3.77       3.16  67.81
Polychaeta Orbiniidae                               1.59        1.79        1.61       3.11  70.92
Crustacea Callianassidae                            1.31        1.65        1.61       2.87  73.79
Polychaeta Lumbrineridae                            1.59        1.41        1.16       2.45  76.25
Mollusca Chaetodermatidae                           1.45        1.33        1.01       2.31  78.56
Crustacea Leptocheliidae                            1.57        1.20        1.16       2.08  80.64
Polychaeta Paraonidae                               1.19        1.14        1.16       1.99  82.63
Crustacea Lysianassidae                             1.22        0.97        0.90       1.68  84.31
Crustacea Goneplacidae                              0.86        0.82        0.86       1.42  85.73
Polychaeta Opheliidae                               0.91        0.81        0.88       1.41  87.14
Polychaeta Ampharetidae                             1.11        0.80        0.88       1.39  88.53
Crustacea Ampeliscidae                              0.98        0.64        0.68       1.11  89.64
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      0.88        0.56        0.68       0.98  90.61
Crustacea Bodotriidae                               0.79        0.55        0.68       0.95  91.56
Polychaeta Pectinariidae                            0.60        0.53        0.67       0.92  92.49
Polychaeta Onuphidae                                0.62        0.40        0.52       0.70  93.18
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Echinodermata Echinoidea                            0.69       0.35        0.50        0.61  93.79
Crustacea Oedicerotidae                             0.65       0.35        0.51        0.61  94.40
Crustacea Diastylidae/Gynodiastylidae               0.66       0.34        0.52        0.59  94.99
Polychaeta Oenonidae                                0.44       0.26        0.39        0.46  95.45
Polychaeta Sabellidae                               0.67       0.25        0.37        0.43  95.88
Mollusca Nassariidae                                0.48       0.21        0.38        0.37  96.25
Crustacea Philomedidae                              0.44       0.21        0.38        0.36  96.61
Polychaeta Capitellidae                             0.44       0.20        0.38        0.35  96.96
Crustacea Cylindroleberidae                         0.48       0.20        0.37        0.34  97.31
Crustacea Ischyroceridae                            0.52       0.18        0.38        0.32  97.63
Polychaeta Sigalionidae                             0.40       0.18        0.38        0.31  97.93
Mollusca Laevidentaliidae                           0.42       0.14        0.26        0.24  98.17
Crustacea Synopiidae                                0.30       0.13        0.26        0.23  98.40
Polychaeta Nereididae                               0.34       0.12        0.26        0.20  98.60
Polychaeta Nephtyidae                               0.34       0.11        0.26        0.19  98.79
Crustacea Paguridae                                 0.37       0.10        0.26        0.17  98.96
Mollusca Lucinidae                                  0.34       0.10        0.26        0.17  99.13
Crustacea Liljeborgiidae                            0.34       0.08        0.26        0.14  99.27
Mollusca Solemyidae                                 0.37       0.04        0.15        0.07  99.34
Mollusca Acteonidae                                 0.20       0.04        0.15        0.07  99.42
Mollusca Nuculidae                                  0.24       0.03        0.15        0.06  99.48
Crustacea Cypridinidae/Rutidermatidae               0.24       0.03        0.15        0.06  99.54
Polychaeta Polynoidae                               0.20       0.03        0.15        0.06  99.60
Crustacea Sarsiellidae                              0.20       0.03        0.15        0.06  99.66
Mollusca Rissoidae                                  0.20       0.03        0.15        0.06  99.71
Polychaeta Apistobranchidae                         0.20       0.03        0.15        0.06  99.77
Crustacea Paramunnidae                              0.20       0.03        0.15        0.05  99.82
Crustacea Nebaliidae                                0.20       0.03        0.15        0.05  99.87
Polychaeta Poecilochaetidae                         0.20       0.03        0.15        0.05  99.91
Polychaeta Chaetopteridae                           0.20       0.03        0.15        0.04  99.96
Polychaeta Trichobranchidae                         0.27       0.03        0.15        0.04 100.00


Group M3-2005
Average similarity: 55.72
Species                                         Av.Abund     Av.Sim      Sim/SD    Contrib%  Cum.%
Polychaeta Oweniidae                               13.01       6.82        0.90       12.24  12.24
Polychaeta Spionidae                                5.02       4.56        2.58        8.19  20.43
Polychaeta Maldanidae                               5.18       3.82        2.34        6.86  27.29
Polychaeta Cirratulidae                             3.48       2.92        2.18        5.24  32.53
Crustacea Apseudidae                                3.57       2.84        2.08        5.10  37.63
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      2.75       2.35        2.37        4.22  41.85
Crustacea Lysianassidae                             2.15       1.87        3.55        3.35  45.20
Crustacea Phoxocephalidae                           2.52       1.78        2.33        3.20  48.40
Polychaeta Syllidae                                 2.04       1.66        2.17        2.98  51.38
Crustacea Ampeliscidae                              1.86       1.56        1.97        2.80  54.18
Crustacea Anthuridae                                1.66       1.45        4.45        2.60  56.78
Mollusca Chaetodermatidae                           1.72       1.42        1.66        2.55  59.34
Polychaeta Lumbrineridae                            1.74       1.42        3.49        2.55  61.89
Crustacea Philomedidae                              1.71       1.39        1.36        2.50  64.39
Crustacea Pasiphaeidae                              1.21       1.20        5.04        2.16  66.55
Echinodermata Ophiuroidea                           3.99       1.20        0.63        2.15  68.69
Polychaeta Orbiniidae                               1.37       1.14        1.63        2.04  70.73
Crustacea Bodotriidae                               1.41       1.11        1.79        2.00  72.73
Crustacea Ischyroceridae                            1.20       0.97        1.84        1.73  74.46
Crustacea Melitidae                                 1.13       0.94        1.68        1.70  76.16
Mollusca Nassariidae                                1.10       0.78        1.19        1.39  77.55
Polychaeta Opheliidae                               1.01       0.74        1.19        1.33  78.88
Crustacea Goneplacidae                              1.00       0.72        1.22        1.28  80.16
Crustacea Callianassidae                            0.98       0.70        0.91        1.26  81.42
Crustacea Oedicerotidae                             1.14       0.65        0.82        1.16  82.58
Polychaeta Paraonidae                               1.08       0.61        0.84        1.10  83.68
Polychaeta Onuphidae                                0.94       0.59        0.89        1.06  84.74
Echinodermata Echinoidea                            1.11       0.58        0.85        1.05  85.79
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Polychaeta Chaetopteridae                           0.86       0.54        0.91       0.97   86.76
Crustacea Cylindroleberidae                         0.74       0.51        0.91       0.91   87.67
Polychaeta Trichobranchidae                         1.24       0.47        0.65       0.84   88.50
Polychaeta Sabellidae                               1.32       0.45        0.63       0.81   89.31
Crustacea Paranthuridae                             0.86       0.43        0.68       0.78   90.09
Crustacea Gnathiidae                                0.93       0.42        0.68       0.75   90.84
Polychaeta Phyllodocidae                            0.86       0.40        0.68       0.71   91.55
Polychaeta Nephtyidae                               0.64       0.39        0.69       0.69   92.25
Mollusca Anabathridae                               0.81       0.37        0.68       0.67   92.92
Crustacea Leptocheliidae                            1.26       0.34        0.47       0.60   93.52
Crustacea Paratanaidae                              0.79       0.33        0.51       0.59   94.12
Mollusca Lucinidae                                  0.88       0.31        0.50       0.56   94.67
Mollusca Nuculanidae                                0.50       0.25        0.52       0.45   95.12
Crustacea Sphaeromatidae                            0.54       0.22        0.52       0.40   95.52
Crustacea Paguridae                                 0.63       0.19        0.38       0.34   95.86
Crustacea Liljeborgiidae                            0.48       0.18        0.38       0.32   96.18
Mollusca Turridae                                   0.44       0.16        0.39       0.29   96.47
Polychaeta Fauveliopsidae                           0.51       0.16        0.38       0.29   96.77
Crustacea Leptanthuridae                            0.56       0.16        0.38       0.29   97.05
Crustacea Diastylidae/Gynodiastylidae               0.44       0.16        0.39       0.28   97.34
Mollusca Nuculidae                                  0.50       0.15        0.38       0.26   97.60
Crustacea Nebaliidae                                0.50       0.14        0.39       0.26   97.86
Polychaeta Terebellidae                             0.50       0.14        0.38       0.25   98.11
Mollusca Solemyidae                                 0.48       0.14        0.38       0.24   98.35
Crustacea Cypridinidae/Rutidermatidae               0.44       0.13        0.38       0.24   98.59
Crustacea Urohaustoriidae                           0.30       0.09        0.26       0.16   98.75
Polychaeta Scalibregmatidae                         0.30       0.08        0.26       0.15   98.90
Mollusca Veneridae                                  0.42       0.08        0.26       0.14   99.04
Polychaeta Polynoidae                               0.30       0.07        0.26       0.13   99.17
Crustacea Raninidae                                 0.34       0.07        0.26       0.12   99.30
Mollusca Propeamussiidae                            0.30       0.07        0.26       0.12   99.42
Crustacea Nannastacidae                             0.24       0.03        0.15       0.05   99.47
Crustacea Melphidippidae                            0.20       0.03        0.15       0.05   99.53
Crustacea Amaryllididae                             0.20       0.03        0.15       0.05   99.58
Mollusca Trigonidae                                 0.20       0.03        0.15       0.05   99.62
Polychaeta Ampharetidae                             0.20       0.03        0.15       0.05   99.67
Crustacea Agathotanaidae                            0.24       0.03        0.15       0.05   99.72
Mollusca Philinidae                                 0.24       0.03        0.15       0.05   99.76
Crustacea Urothoidae                                0.20       0.02        0.15       0.04   99.81
Mollusca Laevidentaliidae                           0.24       0.02        0.15       0.04   99.85
Crustacea Sarsiellidae                              0.20       0.02        0.15       0.04   99.89
Polychaeta Goniadidae                               0.20       0.02        0.15       0.04   99.93
Polychaeta Oenonidae                                0.20       0.02        0.15       0.04   99.97
Polychaeta Sphaerodoridae                           0.20       0.02        0.15       0.03  100.00

Group M3-2008
Average similarity: 56.85
Species                                         Av.Abund     Av.Sim      Sim/SD   Contrib%   Cum.%
Polychaeta Spionidae                                4.90       5.43        6.34       9.55    9.55
Polychaeta Ampharetidae                             3.83       3.78        1.80       6.65   16.21
Polychaeta Cirratulidae                             3.03       3.12        2.71       5.49   21.70
Crustacea Apseudidae                                2.57       2.90        4.10       5.09   26.79
Polychaeta Lumbrineridae                            2.62       2.86        3.08       5.03   31.82
Polychaeta Onuphidae                                2.67       2.82        2.68       4.96   36.78
Crustacea Ampeliscidae                              2.91       2.71        2.39       4.76   41.54
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      3.15       2.64        2.03       4.64   46.19
Polychaeta Maldanidae                               2.90       2.54        3.23       4.47   50.66
Crustacea Phoxocephalidae                           2.14       1.96        2.84       3.46   54.11
Polychaeta Opheliidae                               1.78       1.73        3.24       3.05   57.16
Polychaeta Syllidae                                 1.95       1.45        1.75       2.55   59.71
Crustacea Oedicerotidae                             1.65       1.19        1.04       2.09   61.79
Polychaeta Paraonidae                               1.21       1.00        1.11       1.76   63.55
Polychaeta Sabellidae                               1.17       0.95        1.21       1.67   65.23
Crustacea Bodotriidae                               1.30       0.95        1.14       1.66   66.89
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Crustacea Philomedidae	1.25	0.93	1.21	1.64	68.53
Crustacea Diastylidae/Gynodiastylidae	1.55	0.92	0.85	1.62	70.15
Crustacea Anthuridae	1.12	0.91	1.17	1.60	71.75
Polychaeta Terebellidae	1.01	0.90	1.19	1.59	73.34
Mollusca Chaetodermatidae	1.08	0.90	1.22	1.57	74.92
Crustacea Lysianassidae	1.16	0.89	1.23	1.57	76.48
Crustacea Paratanaidae	1.14	0.88	1.17	1.55	78.04
Crustacea Nebaliidae	1.24	0.87	0.86	1.53	79.57
Echinodermata Ophiuroidea	1.37	0.80	0.88	1.41	80.98
Crustacea Ischyroceridae	1.15	0.79	0.79	1.39	82.37
Crustacea Melitidae	0.97	0.73	0.87	1.29	83.67
Polychaeta Scalibregmatidae	0.74	0.65	0.91	1.14	84.81
Mollusca Nassariidae	0.88	0.61	0.90	1.08	85.89
Polychaeta Pectinariidae	0.78	0.58	0.89	1.01	86.90
Crustacea Leptocheliidae	1.03	0.52	0.68	0.92	87.82
Polychaeta Phyllodocidae	0.76	0.52	0.69	0.91	88.73
Crustacea Cylindroleberidae	0.91	0.46	0.67	0.81	89.54
Polychaeta Orbiniidae	0.90	0.45	0.63	0.79	90.33
Mollusca Capulidae	0.78	0.44	0.66	0.77	91.09
Crustacea Cypridinidae/Rutidermatidae	0.64	0.42	0.68	0.74	91.83
Mollusca Solemyidae	0.72	0.42	0.69	0.73	92.56
Mollusca Marginellidae	0.60	0.41	0.68	0.72	93.28
Crustacea Gnathiidae	0.62	0.27	0.51	0.48	93.77
Mollusca Nuculidae	0.68	0.27	0.52	0.47	94.23
Crustacea Pasiphaeidae	0.50	0.26	0.52	0.46	94.69
Mollusca Nuculanidae	0.56	0.23	0.38	0.40	95.09
Crustacea Callianassidae	0.48	0.22	0.38	0.38	95.48
Mollusca Propeamussiidae	0.48	0.21	0.37	0.37	95.84
Mollusca Rissoidae	0.52	0.18	0.38	0.32	96.17
Crustacea Atylidae	0.48	0.16	0.38	0.28	96.45
Crustacea Raninidae	0.40	0.15	0.38	0.27	96.72
Mollusca Lucinidae	0.40	0.15	0.38	0.27	96.98
Echinodermata Echinoidea	0.52	0.14	0.38	0.25	97.23
Mollusca Laevidentaliidae	0.50	0.11	0.25	0.19	97.42
Polychaeta Nephtyidae	0.46	0.10	0.26	0.17	97.59
Crustacea Leptanthuridae	0.34	0.10	0.26	0.17	97.76
Polychaeta Capitellidae	0.37	0.09	0.26	0.16	97.92
Crustacea Arcturididae	0.30	0.09	0.26	0.16	98.08
Crustacea Goneplacidae	0.34	0.09	0.26	0.16	98.23
Mollusca Veneridae	0.34	0.08	0.26	0.15	98.38
Mollusca Mytilidae	0.37	0.08	0.26	0.15	98.53
Mollusca Galeommatidae	0.30	0.08	0.26	0.15	98.68
Polychaeta Goniadidae	0.34	0.08	0.26	0.14	98.81
Crustacea Penaeidae	0.30	0.07	0.26	0.12	98.93
Crustacea Arcturidae	0.30	0.07	0.26	0.12	99.06
Crustacea Paramunnidae	0.40	0.07	0.26	0.12	99.18
Crustacea Mysidae	0.28	0.04	0.15	0.07	99.25
Crustacea Corophiidae	0.35	0.04	0.15	0.06	99.31
Polychaeta Glyceridae	0.20	0.03	0.15	0.06	99.37
Polychaeta Aphroditidae	0.20	0.03	0.15	0.06	99.43
Mollusca Anabathridae	0.41	0.03	0.15	0.05	99.48
Crustacea Cirolanidae	0.20	0.03	0.15	0.05	99.53
Mollusca Acteonidae	0.20	0.03	0.15	0.05	99.58
Crustacea Caprellidae	0.20	0.03	0.15	0.05	99.63
Crustacea Paranthuridae	0.24	0.03	0.15	0.05	99.68
Polychaeta Sigalionidae	0.20	0.03	0.15	0.05	99.73
Mollusca Pyramidellidae	0.20	0.03	0.15	0.05	99.77
Polychaeta Flabelligeridae	0.20	0.03	0.15	0.04	99.82
Mollusca Myochamidae	0.20	0.03	0.15	0.04	99.86
Polychaeta Trichobranchidae	0.20	0.02	0.15	0.04	99.89
Crustacea Sphaeromatidae	0.46	0.02	0.15	0.04	99.93
Crustacea Urohaustoriidae	0.24	0.02	0.15	0.04	99.97
Polychaeta Nereididae	0.30	0.02	0.15	0.03	100.00

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Group M3-2011
Average similarity: 61.28
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Spionidae                               9.21        7.80        2.77      12.73  12.73
Polychaeta Cirratulidae                            5.60        5.32        2.42       8.68  21.42
Polychaeta Maldanidae                              5.90        4.69        2.88       7.65  29.07
Polychaeta Syllidae                                3.92        3.23        2.80       5.27  34.33
Polychaeta Lumbrineridae                           3.41        3.03        1.98       4.95  39.28
Crustacea Paranthuridae                            2.58        2.36        3.48       3.85  43.13
Polychaeta Sabellidae                              2.51        2.08        3.07       3.40  46.53
Mollusca Lucinidae                                 2.22        1.76        2.05       2.87  49.39
Polychaeta Orbiniidae                              1.85        1.54        4.05       2.51  51.91
Crustacea Ampeliscidae                             2.03        1.51        1.80       2.47  54.37
Polychaeta Ampharetidae                            2.89        1.50        1.47       2.45  56.82
Crustacea Apseudidae                               2.14        1.47        1.53       2.40  59.22
Polychaeta Paraonidae                              2.27        1.45        1.32       2.36  61.58
Crustacea Anthuridae                               1.87        1.44        1.65       2.34  63.93
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     1.89        1.27        1.66       2.07  65.99
Crustacea Lysianassidae                            1.68        1.23        1.80       2.02  68.01
Polychaeta Opheliidae                              1.59        1.22        1.51       1.99  69.99
Mollusca Chaetodermatidae                          1.65        1.15        1.53       1.88  71.87
Crustacea Goneplacidae                             1.24        1.09        1.74       1.77  73.65
Polychaeta Oweniidae                               1.64        1.02        1.11       1.66  75.31
Crustacea Phoxocephalidae                          1.31        1.02        1.82       1.66  76.97
Echinodermata Echinoidea                           1.42        0.98        1.16       1.59  78.56
Polychaeta Sigalionidae                            1.32        0.92        1.20       1.51  80.07
Crustacea Bodotriidae                              1.34        0.92        1.17       1.49  81.56
Echinodermata Ophiuroidea                          1.30        0.82        1.12       1.34  82.90
Crustacea Paratanaidae                             1.60        0.77        0.87       1.26  84.15
Crustacea Callianassidae                           1.10        0.75        0.84       1.23  85.38
Polychaeta Trichobranchidae                        1.13        0.67        0.90       1.10  86.48
Crustacea Ischyroceridae                           1.18        0.67        0.90       1.10  87.58
Crustacea Leptocheliidae                           1.42        0.65        0.85       1.06  88.64
Crustacea Philomedidae                             1.11        0.63        0.86       1.03  89.66
Mollusca Nuculidae                                 0.94        0.63        0.87       1.03  90.69
Crustacea Melitidae                                1.02        0.61        0.88       1.00  91.69
Polychaeta Scalibregmatidae                        0.94        0.60        0.90       0.98  92.67
Polychaeta Chaetopteridae                          0.99        0.59        0.89       0.96  93.63
Crustacea Diastylidae/Gynodiastylidae              1.01        0.48        0.69       0.78  94.40
Mollusca Laevidentaliidae                          0.72        0.36        0.68       0.59  94.99
Polychaeta Phyllodocidae                           0.78        0.35        0.68       0.57  95.57
Crustacea Leptanthuridae                           0.69        0.26        0.52       0.43  96.00
Polychaeta Onuphidae                               0.61        0.26        0.52       0.42  96.42
Mollusca Mytilidae                                 0.67        0.25        0.52       0.41  96.83
Polychaeta Oenonidae                               0.62        0.18        0.38       0.30  97.13
Crustacea Oedicerotidae                            0.88        0.17        0.35       0.28  97.41
Mollusca Rissoidae                                 0.51        0.17        0.38       0.28  97.69
Polychaeta Dorvilleidae                            0.40        0.14        0.38       0.23  97.91
Mollusca Nassariidae                               0.48        0.14        0.38       0.22  98.14
Polychaeta Nereididae                              0.40        0.12        0.38       0.20  98.34
Mollusca Marginellidae                             0.41        0.09        0.26       0.14  98.47
Crustacea Cylindroleberidae                        0.30        0.07        0.26       0.12  98.60
Polychaeta Nephtyidae                              0.42        0.07        0.26       0.12  98.71
Crustacea Cypridinidae/Rutidermatidae              0.34        0.07        0.26       0.12  98.83
Mollusca Pyramidellidae                            0.40        0.07        0.26       0.12  98.95
Crustacea Pasiphaeidae                             0.44        0.07        0.26       0.11  99.06
Mollusca Solemyidae                                0.30        0.07        0.26       0.11  99.17
Crustacea Nebaliidae                               0.34        0.07        0.26       0.11  99.28
Crustacea Liljeborgiidae                           0.34        0.06        0.26       0.11  99.38
Mollusca Mitridae                                  0.40        0.06        0.26       0.10  99.48
Crustacea Sarsiellidae                             0.34        0.06        0.26       0.10  99.59
Crustacea Sphaeromatidae                           0.20        0.03        0.15       0.05  99.64
Mollusca Volutomitridae                            0.20        0.03        0.15       0.05  99.68
Crustacea Gnathiidae                               0.34        0.03        0.15       0.04  99.73
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Crustacea Antarcturidae                             0.24        0.03        0.15        0.04   99.77
Mollusca Turridae                                   0.20        0.02        0.15        0.04   99.81
Mollusca Cuspidariidae                              0.20        0.02        0.15        0.04   99.85
Crustacea Nannastacidae                             0.20        0.02        0.15        0.03   99.88
Mollusca Galeommatidae                              0.24        0.02        0.15        0.03   99.91
Polychaeta Capitellidae                             0.27        0.02        0.15        0.03   99.94
Polychaeta Goniadidae                               0.20        0.02        0.15        0.03   99.97
Mollusca Propeamussiidae                            0.24        0.02        0.15        0.03  100.00

Group M3-2014
Average similarity: 56.09
Species                                         Av.Abund      Av.Sim      Sim/SD    Contrib%   Cum.%
Polychaeta Maldanidae                               3.82        7.82        3.39       13.94   13.94
Polychaeta Cirratulidae                             2.89        5.64        3.27       10.06   24.00
Crustacea Apseudidae                                1.89        4.19        3.88        7.47   31.47
Polychaeta Spionidae                                1.97        3.73        3.28        6.64   38.11
Crustacea Callianassidae                            1.56        3.19        3.87        5.69   43.80
Crustacea Anthuridae                                1.33        2.69        1.74        4.79   48.60
Polychaeta Ampharetidae                             1.90        2.63        1.66        4.69   53.29
Crustacea Melitidae                                 1.23        2.43        1.68        4.33   57.62
Crustacea Phoxocephalidae                           1.56        2.38        1.17        4.25   61.87
Crustacea Paratanaidae                              1.41        2.37        1.61        4.23   66.10
Polychaeta Oweniidae                                1.44        2.11        1.17        3.76   69.85
Polychaeta Syllidae                                 1.16        1.90        1.13        3.38   73.24
Crustacea Hexapodidae                               0.96        1.82        1.19        3.24   76.47
Polychaeta Lumbrineridae                            1.15        1.60        1.18        2.86   79.33
Echinodermata Ophiuroidea                           1.06        1.31        0.90        2.33   81.66
Polychaeta Orbiniidae                               0.82        1.15        0.90        2.05   83.71
Polychaeta Opheliidae                               0.81        1.15        0.88        2.05   85.76
Polychaeta Sabellidae                               0.80        0.89        0.69        1.59   87.35
Crustacea Ampeliscidae                              0.84        0.85        0.68        1.51   88.86
Polychaeta Sigalionidae                             0.70        0.69        0.69        1.24   90.09
Echinodermata Echinoidea                            0.58        0.56        0.51        1.00   91.09
Mollusca Rissoidae                                  0.61        0.52        0.52        0.92   92.01
Polychaeta Onuphidae                                0.54        0.51        0.51        0.91   92.92
Mollusca Nassariidae                                0.57        0.49        0.52        0.88   93.80
Crustacea Paranthuridae                             0.62        0.49        0.52        0.88   94.67
Polychaeta Paraonidae                               0.54        0.49        0.52        0.87   95.54
Mollusca Laevidentaliidae                           0.54        0.44        0.53        0.78   96.32
Crustacea Cylindroleberidae                         0.40        0.30        0.38        0.54   96.85
Mollusca Chaetodermatidae                           0.48        0.29        0.38        0.52   97.38
Crustacea Lysianassidae                             0.47        0.29        0.38        0.52   97.89
Mollusca Acteonidae                                 0.34        0.17        0.26        0.31   98.20
Polychaeta Oenonidae                                0.30        0.16        0.26        0.28   98.48
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      0.41        0.16        0.26        0.28   98.77
Mollusca Nuculidae                                  0.30        0.14        0.26        0.24   99.01
Crustacea Oedicerotidae                             0.37        0.12        0.26        0.22   99.23
Mollusca Marginellidae                              0.28        0.07        0.15        0.12   99.35
Mollusca Anabathridae                               0.20        0.06        0.15        0.10   99.45
Polychaeta Nephtyidae                               0.20        0.05        0.15        0.09   99.55
Crustacea Philomedidae                              0.20        0.05        0.15        0.09   99.64
Crustacea Leptocheliidae                            0.24        0.04        0.15        0.08   99.71
Crustacea Diastylidae/Gynodiastylidae               0.20        0.04        0.15        0.08   99.79
Mollusca Lucinidae                                  0.20        0.04        0.15        0.08   99.87
Crustacea Ischyroceridae                            0.24        0.04        0.15        0.07   99.93
Crustacea Raninidae                                 0.20        0.04        0.15        0.07  100.00
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Group M5-2002
Average similarity: 57.64
Species                                         Av.Abund    Av.Sim    Sim/SD  Contrib%   Cum.%
Polychaeta Spionidae                                5.13      6.31      3.65     10.95   10.95
Polychaeta Maldanidae                               4.47      4.38      1.83      7.59   18.54
Polychaeta Oweniidae                                2.98      3.17      2.71      5.49   24.03
Crustacea Leptocheliidae                            3.18      3.08      2.36      5.35   29.38
Polychaeta Cirratulidae                             2.28      2.77      3.05      4.80   34.18
Polychaeta Syllidae                                 2.17      2.51      3.49      4.35   38.53
Crustacea Apseudidae                                2.21      2.40      2.73      4.17   42.70
Polychaeta Ampharetidae                             2.48      2.32      1.75      4.02   46.72
Crustacea Ischyroceridae                            2.21      2.28      2.34      3.96   50.68
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      1.92      2.25      3.38      3.90   54.58
Crustacea Ampeliscidae                              1.85      2.16      2.38      3.75   58.34
Crustacea Callianassidae                            1.57      1.95      3.89      3.39   61.73
Echinodermata Echinoidea                            1.57      1.76      5.03      3.05   64.78
Mollusca Lucinidae                                  1.77      1.59      1.60      2.77   67.55
Polychaeta Opheliidae                               1.34      1.43      1.86      2.49   70.03
Echinodermata Ophiuroidea                           1.49      1.22      1.14      2.12   72.15
Crustacea Leptanthuridae                            1.40      1.17      1.05      2.03   74.18
Polychaeta Lumbrineridae                            1.19      1.10      1.20      1.91   76.09
Crustacea Paguridae                                 1.17      1.03      1.20      1.79   77.88
Polychaeta Paraonidae                               1.14      0.97      1.12      1.68   79.56
Mollusca Galeommatidae                              0.84      0.89      1.25      1.55   81.11
Mollusca Nassariidae                                0.99      0.72      0.87      1.25   82.36
Crustacea Phoxocephalidae                           0.84      0.68      0.91      1.18   83.54
Polychaeta Sigalionidae                             0.78      0.68      0.91      1.17   84.72
Crustacea Diastylidae/Gynodiastylidae               0.80      0.66      0.92      1.14   85.86
Mollusca Laevidentaliidae                           0.74      0.64      0.92      1.11   86.96
Polychaeta Sabellidae                               1.11      0.57      0.64      1.00   87.96
Mollusca Chaetodermatidae                           0.85      0.57      0.67      0.99   88.95
Polychaeta Trichobranchidae                         0.85      0.55      0.65      0.95   89.90
Crustacea Pasiphaeidae                              0.68      0.50      0.69      0.87   90.77
Polychaeta Orbiniidae                               0.71      0.47      0.68      0.81   91.58
Crustacea Anthuridae                                0.72      0.41      0.52      0.72   92.30
Crustacea Melitidae                                 0.66      0.37      0.52      0.65   92.94
Polychaeta Phyllodocidae                            0.69      0.34      0.52      0.60   93.54
Mollusca Thyasiridae                                0.67      0.34      0.52      0.58   94.12
Crustacea Oedicerotidae                             0.58      0.32      0.53      0.55   94.67
Polychaeta Scalibregmatidae                         0.40      0.22      0.39      0.39   95.06
Crustacea Goneplacidae                              0.51      0.22      0.39      0.38   95.44
Crustacea Lysianassidae                             0.64      0.21      0.39      0.36   95.80
Polychaeta Capitellidae                             0.40      0.20      0.38      0.35   96.15
Mollusca Solemyidae                                 0.44      0.19      0.39      0.33   96.48
Polychaeta Onuphidae                                0.54      0.19      0.39      0.33   96.81
Mollusca Rissoidae                                  0.47      0.17      0.39      0.30   97.11
Mollusca Pyramidellidae                             0.44      0.17      0.39      0.29   97.39
Polychaeta Chaetopteridae                           0.34      0.10      0.26      0.18   97.58
Polychaeta Apistobranchidae                         0.44      0.10      0.26      0.18   97.75
Mollusca Marginellidae                              0.40      0.09      0.26      0.16   97.92
Polychaeta Flabelligeridae                          0.34      0.09      0.26      0.16   98.08
Crustacea Cypridinidae/Rutidermatidae               0.34      0.09      0.26      0.16   98.24
Mollusca Nuculidae                                  0.37      0.09      0.26      0.16   98.40
Crustacea Cylindroleberidae                         0.38      0.09      0.26      0.16   98.56
Crustacea Bodotriidae                               0.34      0.09      0.26      0.15   98.71
Polychaeta Sabellariidae                            0.40      0.08      0.15      0.15   98.86
Polychaeta Poecilochaetidae                         0.30      0.08      0.26      0.14   99.00
Crustacea Sphaeromatidae                            0.34      0.08      0.26      0.14   99.14
Mollusca Acteonidae                                 0.30      0.08      0.26      0.14   99.28
Crustacea Nebaliidae                                0.20      0.04      0.15      0.07   99.35
Crustacea Paratanaidae                              0.20      0.04      0.15      0.07   99.42
Crustacea Paramunnidae                              0.20      0.04      0.15      0.07   99.48
Polychaeta Nephtyidae                               0.24      0.04      0.15      0.07   99.55
Crustacea Antarcturidae                             0.20      0.04      0.15      0.06   99.61
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Crustacea Atylidae                                  0.24       0.04        0.15        0.06  99.67
Crustacea Amaryllididae                             0.20       0.03        0.15        0.05  99.72
Crustacea Synopiidae                                0.20       0.03        0.15        0.05  99.77
Polychaeta Polynoidae                               0.24       0.03        0.15        0.05  99.82
Polychaeta Pectinariidae                            0.27       0.03        0.15        0.04  99.87
Polychaeta Oenonidae                                0.20       0.03        0.15        0.04  99.91
Echinodermata Holothuroidea                         0.27       0.03        0.15        0.04  99.96
Crustacea Leucosiidae                               0.24       0.03        0.15        0.04 100.00

Group M5-2005
Average similarity: 55.39
Species                                         Av.Abund  Av.Sim      Sim/SD Contrib%    Cum.%
Polychaeta Oweniidae                               10.26    6.51        1.77    11.76    11.76
Crustacea Leptocheliidae                            4.81    4.44        4.29     8.02    19.78
Polychaeta Maldanidae                               3.86    3.00        1.62     5.42    25.20
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      3.13    2.98        2.34     5.37    30.57
Polychaeta Spionidae                                2.97    2.62        2.84     4.74    35.31
Polychaeta Syllidae                                 2.73    2.49        2.93     4.49    39.80
Crustacea Apseudidae                                1.99    1.98        3.46     3.57    43.37
Crustacea Ischyroceridae                            2.59    1.81        1.42     3.28    46.64
Crustacea Oedicerotidae                             1.90    1.80        3.46     3.26    49.90
Polychaeta Cirratulidae                             1.97    1.77        3.61     3.19    53.09
Crustacea Bodotriidae                               2.16    1.76        1.79     3.18    56.27
Echinodermata Ophiuroidea                           1.84    1.76        6.29     3.18    59.45
Crustacea Phoxocephalidae                           2.10    1.74        3.48     3.14    62.59
Crustacea Paratanaidae                              1.91    1.71        1.73     3.08    65.67
Polychaeta Lumbrineridae                            2.22    1.68        1.25     3.03    68.70
Mollusca Nassariidae                                1.66    1.09        1.10     1.97    70.67
Crustacea Lysianassidae                             1.42    1.07        1.24     1.92    72.60
Echinodermata Echinoidea                            1.60    1.02        1.11     1.85    74.44
Crustacea Anthuridae                                1.67    1.02        1.08     1.84    76.28
Mollusca Nuculidae                                  1.10    0.94        1.89     1.70    77.98
Crustacea Ampeliscidae                              1.50    0.92        1.12     1.65    79.63
Crustacea Gnathiidae                                1.03    0.76        1.23     1.37    81.01
Crustacea Diastylidae/Gynodiastylidae               1.04    0.73        0.87     1.32    82.33
Mollusca Chaetodermatidae                           1.21    0.67        0.89     1.21    83.54
Polychaeta Paraonidae                               1.02    0.57        0.66     1.04    84.58
Crustacea Callianassidae                            0.90    0.56        0.91     1.01    85.59
Polychaeta Sabellidae                               0.91    0.54        0.90     0.97    86.56
Crustacea Amaryllididae                             0.86    0.52        0.90     0.95    87.51
Polychaeta Onuphidae                                0.77    0.45        0.65     0.80    88.31
Mollusca Marginellidae                              0.68    0.39        0.68     0.71    89.03
Polychaeta Opheliidae                               0.84    0.39        0.68     0.71    89.73
Crustacea Philomedidae                              1.22    0.38        0.34     0.68    90.41
Mollusca Trigonidae                                 0.68    0.37        0.68     0.67    91.08
Crustacea Sphaeromatidae                            0.68    0.36        0.69     0.65    91.73
Polychaeta Trichobranchidae                         0.62    0.28        0.51     0.50    92.23
Mollusca Lucinidae                                  0.61    0.27        0.52     0.48    92.71
Crustacea Leptanthuridae                            0.65    0.26        0.51     0.47    93.18
Crustacea Cylindroleberidae                         0.62    0.26        0.52     0.46    93.64
Crustacea Melitidae                                 0.76    0.25        0.51     0.46    94.10
Crustacea Arcturidae                                0.50    0.24        0.52     0.43    94.53
Crustacea Goneplacidae                              0.58    0.22        0.52     0.40    94.93
Crustacea Atylidae                                  0.62    0.19        0.38     0.34    95.28
Crustacea Sarsiellidae                              0.48    0.19        0.38     0.34    95.62
Crustacea Pasiphaeidae                              0.56    0.18        0.38     0.33    95.95
Polychaeta Orbiniidae                               0.51    0.16        0.38     0.29    96.24
Mollusca Skeneidae                                  0.40    0.15        0.39     0.26    96.51
Crustacea Leucosiidae                               0.44    0.14        0.39     0.26    96.77
Polychaeta Nereididae                               0.40    0.14        0.39     0.25    97.01
Mollusca Propeamussiidae                            0.44    0.13        0.38     0.24    97.26
Polychaeta Chaetopteridae                           0.47    0.13        0.39     0.23    97.49
Crustacea Cypridinidae/Rutidermatidae               0.50    0.12        0.25     0.21    97.70
Mollusca Nuculanidae                                0.64    0.10        0.15     0.18    97.88
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Crustacea Paguridae                                 0.34    0.10        0.26      0.18   98.05
Crustacea Whiteleggiidae                            0.53    0.09        0.15      0.16   98.22
Crustacea Corophiidae                               0.38    0.09        0.26      0.16   98.38
Polychaeta Phyllodocidae                            0.41    0.08        0.26      0.14   98.51
Crustacea Pagurapseudidae                           0.46    0.07        0.15      0.13   98.65
Polychaeta Oenonidae                                0.30    0.07        0.26      0.13   98.77
Polychaeta Nephtyidae                               0.30    0.07        0.26      0.12   98.90
Crustacea Cirolanidae                               0.34    0.07        0.26      0.12   99.02
Crustacea Agathotanaidae                            0.34    0.07        0.26      0.12   99.15
Crustacea Paramunnidae                              0.30    0.06        0.26      0.12   99.26
Crustacea Podoceridae                               0.34    0.06        0.26      0.11   99.37
Crustacea Paranthuridae                             0.35    0.04        0.15      0.07   99.44
Crustacea Synopiidae                                0.27    0.04        0.15      0.07   99.51
Polychaeta Terebellidae                             0.28    0.03        0.15      0.06   99.56
Polychaeta Goniadidae                               0.24    0.03        0.15      0.06   99.62
Crustacea Raninidae                                 0.20    0.03        0.15      0.05   99.67
Crustacea Liljeborgiidae                            0.20    0.03        0.15      0.05   99.72
Mollusca Philinidae                                 0.20    0.03        0.15      0.05   99.77
Polychaeta Apistobranchidae                         0.24    0.02        0.15      0.04   99.81
Polychaeta Capitellidae                             0.20    0.02        0.15      0.04   99.85
Polychaeta Ampharetidae                             0.27    0.02        0.15      0.04   99.89
Polychaeta Amphinomidae                             0.27    0.02        0.15      0.04   99.93
Mollusca Laevidentaliidae                           0.24    0.02        0.15      0.04   99.96
Mollusca Solemyidae                                 0.20    0.02        0.15      0.04  100.00

Group M5-2008
Average similarity: 52.00
Species                                         Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Spionidae                                5.09        5.11        1.78       9.83   9.83
Polychaeta Cirratulidae                             3.26        3.97        2.31       7.63  17.46
Polychaeta Maldanidae                               4.63        3.79        2.70       7.28  24.75
Polychaeta Lumbrineridae                            2.98        3.39        4.32       6.52  31.27
Crustacea Ampeliscidae                              2.61        3.36        3.36       6.46  37.72
Crustacea Phoxocephalidae                           2.37        2.44        4.71       4.69  42.41
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      2.33        2.29        1.80       4.40  46.81
Polychaeta Syllidae                                 2.00        2.16        2.52       4.15  50.96
Polychaeta Onuphidae                                1.47        1.78        3.37       3.41  54.37
Crustacea Anthuridae                                1.49        1.71        3.14       3.29  57.66
Crustacea Leptocheliidae                            2.24        1.70        1.62       3.27  60.93
Polychaeta Paraonidae                               1.59        1.68        1.48       3.22  64.15
Crustacea Lysianassidae                             1.62        1.51        1.79       2.91  67.06
Crustacea Melitidae                                 1.02        0.99        1.13       1.91  68.97
Crustacea Apseudidae                                1.17        0.99        1.06       1.90  70.87
Polychaeta Opheliidae                               1.17        0.94        0.88       1.81  72.67
Mollusca Lucinidae                                  1.24        0.92        0.88       1.77  74.44
Polychaeta Orbiniidae                               1.06        0.90        1.13       1.73  76.18
Polychaeta Ampharetidae                             1.55        0.87        0.77       1.68  77.85
Polychaeta Oweniidae                                4.95        0.85        0.29       1.63  79.49
Crustacea Bodotriidae                               0.96        0.71        0.88       1.37  80.86
Polychaeta Phyllodocidae                            0.87        0.70        0.89       1.34  82.20
Crustacea Nebaliidae                                0.86        0.70        0.84       1.34  83.54
Mollusca Chaetodermatidae                           1.00        0.66        0.89       1.26  84.80
Echinodermata Ophiuroidea                           0.99        0.66        0.81       1.26  86.07
Mollusca Laevidentaliidae                           0.88        0.65        0.67       1.24  87.31
Crustacea Gnathiidae                                0.72        0.61        0.64       1.16  88.47
Crustacea Diastylidae/Gynodiastylidae               0.88        0.50        0.68       0.96  89.43
Polychaeta Capitellidae                             0.72        0.43        0.68       0.83  90.26
Crustacea Paratanaidae                              1.01        0.36        0.50       0.70  90.96
Mollusca Nuculanidae                                0.71        0.34        0.49       0.65  91.61
Crustacea Goneplacidae                              0.50        0.30        0.52       0.59  92.19
Crustacea Raninidae                                 0.54        0.30        0.51       0.58  92.77
Mollusca Marginellidae                              0.66        0.28        0.50       0.55  93.32
Crustacea Callianassidae                            0.54        0.27        0.52       0.51  93.83
Crustacea Leptanthuridae                            0.87        0.26        0.39       0.51  94.34
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Mollusca Solemyidae                                   0.54        0.26        0.52        0.50  94.84
Crustacea Philomedidae                                0.44        0.23        0.37        0.45  95.28
Mollusca Nuculidae                                    0.64        0.22        0.38        0.42  95.70
Echinodermata Echinoidea                              0.59        0.20        0.38        0.39  96.10
Polychaeta Terebellidae                               0.52        0.19        0.38        0.36  96.46
Mollusca Rissoidae                                    0.40        0.17        0.38        0.34  96.79
Polychaeta Sabellidae                                 0.51        0.17        0.38        0.34  97.13
Crustacea Cylindroleberidae                           0.59        0.17        0.38        0.34  97.47
Crustacea Ischyroceridae                              0.58        0.17        0.38        0.33  97.79
Mollusca Veneridae                                    0.34        0.11        0.26        0.22  98.01
Crustacea Oedicerotidae                               0.38        0.11        0.26        0.21  98.22
Crustacea Pasiphaeidae                                0.30        0.10        0.26        0.19  98.41
Polychaeta Pectinariidae                              0.30        0.08        0.26        0.16  98.57
Crustacea Atylidae                                    0.52        0.08        0.26        0.16  98.72
Polychaeta Goniadidae                                 0.30        0.07        0.26        0.13  98.85
Mollusca Trigonidae                                   0.30        0.07        0.26        0.13  98.98
Crustacea Arcturididae                                0.34        0.07        0.26        0.13  99.11
Mollusca Galeommatidae                                0.24        0.05        0.15        0.09  99.19
Crustacea Sarsiellidae                                0.28        0.04        0.15        0.07  99.27
Mollusca Cuspidariidae                                0.24        0.03        0.15        0.07  99.33
Mollusca Anabathridae                                 0.27        0.03        0.15        0.06  99.39
Polychaeta Nereididae                                 0.20        0.03        0.15        0.06  99.45
Crustacea Cypridinidae/Rutidermatidae                 0.20        0.03        0.15        0.06  99.50
Mollusca Mytilidae                                    0.20        0.03        0.15        0.06  99.56
Polychaeta Scalibregmatidae                           0.20        0.03        0.15        0.05  99.61
Polychaeta Chaetopteridae                             0.24        0.02        0.15        0.05  99.66
Polychaeta Sigalionidae                               0.20        0.02        0.15        0.04  99.70
Mollusca Propeamussiidae                              0.20        0.02        0.15        0.04  99.75
Mollusca Turridae                                     0.20        0.02        0.15        0.04  99.79
Mollusca Pectinidae                                   0.20        0.02        0.15        0.04  99.84
Crustacea Podoceridae                                 0.27        0.02        0.15        0.04  99.88
Mollusca Nassariidae                                  0.20        0.02        0.15        0.04  99.92
Crustacea Sphaeromatidae                              0.27        0.02        0.15        0.04  99.96
Crustacea Ochlesidae                                  0.20        0.02        0.15        0.04 100.00

Group M5-2011
Average similarity: 60.96
Species                               Av.Abund    Av.Sim      Sim/SD      Contrib%  Cum.%
Polychaeta Spionidae                      8.87      6.95        2.40       11.41  11.41
Polychaeta Maldanidae                     6.99      4.54        2.14        7.44  18.85
Polychaeta Cirratulidae                   4.79      4.36        4.76        7.16  26.01
Polychaeta Syllidae                       4.77      3.22        3.40        5.28  31.28
Crustacea Leptocheliidae                  3.69      2.55        3.11        4.17  35.46
Mollusca Lucinidae                        2.86      2.32        2.31        3.81  39.27
Polychaeta Ampharetidae                   2.73      2.18        2.27        3.57  42.84
Crustacea Apseudidae                      2.96      2.17        3.20        3.55  46.39
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae  2.67      1.91        2.59        3.14    49.53
Polychaeta Lumbrineridae                  2.20      1.73        2.89        2.84  52.37
Echinodermata Ophiuroidea                 2.11      1.57        3.14        2.57  54.94
Crustacea Paranthuridae                   1.91      1.55        2.81        2.54  57.48
Crustacea Ampeliscidae                    2.09      1.33        1.65        2.19  59.67
Polychaeta Sigalionidae                   1.96      1.32        1.59        2.17  61.84
Crustacea Ischyroceridae                  1.90      1.32        1.66        2.17  64.01
Polychaeta Paraonidae                     2.25      1.27        1.44        2.09  66.09
Polychaeta Onuphidae                      1.70      1.18        1.75        1.93  68.03
Polychaeta Sabellidae                     1.89      1.10        1.10        1.80  69.82
Crustacea Anthuridae                      1.59      1.04        1.52        1.70  71.53
Echinodermata Echinoidea                  1.54      1.02        1.75        1.67  73.19
Crustacea Lysianassidae                   1.42      0.96        1.62        1.58  74.77
Mollusca Chaetodermatidae                 1.46      0.89        1.13        1.46  76.23
Crustacea Oedicerotidae                   1.67      0.87        1.20        1.43  77.66
Crustacea Callianassidae                  1.18      0.84        1.15        1.37  79.03
Crustacea Melitidae                       1.31      0.80        1.19        1.31  80.34
Crustacea Philomedidae                    1.02      0.70        1.19        1.15  81.49
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Crustacea Goneplacidae                     0.96      0.68        1.20         1.11  82.59
Mollusca Nuculidae                         1.08      0.65        1.20         1.06  83.66
Crustacea Diastylidae/Gynodiastylidae      1.22      0.59        0.90         0.97  84.63
Crustacea Pasiphaeidae                     1.10      0.59        0.88         0.96  85.59
Mollusca Rissoidae                         1.22      0.59        0.85         0.96  86.55
Crustacea Paratanaidae                     0.91      0.57        0.90         0.93  87.48
Crustacea Phoxocephalidae                  1.14      0.53        0.90         0.87  88.35
Polychaeta Phyllodocidae                   0.99      0.51        0.90         0.83  89.18
Polychaeta Oweniidae                       1.01      0.50        0.90         0.82  90.00
Polychaeta Oenonidae                       0.82      0.50        0.90         0.81  90.82
Polychaeta Orbiniidae                      0.89      0.47        0.89         0.77  91.59
Mollusca Marginellidae                     0.99      0.47        0.88         0.77  92.36
Crustacea Agathotanaidae                   1.06      0.46        0.66         0.76  93.12
Polychaeta Nephtyidae                      0.78      0.44        0.89         0.73  93.85
Crustacea Bodotriidae                      1.58      0.36        0.47         0.58  94.43
Mollusca Laevidentaliidae                  0.88      0.32        0.50         0.52  94.95
Polychaeta Opheliidae                      0.77      0.27        0.49         0.44  95.38
Polychaeta Flabelligeridae                 0.81      0.23        0.50         0.38  95.77
Polychaeta Nereididae                      0.62      0.22        0.51         0.36  96.13
Mollusca Mytilidae                         0.67      0.21        0.52         0.35  96.48
Crustacea Cylindroleberidae                0.58      0.18        0.52         0.30  96.78
Mollusca Nassariidae                       0.61      0.18        0.38         0.30  97.08
Mollusca Turridae                          0.48      0.14        0.38         0.23  97.31
Crustacea Leptanthuridae                   0.44      0.14        0.38         0.23  97.54
Polychaeta Scalibregmatidae                0.44      0.14        0.39         0.23  97.77
Polychaeta Capitellidae                    0.51      0.13        0.38         0.22  97.99
Mollusca Veneridae                         0.51      0.13        0.38         0.21  98.20
Polychaeta Pectinariidae                   0.48      0.12        0.38         0.20  98.40
Mollusca Solemyidae                        0.40      0.12        0.38         0.20  98.60
Polychaeta Amphinomidae                    0.51      0.12        0.38         0.20  98.80
Polychaeta Trichobranchidae                0.47      0.10        0.38         0.17  98.97
Crustacea Sarsiellidae                     0.51      0.07        0.26         0.12  99.09
Crustacea Raninidae                        0.34      0.07        0.26         0.11  99.20
Mollusca Anabathridae                      0.54      0.06        0.26         0.10  99.30
Polychaeta Chaetopteridae                  0.30      0.05        0.26         0.09  99.39
Crustacea Ochlesidae                       0.34      0.05        0.26         0.08  99.47
Polychaeta Chrysopetalidae                 0.34      0.05        0.26         0.08  99.54
Mollusca Thyasiridae                       0.24      0.03        0.15         0.05  99.59
Crustacea Serolidae                        0.37      0.03        0.15         0.05  99.64
Crustacea Calliopiidae                     0.34      0.03        0.15         0.04  99.68
Echinodermata Holothuroidea                0.20      0.02        0.15         0.04  99.73
Mollusca Pyramidellidae                    0.27      0.02        0.15         0.04  99.76
Crustacea Amaryllididae                    0.28      0.02        0.15         0.03  99.79
Crustacea Cirolanidae                      0.20      0.02        0.15         0.03  99.83
Crustacea Munnopsidae                      0.24      0.02        0.15         0.03  99.86
Polychaeta Goniadidae                      0.20      0.02        0.15         0.03  99.89
Polychaeta Sphaerodoridae                  0.20      0.02        0.15         0.03  99.92
Polychaeta Poecilochaetidae                0.20      0.02        0.15         0.03  99.95
Crustacea Antarcturidae                    0.20      0.02        0.15         0.03  99.98
Mollusca Skeneidae                         0.20      0.01        0.15         0.02 100.00

Group M5-2014
Average similarity: 49.19
Species                                 Av.Abund   Av.Sim      Sim/SD     Contrib%  Cum.%
Polychaeta Maldanidae                       3.07     8.17        5.08        16.61  16.61
Polychaeta Cirratulidae                     2.30     5.97        2.91        12.13  28.74
Polychaeta Spionidae                        2.56     5.72        3.23        11.63  40.37
Crustacea Callianassidae                    1.69     3.76        1.45         7.64  48.00
Crustacea Apseudidae                        1.54     3.66        4.05         7.44  55.44
Crustacea Hexapodidae                       1.08     3.13        5.17         6.37  61.81
Polychaeta Opheliidae                       1.08     2.06        1.20         4.18  65.99
Crustacea Ampeliscidae                      1.00     1.91        1.24         3.88  69.87
Crustacea Anthuridae                        1.03     1.86        0.89         3.78  73.66
Mollusca Lucinidae                          1.29     1.78        0.81         3.63  77.28
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Echinodermata Ophiuroidea                   1.07    1.40        0.88         2.84  80.12
Polychaeta Onuphidae                        0.87    1.15        0.66         2.33  82.45
Polychaeta Ampharetidae                     0.86    1.01        0.67         2.06  84.52
Polychaeta Oweniidae                        0.90    0.77        0.50         1.56  86.08
Polychaeta Syllidae                         0.80    0.75        0.51         1.52  87.60
Echinodermata Echinoidea                    0.54    0.63        0.53         1.28  88.88
Crustacea Melitidae                         0.64    0.62        0.52         1.26  90.14
Crustacea Paranthuridae                     0.51    0.51        0.39         1.03  91.17
Polychaeta Nephtyidae                       0.48    0.45        0.37         0.91  92.08
Mollusca Laevidentaliidae                   0.48    0.43        0.38         0.87  92.95
Crustacea Phoxocephalidae                   0.40    0.42        0.38         0.86  93.81
Mollusca Nassariidae                        0.65    0.42        0.37         0.85  94.65
Polychaeta Lumbrineridae                    0.50    0.41        0.39         0.82  95.48
Crustacea Leptocheliidae                    0.51    0.26        0.26         0.54  96.01
Crustacea Philomedidae                      0.53    0.24        0.26         0.50  96.51
Polychaeta Orbiniidae                       0.30    0.23        0.26         0.46  96.97
Polychaeta Sabellidae                       0.30    0.21        0.26         0.42  97.39
Polychaeta Oenonidae                        0.30    0.18        0.26         0.37  97.76
Mollusca Chaetodermatidae                   0.30    0.18        0.26         0.36  98.12
Mollusca Mytilidae                          0.34    0.17        0.26         0.36  98.48
Crustacea Paratanaidae                      0.34    0.16        0.26         0.32  98.79
Crustacea Lysianassidae                     0.27    0.08        0.15         0.16  98.95
Polychaeta Pectinariidae                    0.20    0.08        0.15         0.15  99.10
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae        0.24     0.06         0.15      0.13    99.23
Mollusca Volutomitridae                     0.20    0.06        0.15         0.12  99.35
Crustacea Leptognathiidae                   0.20    0.06        0.15         0.11  99.47
Crustacea Leptanthuridae                    0.20    0.05        0.15         0.11  99.57
Polychaeta Sigalionidae                     0.30    0.05        0.15         0.11  99.68
Mollusca Rissoidae                          0.30    0.05        0.15         0.11  99.79
Crustacea Cylindroleberidae                 0.20    0.05        0.15         0.11  99.89
Crustacea Leucosiidae                       0.20    0.05        0.15         0.11 100.00

Group M7-2002
Average similarity: 58.84
Species                                        Av.Abund   Av.Sim    Sim/SD   Contrib%   Cum.%
Polychaeta Maldanidae                              7.23     6.37      2.42      10.83   10.83
Polychaeta Oweniidae                               6.57     5.35      2.79       9.09   19.92
Polychaeta Syllidae                                3.86     3.29      1.98       5.59   25.52
Polychaeta Spionidae                               3.55     3.25      1.86       5.52   31.03
Crustacea Leptocheliidae                           3.94     3.11      2.60       5.29   36.32
Crustacea Leptanthuridae                           2.45     2.60      5.12       4.42   40.74
Polychaeta Ampharetidae                            2.32     2.38      2.74       4.05   44.79
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     2.20     2.07      2.58       3.52   48.31
Mollusca Lucinidae                                 2.58     1.97      1.23       3.34   51.65
Mollusca Chaetodermatidae                          1.92     1.93      3.39       3.29   54.94
Crustacea Apseudidae                               1.91     1.75      1.55       2.98   57.92
Echinodermata Ophiuroidea                          1.68     1.74      3.49       2.96   60.88
Polychaeta Cirratulidae                            1.88     1.59      1.59       2.70   63.58
Crustacea Ampeliscidae                             1.64     1.46      2.62       2.48   66.06
Polychaeta Opheliidae                              1.64     1.41      1.58       2.40   68.46
Crustacea Ischyroceridae                           1.86     1.40      1.46       2.38   70.85
Echinodermata Echinoidea                           1.70     1.38      1.66       2.35   73.19
Crustacea Phoxocephalidae                          1.50     1.37      1.59       2.33   75.53
Crustacea Lysianassidae                            1.44     1.00      1.10       1.70   77.22
Polychaeta Onuphidae                               1.32     0.97      1.17       1.65   78.87
Polychaeta Lumbrineridae                           1.21     0.95      1.19       1.61   80.48
Polychaeta Sabellidae                              1.13     0.86      1.20       1.46   81.94
Crustacea Anthuridae                               1.02     0.83      1.22       1.42   83.36
Crustacea Oedicerotidae                            1.11     0.74      0.84       1.26   84.62
Polychaeta Paraonidae                              1.00     0.66      0.88       1.12   85.74
Crustacea Pasiphaeidae                             0.91     0.59      0.90       1.01   86.75
Polychaeta Orbiniidae                              0.78     0.59      0.91       1.01   87.76
Polychaeta Nephtyidae                              0.74     0.55      0.91       0.93   88.69
Polychaeta Sigalionidae                            0.79     0.44      0.67       0.75   89.44
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Polychaeta Trichobranchidae                        0.68     0.43      0.68       0.74    90.18
Crustacea Callianassidae                           0.78     0.43      0.68       0.73    90.91
Polychaeta Phyllodocidae                           0.67     0.41      0.69       0.69    91.60
Crustacea Cylindroleberidae                        0.76     0.40      0.69       0.68    92.28
Mollusca Mytilidae                                 0.67     0.39      0.69       0.66    92.94
Polychaeta Chaetopteridae                          0.76     0.38      0.69       0.65    93.59
Crustacea Paguridae                                0.72     0.32      0.51       0.54    94.13
Crustacea Philomedidae                             0.54     0.26      0.52       0.44    94.57
Mollusca Marginellidae                             0.67     0.25      0.51       0.42    94.99
Polychaeta Capitellidae                            0.61     0.18      0.38       0.31    95.30
Mollusca Solemyidae                                0.48     0.18      0.37       0.31    95.61
Mollusca Nuculidae                                 0.48     0.18      0.38       0.30    95.91
Mollusca Nassariidae                               0.47     0.17      0.39       0.30    96.20
Polychaeta Pectinariidae                           0.59     0.17      0.38       0.29    96.50
Crustacea Diastylidae/Gynodiastylidae              0.54     0.17      0.39       0.29    96.78
Crustacea Urothoidae                               0.44     0.17      0.38       0.28    97.06
Crustacea Bodotriidae                              0.44     0.16      0.39       0.27    97.33
Crustacea Sarsiellidae                             0.40     0.16      0.39       0.27    97.60
Crustacea Cypridinidae/Rutidermatidae              0.51     0.16      0.39       0.26    97.86
Crustacea Melitidae                                0.41     0.10      0.26       0.17    98.03
Polychaeta Fauveliopsidae                          0.38     0.09      0.26       0.16    98.19
Crustacea Goneplacidae                             0.34     0.09      0.26       0.15    98.34
Crustacea Whiteleggiidae                           0.37     0.09      0.26       0.15    98.49
Mollusca Cylichnidae                               0.30     0.09      0.26       0.15    98.64
Polychaeta Scalibregmatidae                        0.34     0.08      0.26       0.14    98.78
Mollusca Pyramidellidae                            0.30     0.08      0.26       0.14    98.92
Mollusca Skeneidae                                 0.30     0.08      0.26       0.13    99.05
Polychaeta Goniadidae                              0.30     0.07      0.26       0.12    99.17
Crustacea Corophiidae                              0.30     0.07      0.26       0.11    99.28
Mollusca Laevidentaliidae                          0.20     0.03      0.15       0.06    99.34
Polychaeta Oenonidae                               0.24     0.03      0.15       0.05    99.40
Mollusca Acteonidae                                0.24     0.03      0.15       0.05    99.45
Polychaeta Polynoidae                              0.20     0.03      0.15       0.05    99.50
Crustacea Nebaliidae                               0.20     0.03      0.15       0.05    99.54
Mollusca Turridae                                  0.20     0.03      0.15       0.05    99.59
Crustacea Antarcturidae                            0.24     0.03      0.15       0.05    99.64
Mollusca Thyasiridae                               0.20     0.03      0.15       0.04    99.68
Polychaeta Terebellidae                            0.24     0.02      0.15       0.04    99.72
Polychaeta Dorvilleidae                            0.24     0.02      0.15       0.04    99.76
Polychaeta Flabelligeridae                         0.24     0.02      0.15       0.04    99.80
Crustacea Leucosiidae                              0.20     0.02      0.15       0.04    99.84
Polychaeta Apistobranchidae                        0.24     0.02      0.15       0.04    99.88
Crustacea Synopiidae                               0.20     0.02      0.15       0.04    99.92
Polychaeta Eunicidae                               0.20     0.02      0.15       0.04    99.96
Crustacea Paratanaidae                             0.30     0.02      0.15       0.04   100.00

Group M7-2005
Average similarity: 52.83
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Oweniidae                               7.03        5.27        1.53       9.98   9.98
Crustacea Leptocheliidae                           4.26        3.76        1.43       7.12  17.10
Polychaeta Maldanidae                              3.04        3.60        4.32       6.82  23.92
Polychaeta Spionidae                               3.16        3.03        2.18       5.73  29.66
Crustacea Apseudidae                               2.50        2.77        3.78       5.23  34.89
Crustacea Phoxocephalidae                          2.00        2.59        2.90       4.90  39.79
Polychaeta Lumbrineridae                           2.16        2.07        1.64       3.91  43.70
Crustacea Anthuridae                               1.92        2.04        2.90       3.87  47.57
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     2.08        2.02        1.90       3.82  51.39
Crustacea Ischyroceridae                           2.38        2.01        1.17       3.80  55.20
Polychaeta Syllidae                                2.08        1.92        1.58       3.64  58.83
Crustacea Paratanaidae                             2.14        1.68        1.20       3.18  62.02
Crustacea Lysianassidae                            1.30        1.30        1.15       2.47  64.48
Polychaeta Opheliidae                              1.30        1.18        1.20       2.23  66.71
Crustacea Ampeliscidae                             1.39        1.10        1.14       2.08  68.79
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Crustacea Diastylidae/Gynodiastylidae              1.27      1.08      1.07      2.05   70.84
Polychaeta Cirratulidae                            1.08      1.04      1.21      1.97   72.81
Mollusca Nuculidae                                 1.00      1.01      1.18      1.92   74.73
Crustacea Philomedidae                             1.28      0.98      0.86      1.85   76.57
Crustacea Bodotriidae                              1.20      0.96      1.21      1.81   78.38
Polychaeta Onuphidae                               1.18      0.90      0.81      1.71   80.10
Crustacea Cylindroleberidae                        1.09      0.86      0.88      1.62   81.72
Mollusca Chaetodermatidae                          1.10      0.74      0.69      1.39   83.11
Crustacea Pasiphaeidae                             0.87      0.72      0.89      1.37   84.48
Polychaeta Chaetopteridae                          0.85      0.63      0.90      1.20   85.68
Crustacea Cypridinidae/Rutidermatidae              0.78      0.62      0.91      1.18   86.86
Echinodermata Ophiuroidea                          0.76      0.59      0.66      1.12   87.98
Crustacea Leptanthuridae                           0.87      0.57      0.67      1.08   89.06
Polychaeta Capitellidae                            0.68      0.50      0.68      0.94   90.00
Crustacea Callianassidae                           0.71      0.47      0.68      0.89   90.89
Polychaeta Paraonidae                              0.87      0.46      0.67      0.87   91.76
Crustacea Paranthuridae                            0.66      0.36      0.50      0.69   92.45
Crustacea Gnathiidae                               0.57      0.30      0.52      0.58   93.03
Crustacea Oedicerotidae                            0.83      0.27      0.38      0.51   93.53
Crustacea Sarsiellidae                             0.44      0.21      0.38      0.39   93.92
Polychaeta Orbiniidae                              0.40      0.20      0.38      0.39   94.31
Mollusca Lucinidae                                 0.40      0.20      0.39      0.38   94.69
Crustacea Sphaeromatidae                           0.52      0.19      0.37      0.37   95.06
Polychaeta Terebellidae                            0.58      0.19      0.38      0.37   95.42
Polychaeta Pectinariidae                           0.44      0.18      0.38      0.35   95.77
Polychaeta Sigalionidae                            0.40      0.18      0.39      0.34   96.11
Polychaeta Phyllodocidae                           0.48      0.18      0.38      0.34   96.45
Crustacea Melitidae                                0.48      0.17      0.38      0.33   96.78
Crustacea Arcturididae                             0.40      0.16      0.38      0.30   97.08
Crustacea Diogenidae                               0.41      0.13      0.26      0.25   97.33
Crustacea Corophiidae                              0.46      0.12      0.26      0.22   97.55
Mollusca Marginellidae                             0.41      0.12      0.26      0.22   97.77
Crustacea Nebaliidae                               0.30      0.11      0.26      0.20   97.98
Mollusca Nuculanidae                               0.37      0.10      0.26      0.19   98.17
Crustacea Urohaustoriidae                          0.30      0.10      0.26      0.19   98.36
Echinodermata Asteroidea                           0.34      0.10      0.26      0.19   98.54
Polychaeta Sabellidae                              0.30      0.10      0.26      0.18   98.73
Mollusca Nassariidae                               0.30      0.09      0.26      0.18   98.91
Mollusca Cuspidariidae                             0.30      0.09      0.26      0.18   99.09
Mollusca Laevidentaliidae                          0.30      0.08      0.26      0.15   99.24
Crustacea Goneplacidae                             0.37      0.07      0.26      0.13   99.38
Polychaeta Fauveliopsidae                          0.20      0.04      0.15      0.07   99.44
Echinodermata Echinoidea                           0.27      0.03      0.15      0.07   99.51
Polychaeta Sphaerodoridae                          0.20      0.03      0.15      0.06   99.57
Mollusca Turridae                                  0.20      0.03      0.15      0.06   99.63
Polychaeta Trichobranchidae                        0.24      0.03      0.15      0.06   99.68
Crustacea Paramunnidae                             0.24      0.03      0.15      0.06   99.74
Mollusca Anabathridae                              0.34      0.03      0.15      0.05   99.79
Polychaeta Nephtyidae                              0.20      0.03      0.15      0.05   99.85
Mollusca Veneridae                                 0.27      0.03      0.15      0.05   99.90
Mollusca Trigonidae                                0.20      0.03      0.15      0.05   99.95
Crustacea Nannastacidae                            0.24      0.03      0.15      0.05  100.00
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Group M7-2008

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Average similarity: 54.75
Species                                        Av.Abund    Av.Sim    Sim/SD  Contrib%   Cum.%
Polychaeta Spionidae                               5.76      6.06      2.83     11.06   11.06
Polychaeta Cirratulidae                            3.87      4.58      3.26      8.37   19.44
Polychaeta Maldanidae                              3.59      3.46      2.44      6.33   25.76
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     3.45      3.22      2.47      5.89   31.65
Polychaeta Lumbrineridae                           2.49      2.64      2.21      4.81   36.46
Crustacea Phoxocephalidae                          2.62      2.63      3.36      4.80   41.26
Crustacea Ampeliscidae                             3.00      2.58      1.34      4.70   45.97
Crustacea Diastylidae/Gynodiastylidae              2.44      2.49      2.91      4.55   50.52
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Crustacea Leptocheliidae	2.28	1.93	1.83	3.53	54.05
Echinodermata Ophiuroidea	1.62	1.68	1.52	3.07	57.12
Crustacea Anthuridae	1.76	1.65	1.74	3.01	60.14
Crustacea Apseudidae	1.39	1.53	4.23	2.80	62.93
Polychaeta Syllidae	1.67	1.50	1.75	2.75	65.68
Crustacea Cylindroleberidae	1.46	1.48	1.46	2.70	68.38
Crustacea Bodotriidae	1.49	1.25	1.78	2.28	70.66
Polychaeta Opheliidae	1.33	1.23	1.17	2.24	72.90
Mollusca Chaetodermatidae	1.31	1.14	1.21	2.08	74.98
Polychaeta Onuphidae	1.52	1.12	1.19	2.04	77.02
Crustacea Oedicerotidae	1.20	1.03	1.17	1.87	78.90
Mollusca Marginellidae	0.92	0.91	1.23	1.66	80.56
Crustacea Lysianassidae	1.55	0.76	0.81	1.39	81.95
Mollusca Mytilidae	1.02	0.63	0.69	1.15	83.09
Polychaeta Phyllodocidae	0.86	0.60	0.91	1.10	84.19
Polychaeta Ampharetidae	1.09	0.58	0.69	1.07	85.26
Crustacea Callianassidae	0.82	0.58	0.90	1.06	86.32
Polychaeta Orbiniidae	0.71	0.51	0.67	0.93	87.25
Polychaeta Oweniidae	1.84	0.50	0.42	0.91	88.16
Mollusca Nuculanidae	0.71	0.46	0.69	0.84	89.00
Crustacea Goneplacidae	0.68	0.45	0.68	0.82	89.82
Mollusca Lucinidae	0.71	0.41	0.52	0.75	90.57
Polychaeta Paraonidae	1.03	0.38	0.51	0.69	91.26
Crustacea Paratanaidae	0.75	0.36	0.52	0.67	91.92
Crustacea Gnathiidae	0.74	0.34	0.51	0.63	92.55
Crustacea Cypridinidae/Rutidermatidae	0.69	0.33	0.52	0.60	93.14
Crustacea Liljeborgiidae	0.50	0.31	0.52	0.57	93.71
Crustacea Melitidae	0.54	0.30	0.52	0.54	94.25
Crustacea Sphaeromatidae	0.80	0.23	0.37	0.41	94.66
Crustacea Ischyroceridae	0.77	0.22	0.37	0.39	95.06
Crustacea Philomedidae	0.59	0.20	0.38	0.37	95.43
Polychaeta Nephtyidae	0.58	0.19	0.37	0.35	95.78
Polychaeta Sabellidae	0.44	0.18	0.38	0.33	96.11
Crustacea Atylidae	0.54	0.17	0.38	0.32	96.43
Mollusca Propeamussiidae	0.50	0.16	0.38	0.30	96.73
Crustacea Sarsiellidae	0.44	0.16	0.38	0.29	97.02
Mollusca Skeneidae	0.44	0.16	0.39	0.29	97.31
Polychaeta Pectinariidae	0.34	0.13	0.26	0.23	97.54
Crustacea Arcturidae	0.51	0.11	0.26	0.20	97.74
Crustacea Raninidae	0.30	0.10	0.26	0.19	97.93
Polychaeta Chaetopteridae	0.30	0.10	0.26	0.19	98.12
Crustacea Paramunnidae	0.42	0.10	0.26	0.19	98.31
Mollusca Nuculidae	0.45	0.10	0.25	0.19	98.50
Polychaeta Goniadidae	0.30	0.10	0.26	0.18	98.68
Crustacea Munnopsidae	0.30	0.10	0.26	0.18	98.86
Mollusca Trigonidae	0.30	0.09	0.26	0.16	99.02
Polychaeta Terebellidae	0.34	0.07	0.26	0.13	99.15
Crustacea Nebaliidae	0.30	0.07	0.26	0.13	99.28
Crustacea Urohaustoriidae	0.31	0.04	0.15	0.08	99.36
Crustacea Leptanthuridae	0.34	0.03	0.15	0.06	99.42
Crustacea Synopiidae	0.20	0.03	0.15	0.06	99.48
Polychaeta Capitellidae	0.27	0.03	0.15	0.06	99.53
Mollusca Veneridae	0.20	0.03	0.15	0.06	99.59
Polychaeta Nereididae	0.20	0.03	0.15	0.06	99.64
Mollusca Nassariidae	0.20	0.03	0.15	0.06	99.70
Mollusca Solemyidae	0.20	0.03	0.15	0.05	99.75
Mollusca Laevidentaliidae	0.20	0.03	0.15	0.05	99.81
Polychaeta Scalibregmatidae	0.24	0.03	0.15	0.05	99.86
Mollusca Limidae	0.24	0.03	0.15	0.05	99.91
Mollusca Galeommatidae	0.20	0.02	0.15	0.04	99.96
Mollusca Olivellidae	0.24	0.02	0.15	0.04	100.00

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Group M7-2011
Average similarity: 65.11
Species                                         Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Maldanidae                              10.04        7.50        3.46      11.53  11.53
Polychaeta Spionidae                                6.48        5.53        4.39       8.50  20.03
Crustacea Leptocheliidae                            5.99        4.95        5.84       7.61  27.63
Polychaeta Syllidae                                 5.25        4.13        2.77       6.35  33.98
Crustacea Apseudidae                                3.11        2.58        4.66       3.96  37.94
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      2.84        2.25        4.93       3.46  41.40
Crustacea Paranthuridae                             2.45        1.98        4.58       3.05  44.45
Polychaeta Lumbrineridae                            2.25        1.91        4.84       2.93  47.38
Crustacea Ampeliscidae                              2.77        1.88        1.56       2.89  50.27
Crustacea Anthuridae                                2.10        1.85        9.24       2.84  53.11
Polychaeta Cirratulidae                             2.36        1.81        3.05       2.78  55.89
Echinodermata Echinoidea                            2.01        1.76        5.31       2.70  58.58
Crustacea Paratanaidae                              2.68        1.65        1.57       2.53  61.11
Crustacea Lysianassidae                             2.08        1.52        1.71       2.34  63.45
Mollusca Marginellidae                              1.66        1.40        3.86       2.15  65.60
Crustacea Bodotriidae                               1.62        1.25        4.09       1.92  67.51
Polychaeta Sigalionidae                             1.69        1.20        1.69       1.84  69.35
Crustacea Phoxocephalidae                           1.76        1.16        1.51       1.79  71.14
Echinodermata Ophiuroidea                           2.04        1.10        1.12       1.70  72.83
Polychaeta Opheliidae                               1.64        1.08        1.21       1.66  74.50
Mollusca Rissoidae                                  1.66        1.07        1.63       1.64  76.13
Mollusca Chaetodermatidae                           1.78        1.01        1.07       1.55  77.68
Polychaeta Sabellidae                               1.50        0.99        1.57       1.52  79.20
Crustacea Ischyroceridae                            1.35        0.86        1.21       1.32  80.51
Polychaeta Onuphidae                                1.30        0.76        1.16       1.17  81.68
Crustacea Diastylidae/Gynodiastylidae               1.25        0.70        1.12       1.07  82.75
Polychaeta Phyllodocidae                            1.16        0.69        1.19       1.06  83.81
Polychaeta Ampharetidae                             0.99        0.66        1.23       1.01  84.82
Mollusca Nuculidae                                  1.10        0.65        1.17       1.00  85.82
Crustacea Goneplacidae                              0.92        0.62        1.23       0.95  86.77
Mollusca Mytilidae                                  1.29        0.59        0.86       0.91  87.68
Polychaeta Oweniidae                                1.26        0.58        0.85       0.88  88.57
Crustacea Melitidae                                 0.97        0.52        0.90       0.80  89.37
Crustacea Pasiphaeidae                              0.90        0.52        0.89       0.79  90.16
Mollusca Nassariidae                                1.08        0.51        0.68       0.79  90.95
Polychaeta Pectinariidae                            0.82        0.49        0.90       0.75  91.71
Crustacea Oedicerotidae                             0.89        0.46        0.90       0.71  92.42
Polychaeta Paraonidae                               1.06        0.41        0.67       0.63  93.05
Crustacea Philomedidae                              0.84        0.38        0.69       0.59  93.63
Polychaeta Chaetopteridae                           0.86        0.37        0.68       0.57  94.21
Mollusca Acteonidae                                 0.80        0.37        0.68       0.57  94.77
Crustacea Callianassidae                            0.93        0.37        0.67       0.56  95.34
Polychaeta Flabelligeridae                          0.87        0.34        0.68       0.52  95.86
Polychaeta Orbiniidae                               0.66        0.27        0.51       0.42  96.28
Mollusca Lucinidae                                  0.68        0.24        0.52       0.37  96.65
Crustacea Paguridae                                 0.72        0.22        0.52       0.33  96.98
Mollusca Anabathridae                               0.71        0.21        0.52       0.32  97.30
Mollusca Laevidentaliidae                           0.50        0.20        0.53       0.30  97.61
Polychaeta Trichobranchidae                         0.57        0.14        0.38       0.22  97.82
Crustacea Cylindroleberidae                         0.51        0.13        0.38       0.19  98.02
Mollusca Turridae                                   0.47        0.13        0.39       0.19  98.21
Mollusca Cuspidariidae                              0.47        0.13        0.39       0.19  98.40
Polychaeta Oenonidae                                0.40        0.12        0.39       0.19  98.59
Crustacea Urothoidae                                0.34        0.07        0.26       0.11  98.70
Polychaeta Capitellidae                             0.41        0.07        0.26       0.11  98.81
Crustacea Atylidae                                  0.30        0.06        0.26       0.09  98.90
Mollusca Solemyidae                                 0.37        0.06        0.26       0.09  99.00
Polychaeta Scalibregmatidae                         0.30        0.06        0.26       0.09  99.09
Crustacea Eusiridae                                 0.34        0.06        0.26       0.09  99.18
Crustacea Synopiidae                                0.30        0.06        0.26       0.09  99.27
Mollusca Pyramidellidae                             0.30        0.06        0.26       0.09  99.36
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Crustacea Sarsiellidae                                    0.40        0.06        0.26        0.09  99.45
Crustacea Paramunnidae                                    0.35        0.03        0.15        0.05  99.50
Crustacea Gnathiidae                                      0.40        0.03        0.15        0.05  99.54
Crustacea Agathotanaidae                                  0.37        0.03        0.15        0.04  99.59
Mollusca Olivellidae                                      0.20        0.03        0.15        0.04  99.63
Crustacea Liljeborgiidae                                  0.27        0.02        0.15        0.04  99.67
Mollusca Veneridae                                        0.24        0.02        0.15        0.04  99.70
Mollusca Skeneidae                                        0.20        0.02        0.15        0.04  99.74
Mollusca Nuculanidae                                      0.36        0.02        0.15        0.04  99.78
Crustacea Majidae                                         0.20        0.02        0.15        0.04  99.82
Polychaeta Amphinomidae                                   0.20        0.02        0.15        0.04  99.85
Crustacea Leptanthuridae                                  0.24        0.02        0.15        0.03  99.89
Crustacea Calliopiidae                                    0.27        0.02        0.15        0.03  99.92
Mollusca Propeamussiidae                                  0.20        0.02        0.15        0.03  99.95
Polychaeta Nephtyidae                                     0.24        0.02        0.15        0.03  99.97
Crustacea Amaryllididae                                   0.24        0.02        0.15        0.03 100.00

Group M7-2014
Average similarity: 52.38
Species                                           Av.Abund    Av.Sim    Sim/SD  Contrib%  Cum.%
Polychaeta Maldanidae                                 3.75      5.51      6.00     10.52  10.52
Polychaeta Spionidae                                  4.22      5.17      2.66      9.87  20.38
Crustacea Leptocheliidae                              3.72      4.32      2.30      8.24  28.62
Polychaeta Syllidae                                   2.72      3.25      2.77      6.21  34.83
Crustacea Callianassidae                              1.79      2.49      1.58      4.75  39.58
Crustacea Phoxocephalidae                             1.30      1.93      4.32      3.69  43.27
Polychaeta Onuphidae                                  1.36      1.91      3.58      3.66  46.93
Crustacea Apseudidae                                  1.72      1.73      1.20      3.30  50.22
Echinodermata Ophiuroidea                             1.39      1.54      1.02      2.95  53.17
Polychaeta Oweniidae                                  1.32      1.42      1.17      2.71  55.88
Polychaeta Ampharetidae                               1.57      1.42      1.17      2.70  58.59
Crustacea Cylindroleberidae                           1.38      1.41      1.17      2.70  61.28
Polychaeta Oenonidae                                  0.96      1.23      1.22      2.34  63.63
Mollusca Chaetodermatidae                             1.10      1.16      1.20      2.21  65.83
Crustacea Melitidae                                   0.96      1.12      1.21      2.14  67.97
Crustacea Anthuridae                                  1.08      1.09      0.89      2.07  70.05
Polychaeta Opheliidae                                 1.25      0.89      0.67      1.70  71.75
Crustacea Ampeliscidae                                1.09      0.88      0.87      1.69  73.43
Crustacea Ischyroceridae                              1.19      0.88      0.86      1.68  75.12
Crustacea Oedicerotidae                               0.87      0.81      0.88      1.54  76.66
Crustacea Paratanaidae                                1.24      0.79      0.66      1.51  78.17
Polychaeta Lumbrineridae                              1.08      0.68      0.62      1.30  79.47
Polychaeta Cirratulidae                               0.78      0.65      0.66      1.24  80.70
Mollusca Nassariidae                                  0.84      0.65      0.67      1.23  81.94
Echinodermata Echinoidea                              0.94      0.62      0.65      1.18  83.12
Crustacea Bodotriidae                                 0.77      0.61      0.68      1.17  84.29
Mollusca Nuculidae                                    0.76      0.60      0.66      1.15  85.43
Mollusca Laevidentaliidae                             0.83      0.60      0.52      1.14  86.57
Crustacea Paranthuridae                               0.99      0.59      0.66      1.14  87.71
Polychaeta Sabellidae                                 0.76      0.59      0.69      1.13  88.84
Crustacea Philomedidae                                0.95      0.59      0.49      1.13  89.96
Mollusca Lucinidae                                    0.64      0.59      0.69      1.12  91.09
Polychaeta Sigalionidae                               0.68      0.55      0.68      1.06  92.14
Mollusca Mytilidae                                    0.89      0.47      0.52      0.90  93.04
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      0.73            0.45       0.51       0.85    93.89
Polychaeta Orbiniidae                                 0.61      0.38      0.52      0.72  94.61
Mollusca Rissoidae                                    0.72      0.37      0.52      0.71  95.32
Crustacea Raninidae                                   0.54      0.35      0.53      0.67  95.99
Crustacea Leptognathiidae                             0.75      0.30      0.39      0.58  96.57
Polychaeta Pectinariidae                              0.47      0.25      0.39      0.49  97.05
Polychaeta Phyllodocidae                              0.40      0.20      0.38      0.39  97.44
Polychaeta Scalibregmatidae                           0.40      0.20      0.38      0.37  97.81
Crustacea Lysianassidae                               0.56      0.14      0.26      0.27  98.08
Crustacea Nebaliidae                                  0.54      0.14      0.24      0.26  98.34
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Crustacea Hexapodidae                          0.34      0.12      0.26      0.24  98.58
Echinodermata Holothuroidea                    0.34      0.10      0.26      0.18  98.76
Crustacea Sphaeromatidae                       0.34      0.10      0.26      0.18  98.95
Crustacea Lampropidae                          0.37      0.09      0.26      0.18  99.12
Crustacea Diastylidae/Gynodiastylidae          0.34      0.09      0.26      0.17  99.29
Polychaeta Nephtyidae                          0.20      0.06      0.15      0.12  99.40
Polychaeta Capitellidae                        0.20      0.04      0.15      0.08  99.49
Crustacea Cirolanidae                          0.20      0.04      0.15      0.08  99.57
Crustacea Liljeborgiidae                       0.24      0.04      0.15      0.07  99.64
Polychaeta Paraonidae                          0.20      0.04      0.15      0.07  99.70
Mollusca Thyasiridae                           0.20      0.03      0.15      0.07  99.77
Polychaeta Trichobranchidae                    0.30      0.03      0.15      0.06  99.83
Crustacea Sarsiellidae                         0.20      0.03      0.15      0.06  99.89
Mollusca Marginellidae                         0.27      0.03      0.15      0.06  99.94
Mollusca Pyramidellidae                        0.24      0.03      0.15      0.06 100.00

Group PH-2002
Average similarity: 61.81
Species                                        Av.Abund    Av.Sim    Sim/SD   Contrib%  Cum.%
Polychaeta Maldanidae                              5.51      6.33      2.58      10.25  10.25
Polychaeta Oweniidae                               5.24      5.89      2.71       9.53  19.77
Polychaeta Spionidae                               4.16      4.74      2.46       7.66  27.44
Polychaeta Syllidae                                3.09      3.60      3.28       5.82  33.26
Crustacea Ampeliscidae                             2.83      3.38      3.15       5.47  38.74
Polychaeta Cirratulidae                            2.26      2.86      6.78       4.63  43.36
Mollusca Lucinidae                                 2.45      2.43      2.47       3.93  47.29
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     1.93      2.22      4.58       3.59  50.89
Crustacea Callianassidae                           1.69      2.16      3.62       3.49  54.38
Crustacea Apseudidae                               1.70      1.97      3.44       3.19  57.57
Polychaeta Onuphidae                               1.60      1.93      2.71       3.13  60.69
Crustacea Leptocheliidae                           1.88      1.90      3.19       3.07  63.77
Polychaeta Ampharetidae                            1.79      1.69      1.46       2.73  66.50
Polychaeta Nephtyidae                              1.30      1.45      1.59       2.34  68.84
Polychaeta Lumbrineridae                           1.42      1.44      1.81       2.33  71.17
Mollusca Nassariidae                               1.25      1.40      1.67       2.26  73.43
Crustacea Leptanthuridae                           1.19      1.29      1.77       2.08  75.52
Mollusca Chaetodermatidae                          1.31      1.15      1.21       1.86  77.38
Crustacea Paguridae                                1.33      1.15      1.16       1.86  79.24
Polychaeta Trichobranchidae                        1.19      1.05      1.17       1.70  80.95
Crustacea Pasiphaeidae                             1.11      1.05      1.19       1.70  82.64
Crustacea Bodotriidae                              1.10      0.88      0.90       1.43  84.07
Crustacea Melitidae                                1.12      0.88      0.89       1.42  85.49
Mollusca Thyasiridae                               0.82      0.69      0.90       1.12  86.62
Crustacea Ischyroceridae                           1.02      0.62      0.66       1.01  87.63
Crustacea Goneplacidae                             0.68      0.53      0.69       0.86  88.49
Mollusca Nuculidae                                 0.68      0.51      0.68       0.82  89.32
Crustacea Cylindroleberidae                        0.68      0.49      0.69       0.79  90.10
Polychaeta Poecilochaetidae                        0.68      0.47      0.69       0.76  90.86
Mollusca Laevidentaliidae                          0.68      0.45      0.69       0.72  91.58
Polychaeta Terebellidae                            0.58      0.38      0.52       0.61  92.19
Crustacea Oedicerotidae                            0.70      0.37      0.52       0.60  92.80
Polychaeta Chaetopteridae                          0.77      0.36      0.52       0.59  93.39
Polychaeta Opheliidae                              0.73      0.33      0.51       0.54  93.92
Polychaeta Sabellidae                              0.69      0.32      0.52       0.51  94.44
Polychaeta Sigalionidae                            0.58      0.31      0.53       0.50  94.93
Polychaeta Phyllodocidae                           0.50      0.30      0.53       0.49  95.42
Polychaeta Paraonidae                              0.40      0.22      0.38       0.36  95.78
Mollusca Rissoidae                                 0.44      0.21      0.39       0.33  96.12
Mollusca Acteonidae                                0.40      0.19      0.39       0.31  96.43
Polychaeta Orbiniidae                              0.51      0.19      0.39       0.31  96.74
Crustacea Sarsiellidae                             0.44      0.19      0.39       0.30  97.04
Crustacea Lysianassidae                            0.47      0.18      0.39       0.29  97.33
Crustacea Liljeborgiidae                           0.40      0.18      0.39       0.29  97.62
Polychaeta Flabelligeridae                         0.44      0.17      0.39       0.28  97.90
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Crustacea Tanaidae                                 0.70      0.17      0.26        0.28  98.18
Crustacea Leucosiidae                              0.41      0.10      0.26        0.17  98.35
Crustacea Diastylidae/Gynodiastylidae              0.34      0.10      0.26        0.16  98.50
Crustacea Phoxocephalidae                          0.34      0.10      0.26        0.16  98.66
Mollusca Turridae                                  0.37      0.10      0.26        0.15  98.81
Mollusca Galeommatidae                             0.30      0.09      0.26        0.15  98.96
Crustacea Cypridinidae/Rutidermatidae              0.34      0.09      0.26        0.15  99.11
Crustacea Anthuridae                               0.34      0.09      0.26        0.14  99.25
Crustacea Cirolanidae                              0.34      0.09      0.26        0.14  99.39
Polychaeta Pectinariidae                           0.37      0.08      0.26        0.13  99.52
Mollusca Propeamussiidae                           0.20      0.04      0.15        0.07  99.59
Mollusca Pyramidellidae                            0.24      0.04      0.15        0.06  99.65
Crustacea Philomedidae                             0.20      0.04      0.15        0.06  99.71
Crustacea Raninidae                                0.20      0.03      0.15        0.05  99.77
Mollusca Marginellidae                             0.20      0.03      0.15        0.05  99.82
Crustacea Gnathiidae                               0.20      0.03      0.15        0.05  99.86
Crustacea Xanthidae                                0.20      0.03      0.15        0.05  99.91
Polychaeta Capitellidae                            0.24      0.03      0.15        0.05  99.96
Crustacea Latreillidae                             0.20      0.03      0.15        0.04 100.00

Group PH-2005
Average similarity: 53.78
Species                                        Av.Abund      Av.Sim     Sim/SD  Contrib%    Cum.%
Polychaeta Maldanidae                              3.32        4.99       3.97      9.28     9.28
Polychaeta Spionidae                               2.79        4.11       2.44      7.64    16.92
Polychaeta Syllidae                                2.73        4.10       3.67      7.63    24.55
Crustacea Ischyroceridae                           1.97        2.64       1.51      4.91    29.46
Polychaeta Lumbrineridae                           1.98        2.62       3.80      4.88    34.34
Polychaeta Oweniidae                               1.82        2.44       1.78      4.54    38.88
Crustacea Ampeliscidae                             1.53        2.19       1.70      4.08    42.96
Crustacea Phoxocephalidae                          1.51        2.14       1.56      3.98    46.94
Crustacea Philomedidae                             1.26        2.11       4.23      3.93    50.87
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     1.36        1.56       1.18      2.89    53.77
Crustacea Anthuridae                               1.18        1.49       1.23      2.77    56.53
Crustacea Lysianassidae                            1.15        1.43       1.17      2.65    59.18
Crustacea Diastylidae/Gynodiastylidae              1.25        1.41       1.19      2.62    61.80
Crustacea Leptocheliidae                           1.44        1.28       0.88      2.38    64.18
Crustacea Cypridinidae/Rutidermatidae              0.84        1.20       1.20      2.23    66.41
Mollusca Lucinidae                                 1.13        1.20       0.86      2.22    68.63
Mollusca Chaetodermatidae                          1.24        1.19       0.85      2.21    70.84
Mollusca Marginellidae                             0.96        1.06       0.87      1.97    72.81
Crustacea Tanaidae                                 1.02        0.97       0.89      1.80    74.62
Polychaeta Nephtyidae                              0.77        0.97       0.90      1.80    76.41
Polychaeta Sigalionidae                            0.85        0.91       0.90      1.69    78.10
Polychaeta Cirratulidae                            1.16        0.85       0.67      1.58    79.68
Crustacea Bodotriidae                              0.96        0.84       0.66      1.56    81.24
Crustacea Cylindroleberidae                        0.99        0.83       0.59      1.55    82.79
Crustacea Paranthuridae                            0.90        0.81       0.68      1.51    84.30
Crustacea Oedicerotidae                            0.83        0.72       0.69      1.33    85.63
Polychaeta Paraonidae                              0.88        0.64       0.68      1.20    86.83
Mollusca Laevidentaliidae                          0.72        0.61       0.69      1.13    87.95
Mollusca Veneridae                                 0.50        0.47       0.52      0.87    88.83
Mollusca Solemyidae                                0.54        0.47       0.51      0.87    89.69
Crustacea Callianassidae                           0.65        0.47       0.52      0.87    90.56
Crustacea Pasiphaeidae                             0.54        0.46       0.52      0.86    91.42
Polychaeta Onuphidae                               0.61        0.46       0.50      0.86    92.28
Mollusca Nuculidae                                 0.58        0.44       0.52      0.83    93.11
Polychaeta Sabellidae                              0.70        0.42       0.51      0.78    93.89
Crustacea Apseudidae                               0.68        0.42       0.52      0.78    94.67
Polychaeta Opheliidae                              0.75        0.42       0.51      0.78    95.45
Crustacea Goneplacidae                             0.57        0.40       0.52      0.74    96.19
Mollusca Nassariidae                               0.59        0.39       0.36      0.73    96.91
Crustacea Leptanthuridae                           0.48        0.26       0.38      0.48    97.39
Mollusca Thyasiridae                               0.40        0.24       0.38      0.45    97.84
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Polychaeta Chaetopteridae                           0.48        0.24       0.38      0.44   98.29
Polychaeta Phyllodocidae                            0.48        0.23       0.38      0.42   98.71
Crustacea Melitidae                                 0.46        0.13       0.26      0.24   98.95
Polychaeta Pectinariidae                            0.30        0.12       0.26      0.23   99.18
Polychaeta Terebellidae                             0.34        0.10       0.26      0.18   99.36
Polychaeta Orbiniidae                               0.20        0.06       0.15      0.10   99.46
Crustacea Gnathiidae                                0.31        0.06       0.15      0.10   99.56
Polychaeta Oenonidae                                0.20        0.05       0.15      0.09   99.65
Crustacea Leucosiidae                               0.20        0.05       0.15      0.08   99.74
Crustacea Paramunnidae                              0.24        0.04       0.15      0.08   99.81
Crustacea Antarcturidae                             0.20        0.04       0.15      0.07   99.88
Crustacea Porcellanidae                             0.24        0.03       0.15      0.06   99.94
Crustacea Agathotanaidae                            0.20        0.03       0.15      0.06  100.00

Group PH-2008
Average similarity: 44.47
Species                                         Av.Abund      Av.Sim     Sim/SD  Contrib%   Cum.%
Polychaeta Spionidae                                3.26        6.80       5.22     15.30   15.30
Polychaeta Cirratulidae                             2.16        4.07       3.02      9.16   24.46
Polychaeta Maldanidae                               2.42        3.01       1.16      6.76   31.23
Polychaeta Syllidae                                 1.61        2.88       1.75      6.47   37.70
Mollusca Lucinidae                                  2.34        2.67       0.74      6.01   43.70
Polychaeta Lumbrineridae                            1.83        2.48       1.71      5.57   49.27
Polychaeta Nephtyidae                               0.92        1.68       1.16      3.79   53.06
Crustacea Anthuridae                                1.30        1.67       1.17      3.75   56.81
Polychaeta Onuphidae                                1.26        1.56       1.18      3.52   60.33
Mollusca Chaetodermatidae                           1.12        1.47       1.20      3.30   63.63
Crustacea Ampeliscidae                              1.49        1.34       0.85      3.00   66.64
Crustacea Raninidae                                 0.78        1.18       0.86      2.66   69.29
Crustacea Philomedidae                              0.98        1.07       0.86      2.41   71.71
Polychaeta Paraonidae                               1.07        0.87       0.65      1.95   73.66
Crustacea Melitidae                                 0.77        0.83       0.67      1.87   75.53
Crustacea Diastylidae/Gynodiastylidae               0.72        0.81       0.69      1.83   77.35
Crustacea Ischyroceridae                            1.25        0.80       0.52      1.80   79.15
Polychaeta Phyllodocidae                            0.67        0.65       0.69      1.47   80.62
Polychaeta Terebellidae                             0.50        0.65       0.51      1.47   82.09
Mollusca Solemyidae                                 0.57        0.59       0.50      1.32   83.41
Polychaeta Orbiniidae                               0.70        0.54       0.53      1.21   84.62
Crustacea Cylindroleberidae                         0.77        0.52       0.50      1.18   85.80
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae      0.85        0.50       0.52      1.13   86.92
Crustacea Bodotriidae                               0.74        0.50       0.52      1.13   88.05
Crustacea Phoxocephalidae                           0.79        0.47       0.50      1.05   89.10
Crustacea Callianassidae                            0.54        0.46       0.52      1.03   90.13
Mollusca Laevidentaliidae                           0.72        0.43       0.35      0.97   91.10
Polychaeta Opheliidae                               0.61        0.42       0.52      0.94   92.04
Polychaeta Capitellidae                             0.50        0.41       0.52      0.92   92.96
Crustacea Leptocheliidae                            0.81        0.27       0.37      0.61   93.57
Mollusca Nuculanidae                                0.44        0.27       0.39      0.60   94.17
Mollusca Cardiidae                                  0.47        0.26       0.38      0.57   94.74
Crustacea Paratanaidae                              0.40        0.24       0.38      0.55   95.29
Mollusca Nuculidae                                  0.44        0.17       0.26      0.38   95.67
Crustacea Apseudidae                                0.34        0.15       0.26      0.34   96.01
Polychaeta Pectinariidae                            0.30        0.14       0.26      0.32   96.33
Mollusca Myochamidae                                0.30        0.14       0.26      0.30   96.64
Crustacea Oedicerotidae                             0.34        0.14       0.26      0.30   96.94
Polychaeta Ampharetidae                             0.50        0.13       0.25      0.30   97.24
Crustacea Gnathiidae                                0.34        0.13       0.26      0.30   97.54
Polychaeta Chaetopteridae                           0.38        0.13       0.26      0.29   97.84
Polychaeta Scalibregmatidae                         0.30        0.12       0.26      0.28   98.11
Crustacea Paramunnidae                              0.30        0.11       0.26      0.25   98.36
Crustacea Sphaeromatidae                            0.20        0.06       0.15      0.14   98.51
Crustacea Liljeborgiidae                            0.20        0.06       0.15      0.14   98.64
Mollusca Cuspidariidae                              0.20        0.06       0.15      0.14   98.78
Mollusca Thyasiridae                                0.24        0.06       0.15      0.13   98.91
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Polychaeta Sabellidae                             0.31      0.05      0.15      0.11   99.03
Mollusca Limidae                                  0.20      0.05      0.15      0.11   99.14
Crustacea Lysianassidae                           0.20      0.05      0.15      0.11   99.25
Mollusca Rissoidae                                0.20      0.05      0.15      0.11   99.36
Crustacea Cirolanidae                             0.20      0.05      0.15      0.11   99.46
Mollusca Anabathridae                             0.20      0.04      0.15      0.10   99.56
Polychaeta Oweniidae                              0.24      0.04      0.15      0.10   99.66
Crustacea Goneplacidae                            0.20      0.04      0.15      0.09   99.75
Crustacea Antarcturidae                           0.20      0.04      0.15      0.09   99.84
Polychaeta Sigalionidae                           0.24      0.04      0.15      0.08   99.92
Crustacea Cyproideidae                            0.20      0.03      0.15      0.08  100.00

Group PH-2011
Average similarity: 64.89
Species                                        Av.Abund    Av.Sim    Sim/SD  Contrib%    Cum.%
Polychaeta Maldanidae                             3.92      4.24      4.22      6.53     6.53
Polychaeta Spionidae                              5.09      4.22      2.33      6.50    13.03
Mollusca Lucinidae                                3.16      3.02      2.39      4.65    17.68
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae    3.12      2.84      3.16      4.38    22.07
Polychaeta Syllidae                               2.68      2.56      3.39      3.94    26.01
Polychaeta Cirratulidae                           2.77      2.52      4.11      3.89    29.90
Crustacea Ampeliscidae                            2.46      2.44      7.45      3.76    33.65
Crustacea Bodotriidae                             2.22      2.17      7.14      3.34    36.99
Crustacea Philomedidae                            2.20      2.03      3.11      3.12    40.12
Mollusca Chaetodermatidae                         2.07      1.89      3.49      2.91    43.03
Mollusca Nuculidae                                2.09      1.78      2.86      2.75    45.78
Echinodermata Ophiuroidea                         1.98      1.77      1.70      2.73    48.51
Crustacea Anthuridae                              1.63      1.66      3.50      2.56    51.07
Crustacea Lysianassidae                           1.86      1.63      1.88      2.51    53.57
Crustacea Apseudidae                              2.16      1.59      1.52      2.44    56.02
Mollusca Laevidentaliidae                         1.78      1.53      2.68      2.35    58.37
Crustacea Diastylidae/Gynodiastylidae             1.74      1.52      3.72      2.35    60.72
Mollusca Mytilidae                                1.46      1.44      3.70      2.23    62.94
Polychaeta Lumbrineridae                          1.72      1.44      1.46      2.21    65.15
Crustacea Ischyroceridae                          1.72      1.34      1.76      2.06    67.22
Polychaeta Sigalionidae                           1.51      1.29      1.73      1.99    69.21
Crustacea Paranthuridae                           1.63      1.29      1.57      1.98    71.19
Polychaeta Nephtyidae                             1.26      1.13      1.81      1.74    72.93
Polychaeta Sabellidae                             1.25      1.10      1.80      1.70    74.63
Polychaeta Onuphidae                              1.20      1.03      1.83      1.59    76.22
Crustacea Callianassidae                          1.16      1.00      1.82      1.55    77.77
Polychaeta Paraonidae                             1.29      1.00      1.16      1.54    79.31
Crustacea Melitidae                               1.24      0.98      1.22      1.51    80.82
Polychaeta Ampharetidae                           1.40      0.91      1.13      1.41    82.23
Echinodermata Echinoidea                          1.16      0.89      1.17      1.38    83.60
Crustacea Phoxocephalidae                         1.16      0.87      1.18      1.33    84.94
Crustacea Oedicerotidae                           0.96      0.79      1.25      1.22    86.16
Crustacea Pasiphaeidae                            0.88      0.73      1.24      1.13    87.29
Crustacea Paratanaidae                            1.15      0.71      0.86      1.10    88.39
Polychaeta Orbiniidae                             0.91      0.70      1.25      1.09    89.47
Polychaeta Oweniidae                              1.11      0.67      0.90      1.03    90.50
Crustacea Cypridinidae/Rutidermatidae             0.88      0.56      0.90      0.87    91.37
Crustacea Sarsiellidae                            0.74      0.56      0.92      0.86    92.23
Mollusca Solemyidae                               0.80      0.46      0.67      0.70    92.93
Polychaeta Chaetopteridae                         0.64      0.45      0.70      0.69    93.62
Polychaeta Phyllodocidae                          0.68      0.43      0.68      0.66    94.28
Crustacea Liljeborgiidae                          0.64      0.41      0.69      0.63    94.91
Crustacea Leptocheliidae                          0.74      0.41      0.69      0.63    95.54
Crustacea Cylindroleberidae                       0.65      0.26      0.51      0.40    95.94
Polychaeta Pectinariidae                          0.54      0.25      0.53      0.39    96.33
Crustacea Nannastacidae                           0.54      0.24      0.53      0.37    96.70
Mollusca Veneridae                                0.88      0.22      0.37      0.33    97.03
Mollusca Marginellidae                            0.51      0.18      0.39      0.28    97.32
Polychaeta Capitellidae                           0.44      0.17      0.39      0.26    97.58
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Crustacea Gnathiidae	0.51	0.16	0.38	0.25	97.83
Mollusca Nassariidae	0.48	0.16	0.38	0.25	98.08
Crustacea Raninidae	0.48	0.16	0.38	0.24	98.32
Polychaeta Scalibregmatidae	0.44	0.15	0.39	0.23	98.55
Mollusca Thyasiridae	0.38	0.09	0.26	0.14	98.69
Crustacea Amaryllididae	0.30	0.08	0.26	0.13	98.82
Mollusca Rissoidae	0.34	0.07	0.26	0.12	98.94
Mollusca Pyramidellidae	0.30	0.07	0.26	0.11	99.05
Crustacea Goneplacidae	0.34	0.07	0.26	0.11	99.16
Crustacea Leptanthuridae	0.34	0.07	0.26	0.11	99.26
Polychaeta Flabelligeridae	0.34	0.07	0.26	0.11	99.37
Polychaeta Trichobranchidae	0.30	0.07	0.26	0.10	99.47
Crustacea Paguridae	0.20	0.03	0.15	0.04	99.52
Crustacea Paramunnidae	0.24	0.03	0.15	0.04	99.56
Polychaeta Nereididae	0.20	0.03	0.15	0.04	99.60
Polychaeta Terebellidae	0.20	0.03	0.15	0.04	99.64
Mollusca Nuculanidae	0.20	0.03	0.15	0.04	99.68
Mollusca Acteonidae	0.20	0.03	0.15	0.04	99.72
Crustacea Serolidae	0.24	0.02	0.15	0.04	99.76
Crustacea Synopiidae	0.20	0.02	0.15	0.04	99.79
Echinodermata Asteroidea	0.20	0.02	0.15	0.04	99.83
Crustacea Urothoidae	0.32	0.02	0.15	0.04	99.86
Crustacea Stegocephalidae	0.27	0.02	0.15	0.04	99.90
Mollusca Turridae	0.20	0.02	0.15	0.03	99.93
Crustacea Nebaliidae	0.30	0.02	0.15	0.03	99.97
Mollusca Trigonidae	0.20	0.02	0.15	0.03	100.00

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Group PH-2014
Average similarity: 46.22
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Spionidae                               2.14        5.84        3.17      12.63  12.63
Polychaeta Cirratulidae                            1.61        5.05        2.55      10.94  23.57
Mollusca Lucinidae                                 1.52        4.98        2.56      10.77  34.34
Polychaeta Maldanidae                              1.47        3.81        1.81       8.24  42.57
Crustacea Callianassidae                           1.33        3.66        1.61       7.91  50.48
Polychaeta Lumbrineridae                           1.28        3.11        1.13       6.72  57.21
Polychaeta Nephtyidae                              0.88        1.99        0.84       4.31  61.52
Polychaeta Onuphidae                               0.87        1.90        0.90       4.12  65.63
Polychaeta Syllidae                                0.99        1.86        0.89       4.02  69.66
Mollusca Laevidentaliidae                          0.80        1.60        0.63       3.46  73.11
Polychaeta Oweniidae                               1.00        1.57        0.68       3.39  76.51
Crustacea Ampeliscidae                             0.92        1.22        0.69       2.63  79.14
Mollusca Mytilidae                                 0.64        1.10        0.68       2.37  81.51
Crustacea Paratanaidae                             0.68        1.04        0.69       2.26  83.77
Crustacea Raninidae                                0.66        1.03        0.51       2.23  85.99
Polychaeta Opheliidae                              0.71        0.85        0.51       1.83  87.83
Crustacea Apseudidae                               0.69        0.80        0.51       1.73  89.55
Crustacea Anthuridae                               0.67        0.72        0.52       1.56  91.12
Crustacea Hexapodidae                              0.51        0.53        0.38       1.15  92.27
Mollusca Chaetodermatidae                          0.64        0.49        0.38       1.06  93.33
Echinodermata Echinoidea                           0.44        0.45        0.38       0.97  94.30
Echinodermata Ophiuroidea                          0.48        0.42        0.38       0.91  95.21
Mollusca Nassariidae                               0.38        0.36        0.25       0.78  95.99
Polychaeta Sigalionidae                            0.34        0.25        0.26       0.54  96.53
Polychaeta Paraonidae                              0.30        0.25        0.26       0.53  97.06
Crustacea Melitidae                                0.30        0.23        0.26       0.51  97.57
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     0.37        0.23        0.26       0.50  98.07
Crustacea Phoxocephalidae                          0.34        0.20        0.26       0.44  98.50
Crustacea Ischyroceridae                           0.34        0.17        0.26       0.36  98.86
Polychaeta Orbiniidae                              0.24        0.08        0.15       0.16  99.03
Crustacea Liljeborgiidae                           0.20        0.08        0.15       0.16  99.19
Crustacea Lampropidae                              0.20        0.07        0.15       0.15  99.34
Polychaeta Trichobranchidae                        0.24        0.07        0.15       0.15  99.49
Crustacea Synopiidae                               0.20        0.07        0.15       0.14  99.63
Crustacea Paranthuridae                            0.24        0.06        0.15       0.13  99.76
Crustacea Philomedidae                             0.20        0.06        0.15       0.12  99.88
Crustacea Oedicerotidae                            0.20        0.05        0.15       0.12 100.00
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Group MB-2002
Average similarity: 53.46
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Oweniidae                               5.81        6.07        1.51      11.35  11.35
Polychaeta Spionidae                               3.42        4.88        2.69       9.12  20.47
Polychaeta Maldanidae                              3.09        4.18        2.17       7.81  28.28
Polychaeta Cirratulidae                            2.12        3.08        2.07       5.76  34.05
Mollusca Chaetodermatidae                          1.82        2.83        3.09       5.30  39.35
Crustacea Callianassidae                           1.67        2.65        3.38       4.96  44.31
Crustacea Ampeliscidae                             1.91        2.65        3.22       4.95  49.26
Mollusca Lucinidae                                 1.72        2.42        1.89       4.53  53.79
Polychaeta Nephtyidae                              1.44        2.22        1.71       4.14  57.94
Polychaeta Pectinariidae                           1.59        1.90        1.70       3.56  61.50
Polychaeta Ampharetidae                            1.48        1.84        1.60       3.45  64.95
Crustacea Melitidae                                1.12        1.33        1.17       2.49  67.44
Mollusca Laevidentaliidae                          1.24        1.32        1.17       2.47  69.91
Polychaeta Opheliidae                              0.98        1.07        0.88       2.00  71.91
Polychaeta Onuphidae                               0.89        1.03        0.90       1.93  73.84
Crustacea Leptocheliidae                           0.94        0.97        0.91       1.82  75.66
Polychaeta Paraonidae                              1.00        0.93        0.91       1.74  77.40
Mollusca Nassariidae                               1.08        0.92        0.65       1.73  79.13
Crustacea Pasiphaeidae                             0.96        0.88        0.89       1.65  80.78
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     1.06        0.74        0.69       1.38  82.16
Crustacea Cypridinidae/Rutidermatidae              0.68        0.67        0.67       1.26  83.41
Crustacea Apseudidae                               0.72        0.65        0.69       1.21  84.62
Mollusca Galeommatidae                             0.84        0.62        0.68       1.16  85.78
Crustacea Diastylidae/Gynodiastylidae              0.78        0.61        0.68       1.14  86.93
Polychaeta Syllidae                                0.77        0.59        0.68       1.11  88.03
Crustacea Paguridae                                0.80        0.59        0.68       1.10  89.14
Mollusca Nuculidae                                 0.79        0.59        0.68       1.10  90.24
Polychaeta Chaetopteridae                          0.66        0.54        0.52       1.00  91.24
Polychaeta Lumbrineridae                           0.68        0.52        0.52       0.97  92.21
Polychaeta Sigalionidae                            0.58        0.45        0.52       0.84  93.05
Crustacea Leptanthuridae                           0.78        0.41        0.52       0.76  93.81
Crustacea Phoxocephalidae                          0.50        0.38        0.52       0.71  94.53
Mollusca Thyasiridae                               0.54        0.38        0.53       0.70  95.23
Polychaeta Poecilochaetidae                        0.59        0.35        0.38       0.65  95.88
Polychaeta Orbiniidae                              0.40        0.27        0.39       0.51  96.39
Crustacea Bodotriidae                              0.61        0.27        0.38       0.50  96.90
Crustacea Goneplacidae                             0.47        0.24        0.38       0.44  97.34
Polychaeta Fauveliopsidae                          0.38        0.13        0.26       0.25  97.59
Crustacea Anthuridae                               0.30        0.13        0.26       0.25  97.83
Crustacea Philomedidae                             0.44        0.12        0.26       0.23  98.06
Crustacea Ischyroceridae                           0.30        0.12        0.26       0.22  98.28
Polychaeta Terebellidae                            0.34        0.12        0.26       0.22  98.50
Crustacea Cylindroleberidae                        0.34        0.11        0.26       0.20  98.70
Mollusca Cardiidae                                 0.30        0.11        0.26       0.20  98.89
Crustacea Sphaeromatidae                           0.30        0.10        0.26       0.18  99.08
Crustacea Oedicerotidae                            0.37        0.10        0.26       0.18  99.26
Crustacea Sarsiellidae                             0.34        0.10        0.26       0.18  99.44
Mollusca Turridae                                  0.30        0.04        0.15       0.08  99.51
Mollusca Trigonidae                                0.20        0.04        0.15       0.08  99.59
Crustacea Lysianassidae                            0.20        0.04        0.15       0.08  99.67
Mollusca Solemyidae                                0.20        0.04        0.15       0.08  99.74
Crustacea Melphidippidae                           0.24        0.04        0.15       0.08  99.82
Mollusca Marginellidae                             0.24        0.04        0.15       0.07  99.88
Polychaeta Trichobranchidae                        0.20        0.03        0.15       0.06  99.94
Mollusca Acteonidae                                0.20        0.03        0.15       0.06 100.00
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Group MB-2005
Average similarity: 55.72
Species                                        Av.Abund      Av.Sim      Sim/SD   Contrib%  Cum.%
Polychaeta Spionidae                               3.22        4.45        2.29       7.98   7.98
Polychaeta Maldanidae                              3.01        4.45        3.34       7.98  15.96
Polychaeta Oweniidae                               2.85        3.96        6.30       7.10  23.06
Polychaeta Syllidae                                2.47        3.25        1.90       5.83  28.89
Crustacea Bodotriidae                              2.03        3.06        3.92       5.49  34.39
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     2.41        2.91        2.31       5.23  39.62
Crustacea Ampeliscidae                             2.14        2.62        2.52       4.70  44.32
Crustacea Oedicerotidae                            1.73        2.60        5.30       4.66  48.98
Crustacea Tanaidae                                 2.08        2.38        2.49       4.28  53.26
Crustacea Lysianassidae                            1.24        1.64        1.79       2.95  56.21
Crustacea Cylindroleberidae                        1.32        1.58        1.73       2.83  59.04
Mollusca Nassariidae                               1.43        1.45        1.15       2.59  61.64
Crustacea Leptocheliidae                           1.29        1.35        1.15       2.43  64.06
Crustacea Anthuridae                               1.30        1.27        0.88       2.27  66.33
Crustacea Cypridinidae/Rutidermatidae              1.09        1.25        1.17       2.25  68.58
Mollusca Laevidentaliidae                          1.07        1.22        1.23       2.20  70.78
Crustacea Ischyroceridae                           1.37        1.13        0.84       2.04  72.82
Crustacea Phoxocephalidae                          1.24        1.07        0.84       1.91  74.73
Crustacea Diastylidae/Gynodiastylidae              0.90        0.92        0.90       1.65  76.38
Polychaeta Nephtyidae                              0.86        0.89        0.91       1.60  77.97
Polychaeta Onuphidae                               0.81        0.86        0.91       1.54  79.51
Polychaeta Lumbrineridae                           1.00        0.86        0.90       1.54  81.05
Crustacea Melitidae                                0.78        0.81        0.91       1.45  82.50
Mollusca Lucinidae                                 1.03        0.71        0.49       1.28  83.78
Polychaeta Sigalionidae                            0.85        0.67        0.68       1.20  84.99
Crustacea Leptanthuridae                           0.80        0.63        0.69       1.13  86.12
Polychaeta Cirratulidae                            0.71        0.63        0.69       1.13  87.24
Mollusca Nuculidae                                 0.68        0.61        0.69       1.10  88.34
Crustacea Apseudidae                               0.72        0.60        0.69       1.08  89.42
Polychaeta Phyllodocidae                           0.74        0.57        0.69       1.02  90.44
Polychaeta Chaetopteridae                          0.58        0.39        0.52       0.71  91.15
Mollusca Chaetodermatidae                          0.70        0.39        0.52       0.70  91.84
Polychaeta Opheliidae                              0.65        0.38        0.51       0.68  92.52
Crustacea Leucosiidae                              0.54        0.37        0.53       0.66  93.18
Crustacea Gnathiidae                               0.56        0.25        0.38       0.46  93.63
Crustacea Paranthuridae                            0.44        0.25        0.39       0.45  94.08
Crustacea Philomedidae                             0.51        0.25        0.38       0.44  94.53
Crustacea Sphaeromatidae                           0.51        0.25        0.38       0.44  94.97
Polychaeta Pectinariidae                           0.48        0.23        0.38       0.40  95.37
Crustacea Callianassidae                           0.51        0.23        0.38       0.40  95.78
Mollusca Marginellidae                             0.40        0.20        0.39       0.36  96.14
Mollusca Propeamussiidae                           0.30        0.14        0.26       0.24  96.38
Polychaeta Sabellidae                              0.52        0.14        0.25       0.24  96.62
Mollusca Mytilidae                                 0.44        0.13        0.26       0.23  96.86
Crustacea Porcellanidae                            0.34        0.13        0.26       0.23  97.08
Mollusca Thyasiridae                               0.34        0.12        0.26       0.21  97.30
Polychaeta Paraonidae                              0.34        0.12        0.26       0.21  97.51
Mollusca Veneridae                                 0.34        0.12        0.26       0.21  97.72
Polychaeta Trichobranchidae                        0.34        0.12        0.26       0.21  97.93
Crustacea Paramunnidae                             0.30        0.11        0.26       0.20  98.13
Mollusca Philinidae                                0.30        0.11        0.26       0.20  98.33
Crustacea Goneplacidae                             0.34        0.11        0.26       0.20  98.53
Mollusca Turridae                                  0.34        0.11        0.26       0.19  98.72
Crustacea Pasiphaeidae                             0.30        0.11        0.26       0.19  98.91
Polychaeta Flabelligeridae                         0.34        0.10        0.26       0.18  99.09
Polychaeta Nereididae                              0.20        0.05        0.15       0.08  99.17
Crustacea Cyproideidae                             0.27        0.04        0.15       0.08  99.25
Crustacea Liljeborgiidae                           0.20        0.04        0.15       0.08  99.32
Mollusca Trigonidae                                0.20        0.04        0.15       0.08  99.40
Polychaeta Orbiniidae                              0.20        0.04        0.15       0.08  99.47
Mollusca Solemyidae                                0.20        0.04        0.15       0.07  99.54
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Crustacea Palaemonidae                             0.27        0.04        0.15        0.07  99.61
Crustacea Amaryllididae                            0.20        0.04        0.15        0.07  99.68
Crustacea Atylidae                                 0.20        0.04        0.15        0.07  99.75
Crustacea Paguridae                                0.24        0.04        0.15        0.07  99.82
Crustacea Ochlesidae                               0.20        0.03        0.15        0.06  99.88
Mollusca Myochamidae                               0.20        0.03        0.15        0.06  99.94
Polychaeta Terebellidae                            0.20        0.03        0.15        0.06 100.00

Group MB-2008
Average similarity: 52.05
Species                                 Av.Abund  Av.Sim      Sim/SD     Contrib%  Cum.%
Polychaeta Spionidae                        4.50   10.35        2.44        19.88  19.88
Polychaeta Cirratulidae                     2.33    5.48        3.36        10.52  30.40
Mollusca Lucinidae                          2.64    5.38        1.80        10.34  40.74
Polychaeta Maldanidae                       2.17    5.36        4.27        10.31  51.05
Crustacea Melitidae                         1.22    2.51        1.75         4.83  55.88
Polychaeta Lumbrineridae                    1.68    2.48        1.04         4.77  60.65
Mollusca Nuculidae                          0.96    2.05        1.20         3.93  64.58
Polychaeta Onuphidae                        1.21    1.94        0.85         3.73  68.31
Crustacea Philomedidae                      1.08    1.74        0.90         3.34  71.65
Mollusca Solemyidae                         1.04    1.56        0.90         2.99  74.64
Crustacea Raninidae                         0.77    1.47        0.90         2.82  77.46
Polychaeta Nephtyidae                       0.86    1.43        0.89         2.74  80.20
Polychaeta Terebellidae                     0.77    1.41        0.90         2.72  82.91
Polychaeta Syllidae                         0.76    0.99        0.69         1.89  84.81
Crustacea Callianassidae                    0.70    0.82        0.51         1.57  86.38
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae         0.68     0.67         0.51       1.29    87.67
Polychaeta Paraonidae                       0.54    0.66        0.52         1.28  88.94
Crustacea Ampeliscidae                      0.71    0.64        0.52         1.23  90.17
Polychaeta Sigalionidae                     0.50    0.64        0.53         1.22  91.39
Crustacea Oedicerotidae                     0.54    0.60        0.52         1.16  92.55
Mollusca Galeommatidae                      0.70    0.49        0.39         0.94  93.49
Polychaeta Orbiniidae                       0.40    0.38        0.39         0.73  94.22
Mollusca Chaetodermatidae                   0.47    0.34        0.39         0.64  94.87
Crustacea Cylindroleberidae                 0.40    0.33        0.39         0.64  95.50
Mollusca Cardiidae                          0.47    0.32        0.39         0.61  96.11
Mollusca Nassariidae                        0.61    0.29        0.26         0.56  96.67
Crustacea Cypridinidae/Rutidermatidae       0.30    0.23        0.26         0.44  97.12
Mollusca Laevidentaliidae                   0.41    0.21        0.26         0.41  97.53
Crustacea Pasiphaeidae                      0.30    0.19        0.26         0.36  97.89
Crustacea Cirolanidae                       0.30    0.19        0.26         0.36  98.25
Crustacea Diastylidae/Gynodiastylidae       0.30    0.17        0.26         0.33  98.57
Polychaeta Chaetopteridae                   0.30    0.17        0.26         0.32  98.89
Crustacea Anthuridae                        0.31    0.08        0.15         0.14  99.03
Polychaeta Phyllodocidae                    0.20    0.07        0.15         0.14  99.17
Mollusca Veneridae                          0.34    0.07        0.15         0.13  99.30
Polychaeta Goniadidae                       0.20    0.06        0.15         0.12  99.42
Crustacea Bodotriidae                       0.20    0.06        0.15         0.12  99.54
Crustacea Nebaliidae                        0.20    0.06        0.15         0.12  99.65
Crustacea Apseudidae                        0.20    0.06        0.15         0.12  99.77
Crustacea Phoxocephalidae                   0.20    0.06        0.15         0.12  99.89
Mollusca Trigonidae                         0.20    0.06        0.15         0.11 100.00

Group MB-2011
Average similarity: 60.80
Species                                        Av.Abund      Av.Sim      Sim/SD    Contrib%  Cum.%
Polychaeta Spionidae                               9.56        8.14        1.60       13.38  13.38
Polychaeta Maldanidae                              3.83        3.99        3.28        6.57  19.95
Crustacea Aoridae/Isaeidae/Photidae/Unciolidae     3.42        3.44        3.69        5.66  25.62
Mollusca Lucinidae                                 3.11        3.17        2.56        5.21  30.83
Polychaeta Syllidae                                2.58        2.62        4.45        4.31  35.13
Mollusca Laevidentaliidae                          2.47        2.40        2.82        3.95  39.08
Crustacea Philomedidae                             2.26        2.30        2.76        3.78  42.86
Crustacea Ischyroceridae                           2.20        2.18        3.08        3.59  46.45
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Polychaeta Nephtyidae	1.82	1.99	4.03	3.27	49.72
Crustacea Callianassidae	1.84	1.91	4.02	3.14	52.86
Mollusca Chaetodermatidae	1.72	1.87	4.18	3.07	55.94
Crustacea Bodotriidae	1.94	1.58	1.49	2.60	58.53
Polychaeta Sigalionidae	1.44	1.48	4.00	2.43	60.97
Polychaeta Cirratulidae	1.60	1.44	1.72	2.38	63.34
Crustacea Apseudidae	1.63	1.40	1.44	2.31	65.65
Crustacea Ampeliscidae	1.46	1.25	1.67	2.05	67.71
Mollusca Nuculidae	1.42	1.21	1.66	1.99	69.69
Polychaeta Pectinariidae	1.24	1.18	1.88	1.94	71.63
Crustacea Anthuridae	1.24	1.03	1.21	1.69	73.32
Crustacea Lysianassidae	1.57	1.01	0.70	1.67	74.99
Crustacea Paranthuridae	1.34	1.00	0.86	1.64	76.63
Mollusca Mytilidae	1.24	0.99	1.22	1.63	78.26
Mollusca Galeommatidae	1.54	0.97	1.10	1.59	79.85
Echinodermata Echinoidea	1.26	0.94	1.16	1.55	81.40
Echinodermata Ophiuroidea	1.22	0.94	1.18	1.55	82.95
Polychaeta Lumbrineridae	0.97	0.87	1.20	1.43	84.38
Polychaeta Onuphidae	0.96	0.72	0.87	1.19	85.57
Crustacea Diastylidae/Gynodiastylidae	1.14	0.72	0.84	1.18	86.75
Crustacea Oedicerotidae	0.97	0.69	0.90	1.13	87.88
Polychaeta Ampharetidae	0.98	0.67	0.89	1.10	88.98
Crustacea Cylindroleberidae	1.01	0.66	0.88	1.09	90.06
Crustacea Phoxocephalidae	0.79	0.45	0.69	0.74	90.80
Crustacea Cypridinidae/Rutidermatidae	0.70	0.42	0.70	0.69	91.50
Crustacea Paratanaidae	0.77	0.32	0.51	0.53	92.03
Crustacea Paguridae	0.66	0.31	0.52	0.51	92.55
Polychaeta Oweniidae	0.66	0.31	0.52	0.51	93.06
Mollusca Acteonidae	0.58	0.29	0.52	0.48	93.54
Polychaeta Trichobranchidae	0.50	0.29	0.53	0.48	94.02
Crustacea Leucosiidae	0.67	0.29	0.52	0.47	94.49
Polychaeta Chaetopteridae	0.69	0.29	0.52	0.47	94.96
Mollusca Nassariidae	0.76	0.26	0.37	0.43	95.39
Crustacea Gnathiidae	0.66	0.26	0.38	0.43	95.82
Crustacea Melitidae	0.59	0.21	0.38	0.34	96.16
Polychaeta Sabellidae	0.56	0.20	0.38	0.32	96.49
Crustacea Raninidae	0.40	0.17	0.39	0.28	96.77
Polychaeta Phyllodocidae	0.44	0.17	0.39	0.27	97.04
Crustacea Leptocheliidae	0.47	0.16	0.39	0.27	97.31
Mollusca Turridae	0.40	0.16	0.39	0.27	97.58
Polychaeta Paraonidae	0.44	0.16	0.39	0.27	97.85
Polychaeta Pholoidae	0.40	0.16	0.39	0.26	98.11
Crustacea Leptanthuridae	0.41	0.09	0.26	0.15	98.26
Crustacea Sarsiellidae	0.38	0.09	0.26	0.15	98.41
Mollusca Solemyidae	0.34	0.09	0.26	0.14	98.55
Crustacea Goneplacidae	0.30	0.09	0.26	0.14	98.70
Crustacea Melphidippidae	0.34	0.09	0.26	0.14	98.84
Crustacea Liljeborgiidae	0.37	0.08	0.26	0.14	98.97
Mollusca Rissoidae	0.30	0.08	0.26	0.13	99.11
Polychaeta Capitellidae	0.30	0.08	0.26	0.13	99.24
Mollusca Thyasiridae	0.30	0.08	0.26	0.13	99.37
Crustacea Nannastacidae	0.30	0.08	0.26	0.13	99.50
Mollusca Trigonidae	0.31	0.04	0.15	0.06	99.56
Mollusca Pyramidellidae	0.28	0.04	0.15	0.06	99.62
Mollusca Philinidae	0.20	0.03	0.15	0.05	99.67
Crustacea Pasiphaeidae	0.20	0.03	0.15	0.05	99.72
Mollusca Anabathridae	0.20	0.03	0.15	0.05	99.77
Mollusca Marginellidae	0.24	0.03	0.15	0.05	99.82
Crustacea Urothoidae	0.20	0.03	0.15	0.05	99.87
Polychaeta Opheliidae	0.24	0.03	0.15	0.05	99.91
Crustacea Sphaeromatidae	0.24	0.03	0.15	0.04	99.96
Crustacea Cirolanidae	0.24	0.03	0.15	0.04	100.00

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Group MB-2014
Average similarity: 48.66
Species                                    Av.Abund    Av.Sim   Sim/SD Contrib%  Cum.%
Polychaeta Spionidae                           4.27      7.78     2.56    15.98  15.98
Mollusca Lucinidae                             2.97      5.74     4.61    11.80  27.79
Polychaeta Cirratulidae                        2.43      4.82     3.21     9.91  37.70
Polychaeta Maldanidae                          1.80      3.42     3.43     7.03  44.72
Polychaeta Nephtyidae                          1.27      2.69     1.61     5.53  50.26
Crustacea Callianassidae                       1.15      1.95     0.88     4.00  54.26
Mollusca Laevidentaliidae                      1.18      1.93     1.21     3.96  58.22
Mollusca Chaetodermatidae                      1.08      1.76     1.17     3.62  61.84
Mollusca Mytilidae                             0.84      1.73     1.24     3.54  65.39
Polychaeta Orbiniidae                          0.70      1.29     0.89     2.65  68.04
Crustacea Ischyroceridae                       0.84      1.16     0.91     2.39  70.43
Polychaeta Lumbrineridae                       0.96      1.06     0.68     2.19  72.62
Crustacea Melitidae                            0.60      0.98     0.69     2.02  74.63
Polychaeta Syllidae                            0.81      0.92     0.68     1.90  76.53
Echinodermata Ophiuroidea                      0.64      0.91     0.68     1.86  78.39
Polychaeta Paraonidae                          0.64      0.84     0.69     1.72  80.11
Polychaeta Opheliidae                          0.70      0.77     0.51     1.59  81.70
Crustacea Philomedidae                         0.81      0.73     0.50     1.50  83.20
Mollusca Nuculidae                             0.54      0.68     0.53     1.40  84.59
Crustacea Paratanaidae                         0.97      0.64     0.52     1.31  85.90
Crustacea Oedicerotidae                        0.64      0.62     0.52     1.27  87.18
Crustacea Apseudidae                           0.61      0.58     0.51     1.19  88.37
Crustacea Ampeliscidae                         0.64      0.57     0.52     1.16  89.53
Polychaeta Oweniidae                           0.89      0.54     0.52     1.12  90.65
Polychaeta Onuphidae                           0.58      0.54     0.52     1.11  91.75
Crustacea Raninidae                            0.48      0.41     0.38     0.84  92.59
Crustacea Cylindroleberidae                    0.52      0.40     0.38     0.83  93.42
Polychaeta Ampharetidae                        0.48      0.37     0.38     0.75  94.17
Echinodermata Echinoidea                       0.61      0.34     0.37     0.71  94.88
Crustacea Leptocheliidae                       0.44      0.34     0.39     0.69  95.57
Crustacea Lampropidae                          0.47      0.32     0.38     0.65  96.22
Mollusca Cuspidariidae                         0.40      0.29     0.38     0.60  96.82
Crustacea Cirolanidae                          0.30      0.19     0.26     0.38  97.21
Crustacea Bodotriidae                          0.30      0.19     0.26     0.38  97.59
Crustacea Podoceridae                          0.50      0.18     0.25     0.37  97.96
Polychaeta Sigalionidae                        0.34      0.14     0.26     0.29  98.25
Crustacea Synopiidae                           0.28      0.09     0.15     0.19  98.43
Crustacea Hexapodidae                          0.28      0.08     0.15     0.17  98.60
Mollusca Nassariidae                           0.24      0.08     0.15     0.16  98.77
Crustacea Anthuridae                           0.20      0.07     0.15     0.14  98.91
Polychaeta Pectinariidae                       0.20      0.07     0.15     0.14  99.05
Crustacea Nebaliidae                           0.27      0.06     0.15     0.13  99.19
Mollusca Rissoidae                             0.20      0.06     0.15     0.13  99.31
Polychaeta Trichobranchidae                    0.20      0.06     0.15     0.11  99.43
Polychaeta Oenonidae                           0.20      0.06     0.15     0.11  99.54
Crustacea Diastylidae/Gynodiastylidae          0.20      0.06     0.15     0.11  99.65
Mollusca Pyramidellidae                        0.20      0.04     0.15     0.09  99.75
Crustacea Phoxocephalidae                      0.20      0.04     0.15     0.08  99.83
Polychaeta Sabellidae                          0.20      0.04     0.15     0.08  99.92
Crustacea Pasiphaeidae                         0.20      0.04     0.15     0.08 100.00
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