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Softbottom Benthic Communities in Sydney Harbour, Nova Scotia.
1. 1999 survey. Distribution, relation to contamination, and comparison to previous studies.

by

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ACKNOWLEDGEMENTS

Mike Allen painstakingly carried out the sometimes difficult task of separating animals from sediment samples collected in this study. Ms. Leslie Pezzack of the Nova Scotia Museum of Natural History and Dr. Gerhard Pohle of the Huntsman Marine Science Centre verified polychaetes and many of the miscellaneous taxa.

ABSTRACT

Sydney Harbour, an inlet and major port in northern Cape Breton Island, Nova Scotia, Canada, has experienced more than a century of contamination from industrial and urban activity centred on the Port of Sydney. In particular, the harbour has been exposed to high loadings of polynuclear aromatic hydrocarbons (PAHs) and other contaminants from releases from a steel plant and coking operation, domestic sewage, and contamination from port operations. As part of a study of microbiology, contaminant dynamics, toxicology and geochemistry carried out from 1999-2001, seabed organisms 0.5 mm and larger (macrofauna) were identified, counted and weighed, community distributions and sediment characteristics (total organic carbon and grainsize parameters) determined, from thirty-seven stations deeper than 8 metres in Sydney Harbour. Analysis of data collected in October 1999 is presented here.

Sediments in South Arm, Northwest Arm and the central channel of outer Sydney Harbour were clayey silt, with occasional coarser fractions (sand to gravel). Silty sand to clean sand occurred on the margins of the channel in the outer harbour and at a reference station at the harbour mouth. South Arm sediments were high in total organic carbon (TOC), highest off the Sydney waterfront and Muggah Creek, a major source of PAH contamination. Areas of high TOC coincided with high levels of PAHs, and polychlorinated biphenyls (PCBs). Levels of TOC, PAHs and PCBs in silty sediments in other parts of Sydney Harbour were much lower although still detectable, and PAH and PCB concentrations were negligible to undetectable in sandy sediments in the outer harbour and at the harbour mouth.

Softbottom benthic communities having low abundance and numbers of species, occurred in the areas showing highest concentrations of organic carbon, PAHs and PCBs in sediments. In the most contaminated areas of central and northeast South Arm, the burrowing anemone *Cerianthus borealis*, the polychaete *Nephtys incisa*, the nemertean worm *Cerebratulus* sp, and a phoronid *Phoronis architecta* occurred; while the inner South Arm had few organisms but the common presence of the polychaete worm *Nephtys incisa*. The Northwest arm was dominated by the capitellid polychaete *Mediomastus ambiseta*, the polychaetes *Ninoe nigripes, Nephtys incisa* and *Scolelepis squamatus*, the bubble shell *Acteocina canaliculata*, the burrowing anemone *Cerianthus borealis*, and the nemertean *Cerebratulus* sp. Diverse communities occurred in other areas. The same biological community (in terms of species composition, abundance, diversity and biomass) occurred in the most contaminated areas of Sydney Harbour in 1999 as was found by an earlier study which sampled South Arm in 1978. This finding suggests that conditions affecting biological properties of the system have remained similar to the present over that time period.

RÉSUMÉ

Le havre de Sydney, qui est un bras de mer et un port important du nord de l'île du Cap-Breton, en Nouvelle-Écosse (Canada), souffre de plus d'un siècle d'une contamination d'origine industrielle et urbaine provenant du port de Sydney. Ce havre a en particulier été exposé à de fortes charges en hydrocarbures aromatiques polynucléaires (HAP) et autres contaminants libérés notamment par une aciérie/cokerie, et en polluants provenant des eaux usées domestiques et des activités portuaires. Dans le cadre d'une étude portant sur la microbiologie, la dynamique des contaminants, la toxicologie et la géochimie, réalisée de 1999 à 2001, nous avons identifié, dénombré et pesé les organismes benthiques de 0,5 mm et plus (macrofaune) et déterminé la distribution des communautés et les caractéristiques des sédiments (carbone organique total et granulométrie) à 37 stations situées à plus de 8 m de profondeur dans le havre de Sydney. Nous présentons ici l'analyse des données recueillies en octobre 1999.

Les sédiments du bras sud, du bras nord-ouest et du chenal central de la portion aval du havre de Sydney étaient constitués de limon argileux, avec à l'occasion des fractions plus grossières (du sable au gravier). On trouvait du sable limoneux à propre sur les marges du chenal dans la portion aval du havre et à une station témoin située à l'entrée du havre. Les sédiments du bras sud présentaient des teneurs élevées en carbone organique total (COT), les plus élevées devant le front de mer de Sydney et le ruisseau Muggah, grande source de contamination par les HAP. Les zones où le COT était élevé coïncidaient avec de fortes teneurs en HAP et en polychlorobiphényles (PCB). Les concentrations de COT, de HAP et de PCB dans les sédiments limoneux d'autres portions du havre de Sydney étaient beaucoup plus basses, quoique encore détectables, et les concentrations de PAH et de PCB étaient négligeables à indétectables dans les sédiments sableux de la portion aval et de l'entrée du havre.

Des communautés benthiques des fonds meubles, présentant une faible abondance et un petit nombre d'espèces, étaient présentes dans les zones où les concentrations de carbone organique, de HAP et de PCB dans les sédiments étaient les plus fortes. Dans les zones les plus contaminées du centre et du nord-est du bras sud, on retrouvait l'anémone fouisseuse *Cerianthus borealis*, le polychète *Nephtys incisa*, le ver némertien *Cerebratulus* sp., et un phoronidien, *Phoronis architecta*; dans la portion amont du bras sud, on notait une faible variété d'organismes, mais la présence commune du polychète *Nephtys incisa*. Le bras nord-ouest était dominé par le polychète capitellidé *Mediomastus ambiseta*, les polychètes *Ninoe nigripes, Nephtys incisa* et *Scolelepis squamatus*, la bulle *Acteocina canaliculata*, l'anémone fouisseuse *Cerianthus borealis*, et un némertien, *Cerebratulus* sp. Des communautés diverses étaient présentes dans d'autres zones. Nous avons retrouvé en 1999 dans les secteurs les plus contaminés du havre de Sydney la même communauté biologique (en termes de composition spécifique, d'abondance, de diversité et de biomasse) qu'avait relevée une étude menée en 1978 dans le bras sud. Cette découverte permet de penser que les conditions qui affectaient les propriétés biologiques du système sont demeurées les mêmes pendant toute cette période.

INTRODUCTION

Sydney Harbour, an inlet and major port on the northern coast of Cape Breton Island, has experienced more than a century of contamination from industrial and human activity centred on the Port of Sydney. In particular, the harbour has been exposed to high loadings of polynuclear aromatic hydrocarbons (PAHs) and other contaminants from releases from the Sydney Steel Plant located there, and sewage and other releases from the City of Sydney and associated port activity. Although the probable impact of industrial activities on the environment of the Harbour was known in the 1970s, recognition in the early 1980s of high levels of contamination in the environment and biota of the Harbour led to a shutdown of the coke ovens, the major source of aquatic releases from the Steel Plant, and resulted in a wide range of studies carried out through the 1980s to determine the extent of contamination and potential effects. In 1999, Fisheries and Oceans Canada and Environment Canada, with funding from the Toxic Substance Research Initiative and Health Canada (TSRI), began a multi-year study of the waters and sediments of Sydney Harbour, to assess conditions more than a decade after activities at the Plant were discontinued, to provide a toxicological and oceanographic basis to determine status and potential for recovery of the seabed ecosystem in the Harbour. As part of that project, a benthic seabed sampling program was carried out in 1999 and 2000 to determine distribution and abundance of benthic organisms and sediment characteristics. The results of analysis of samples collected in October 1999 are presented in the current report; a companion report (Stewart *et al.* 2002) deals with data collected in 2000 and summarizes aspects of the data for both years.

METHODS

Background and Previous Studies

The waters of Sydney Harbour, a Y-shaped inlet on the northern coast of Cape Breton Island and one of Nova Scotia's major harbours, have been exposed to a wide range of industrial and human contamination for over a century. Although the Harbour has many of the contamination problems typical of other major industrial ports, including organic loading, BOD, metallic and organic contaminants, and bacterial contamination, it has been impacted more severely than most harbours by decades of uncontrolled release of contaminants from the Sydney Steel Plant, situated near its head. In particular, the Sydney Tar Ponds, the former watershed of Muggah Creek (Figure 1) — used for industrial disposal by the Steel Plant and adjacent community and one of the most severely contaminated waste dump sites in Canada — has been responsible for exchanging large quantities of contaminants including PAHs and other toxic chemicals, with Sydney Harbour.

Suspected contamination of the Ponds, and the status of Sydney Steel as a major industrial site, as well as the discovery of high concentrations of PAHs in commercial catches of lobster in Sydney Harbour in the early 1980s, led to a suspension of critical activities of the steel plant. Through the 1980s and 1990s, a number of environmental studies were carried out which assessed the distribution, concentration, and character of contaminants in various environmental compartments in Sydney Harbour. Wendland (1979), in a study carried out for Environment Canada, assessed sediment contaminants and benthic communities at stations throughout South Arm and at a control station in Northwest Arm. Three subsequent studies by Environment

Canada (Packman *et al.* unpublished; Matheson *et al.* 1983; and Kieley *et al.*1986) examined contamination in sediments and biota in both arms of the harbour and in the outer harbour. P. Lane and Associates (1989, 1990) carried out contaminant and biota sampling, and physical oceanographic modelling in connection with assessment of the impact of effluents from the tar ponds. A 1995 resampling of sediment and biota was carried out for Environment Canada by Jacques Whitford Environment – International Technology Corporation Joint Venture (Ernst *et al* (1999)), and Environment Canada sampled sediments and biological communities at five stations along a contaminant gradient from Muggah Creek to the outer harbour in 1997 (including the current reference station) as part of a study to develop toxicological indicators of sediment contamination (Zajdlik *et al.* 2000).

Biological communities have been sampled in three earlier studies in connection with the assessment and monitoring of contamination problems (Wendland 1979; and P. Lane and Associates, 1988, 1989; Zajdlik *et al.* (2000)). Wendland (1979) focused on South Arm, and P. Lane and Associates (1988 and 1989), though covering all of Sydney Harbour, provided largely descriptive results with only cursory analysis and interpretation. Zajdlik *et al.* (2000) provided species lists and abundances for the biological community and several community measures, and original data was available and consulted.

Station Locations

A standard set of sampling stations for sediments and biota were adopted by Environment Canada in Matheson *et al.* (1983); a subset of these were later sampled in a monitoring study (Kieley *et al.* 1986). A later study (P. Lane and Associates 1989) also used station locations from Matheson *et al.* (1983) but added a number of stations along the axes of the Harbour Arms. This sample grid was also used in the 1995 sampling (Ernst *et al* 1999).

The basic sampling grid for the present study used the Matheson *et al.* (1983) and P. Lane and Associates (1989) stations as a basis (and consequently represents stations in later studies), but added stations to meet particular sampling needs (Figure 1, Table 1). The stations are logically arranged and are suitable for an oceanographic sampling program, covering the Harbour both laterally and longitudinally. The general sampling grid included a series of transects of South Arm, Northwest Arm and the outer Harbour, typically three stations across with one station in the approximate centre. One transect is situated off the mouth of Muggah Creek and would be expected to capture a contaminant gradient from severely contaminated to moderately contaminated.

Field Methods

Sampling was carried out from October 18-22, 1999 on the MV Navicula (BIO Cruise 99-072). Sampling for biological community and sediments was carried out using a 0.1 m^2 Van Veen grab sampler. A given sampling event included taking several grab samples to supply adequate material for various program components. For samples for biological analysis, each grab was placed on wooden frame over a receiving box, and a sample for grain size and TOC was taken from the surface 2-5 cm of sediment. Each sample was logged and allocated a unique serial number. Samples for grain size and TOC were held under ambient conditions during the cruise and later refrigerated prior to analysis. The remainder of each sample was transferred to heavy plastic bags, labelled, and transported to shore for washing.

Single samples for biological community analysis were taken at most stations, although duplicate samples were taken in the most contaminated areas, chiefly in central South Arm off Muggah Creek, and at one Station (Station 21) in the outer harbour. The approach and having TOC and grain size information for each sample, was preferred over use of more replication because it permitted better geographic coverage within Sydney Harbour and was efficient in multivariate analyses, while fitting within the fixed budget for the project.

Chemical Analysis

Grain Size and Total Organic Carbon

Grainsize and TOC analyses were carried out by Seatech Limited, Halifax. Grainsize distribution was determined by pipette analysis and dry sieving (Krumbein and Pettijohn 1938). Samples were washed through a 230 mesh sieve, and the retained portion dried and sieved through U.S. mesh 4, 10, 18, 35, 60, 100, and 230. The eluent from the washing (wet sieving) was made up to 1 L with water, calgon deflocculant added, and pipette samples withdrawn at appropriate time intervals. The results were reported using the Wentworth grade scale.

For determination of organic carbon, one gram of sediment was washed with diluted HCl in a water bath at 60°C to remove carbonates. The acid was diluted and the sample dried at 80°C. Total Organic Carbon (TOC) analyzed on a LECO carbon analyzer (limit of detection, 0.01%).

Grain Size Measures

Measures of grainsize distribution included:

$$\text{Median grain size} = \phi_{50}$$

$$\text{Mean grain size} = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

$$\text{Inman Sorting} = \frac{\phi_{95} - \phi_{05}}{6.6} + \frac{\phi_{84} - \phi_{16}}{4}$$

ϕ (phi) as a measure of grain size is defined as $-\log_2$ (grain diameter in mm). A grain size of 1 mm corresponds to 0 ϕ. Grainsize measures were calculated by a software package (Community Analyses System, Version 4.2. Ecological Data Consultants, Gainesville, Florida) and were based on Folk (1966) and Folk and Ward (1957).

Biological Analysis

Samples for biological analysis were sieved on shore at a field laboratory (surplus Fisheries and Oceans building on the Sydney waterfront) through a 0.5 mm sieve, and preserved in 10% formalin buffered with borax. Animals were sorted by stereomicroscope at 8x magnification; 10% of samples were resorted to determine sorting efficiency, which was always >90%. Because of large sample volume or numbers of organisms, three samples were subsampled (see Table A3) (spread evenly in a circular tray before a divider with measured quadrants was inserted and partioned material placed in separate containers; enough quadrants were sorted to give >200 organisms. The method had been evaluated and proven to give satisfactory consistency among quadrants in a previous project. All organisms were blotted dry and weighed to determine standing crop (wet weight biomass); stored in 70% isopropanol; and identified to the lowest possible taxonomic level, typically to species[1]. Subsequently they were preserved in 70% isopropanol and identified to the lowest possible taxonomic level. Identifications were carried out by Mr. Patrick Stewart and Ms. Patty Kendrick of Envirosphere Consultants. Representative specimens of polychaetes were verified by Ms. Leslie Pezzack of the Nova Scotia Museum of Natural History and certain miscellaneous taxa confirmed by Dr. Gerhard Pohle at the Huntsman Marine Science Centre, St. Andrews, New Brunswick.

For each sample, number of species, number of individuals/m^2 and standing crop were determined. In addition, several indices of community structure commonly used in benthic studies were calculated for each sample.

Species diversity was estimated for each station by the Shannon-Wiener index (H') (Pielou 1974), defined as:

$$H' = - \Sigma (p_i * \log_{10} p_i)$$

where p_i is the proportion of the number of individuals of a species i to the total number of individuals in the sample ($p_i = n_i/N$); N = total number of individuals in the sample; and n_i = number of individuals in the *ith* species in the sample. The Shannon-Wiener Diversity index is widely used in ecology and represents both the number of species and distribution among individuals, with higher numbers of species generally resulting in increased values and high values of single species resulting in low diversity measures. While the Shannon-Wiener index is not universally accepted as a measure of diversity *per se*, it is useful here as an information statistic that aids in describing and interpreting the structure of the species abundance data.

Pielou's evenness index (J') (Pielou 1974) which expresses equitability of distribution of individuals among species, was also estimated. It is defined as:

$$J' = H'/ \log_{10} S$$

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[1] Where exceedingly large numbers of a particular species (>1000/sample, usually small polychaetes (e.g. *Mediomastus* sp.), archiannelids and some nemerteans) were present, a second level of subsampling was applied to the abundant species after all the other species had been removed and identified. The abundant species was spread evenly in a petrie dish and the animals occurring in 10cm^2 (approximately 15% of the dish area) were counted and extrapolated to a number for the sample as a whole.

where S is the total number of species present. Descriptions of each of the indices can be found in Pielou (1973), Legendre and Legendre (1983), and Green (1979).

Multivariate Analysis

Physical chemical data were subjected to Principal Components Analysis (PCA) (Legendre and Legendre 1983). For biological data, cluster analysis and canonical correspondence analysis (CCA) were used to determine groupings of stations based on species composition, and to evaluate relationships of physical factors in determining groupings. Cluster analysis was conducted using the PRIMER multivariate computer package (Clarke and Warwick 1994), PCA in SYSTAT and canonical correspondence analysis using the CANOCO program (Ter Braak 1988; Jongman *et al.* 1995).

Principal Components Analysis (PCA) – Principal components analysis is a data analysis technique which identifies patterns of variation in a data set based on correlations or covariance between physical/chemical variables. It seeks to partition the variance of the dataset along to a number of independent or orthogonal axes. Axes typically represent one or a combination of environmental factors that are responsible for the variation. For PCA analysis, various transformations were applied to normalize the distributions: arcsine square root transformation for percentage grainsize fractions and TOC; log transformations for depth, and contaminants; and median ϕ was not transformed. The datasets were standardized prior to analysis (Sokal and Rohlf 1981). Data from the PCA analyses were presented unrotated.

Cluster Analysis Similarity of stations in terms of biological species composition was assessed by cluster analysis using a similarity index (Bray-Curtis or Czekanowski quantitative, Legendre and Legendre 1983) also known as proportional similarity (Bloom 1981). The index compares the stations based on occurrence and numbers of each species. A matrix consisting of species that occurred at two or more stations was used in the analysis. The Bray-Curtis/Czekanowski index is defined as:

$$\frac{2W}{A+B}$$

where A and B are the total number of individuals of each species at the two stations respectively; and, W is the total of the lower of the two abundances when the two species co-occur. The index is calculated for all possible pairs of stations and the relationships (e.g. stations most and least similar in species composition) are organized into a cluster diagram (dendrogram) to illustrate relationships. Clustering used a group average sorting algorithm. The log (x + 1) transformation was applied to the biological abundance data to normalize the data. The data matrix was reduced in size by dropping species occurring at less than 1% of total abundance. As a result, 58 species were used in the cluster analysis.

Canonical Correspondence Analysis This multivariate technique is applied to species-station and associated environmental information data to allow an interpretation and summary graphic display of species and station relationships as they plot on axes which account for the maximum dispersion of the data and therefore gradients which could be at the root of species distributions. The analysis presents a display of species and station data along axes which correspond to the effects of a small number of environmental variables. The data set used for similarity analysis containing 58 species most abundant overall (see above) was also used in this analysis. The environmental data set used to adjust the analysis for possible effects, included median grain size, as well as individual grain size categories, sorting index, silt/sand ratio, total organic carbon, water content, distance from Muggah Creek and depth. Simple canonical correlation analysis without detrending, and with 'forward selection' of environmental variables and TOC was used (Ter Braak 1988). Separate analyses were conducted which included: 1) all stations; 2) only stations having fine sediments; and 3) stations having fine sediments, using selected environmental variables. Species data and sediment grainsize percentages were transformed by the arcsine square root transformation, while median grain size was used without transformation, and contaminant concentrations (PAHs and PCB contaminations) were log transformed.

RESULTS

Sediments

Sediments in the South Arm, Sydney River, and Northwest Arm and in the central channel of the outer Harbour were predominately silt with a small proportion of clay and sand (Figures 2-5, Table 2). A shoal at the mouth of Northwest Arm (Stn 24) and a station in shallow water shoreward of Stn 15[2] showed sandy to gravely sediments. The reference station (16) and Station 21 in the outer harbour had sand bottoms. Sediments at the mouth of Muggah Creek (Stn 13) were stratified, having a fine clayey silt in the upper 5-10 cm (13-2 in Table 2 and Figure 2) and a layer of coarser sandy sediment (possibly derived from slag) below (Figure 2) (13-1 in Table 2 and Figure 2). Several stations in South Arm in the vicinity of Muggah Creek also had slightly higher sand contents than adjacent areas (Figure 3).

Total organic carbon content was highest in the silty sediments and lowest in sediments having significant coarse or sand fractions (Figure 6, Table 3). In addition, total organic carbon content in silty sediment showed higher levels in South Arm than in Northwest Arm or the outer harbour, and a maximum (reaching 13.7%) in the centre of the South Arm off Muggah Creek.

Water Content[3] was highest in the silty samples, and was typically highest (60-70%) in South Arm, from 52-60% in Northwest Arm and from 18-27% in the sandy parts of the outer harbour. The silty sediments in the central channel of the outer harbour had intermediate water contents (35%) (Figure 7, Table 3).

Sediment grainsize parameters showed a positive correlation between silt and clay and these fractions were negatively correlated with coarser fractions (sand/ gravel) (Tables 4a and 4b). Coarse sand and medium sand showed significant negative correlations, and the clay content had a positive correlation with depth, reflecting the tendency for deeper areas to be more depositional. Contaminants (PAH and constituents and PCBs) showed positive correlations with

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[2] This was sampled first and was found to have sediments unsuitable for the other program components, and was resampled further from shore.

[3] Water content was measured at Institut Maurice Lamontagne on samples submitted for organics analysis.

the silt/clay and fine sand grainsize components, and with the other physical parameters, TOC and water content, which also had positive correlations with fine grainsize fractions. The highest correlations of organic contaminants were with TOC ($r > 0.8$, Table 4a).

Principal Components Analysis (PCA) of a dataset containing all stations, using sediment grainsize parameters, contaminant concentrations, water content, TOC and depth, grouped stations geographically in an obvious grainsize and contaminant gradient (coarser and less contaminated sediments in the outer harbour and finer sediments having higher contaminant concentrations in the inner harbour), based on the scores of stations on the two principal factors (Figure 8). The PCA also separated stations having silt/clay substrate, clearly showing the geographic grouping of South Arm as separate from Northwest Arm. The first two axes in the analysis explained 77.4% of the variance (Table 5a). Silt & clay and environmental variables associated with them (TOC and contaminants) loaded highest positively on Axis 1 of the first PCA (Table 5a). These included silt and clay, water content, TOC and the organic contaminants (PAHs and PCBs) (Table 5a, Figure 8). Coarse sediment fractions and sorting index had high loadings on Axis 2 and PAHs had moderate loadings.

A second PCA in which only the stations having predominately silt/clay were considered, further showed the separation between South Arm and other areas (Figure 9). The analysis accounted for 91.9% of the variance in five factors (71.6% in the first two). South Arm stations tended to score higher on Axis 2 (Figure 9) than other stations. Most sediment grainsize, physical and contaminant parameters as well as TOC had strong loadings on Axis 1 (Table 5b) while only the fine grainsize classes, all contaminants, and water content loaded strongly on Axis 2. Axis 1 represents an unidentified factor which results in both the occurrence of a sandy fraction and the high TOCs observed in silty sediments in the central South Arm near Muggah Creek (Station 30 (Figure 9) had both the highest TOC and median grainsize of the stations having fine (silt/clay) sediment). Axis 2 represents a factor that lends to partitioning of the stations having silt/clay substrate (and the associated contaminant parameters).

Contaminant Distribution

Total PAH and PCBs in sediments were highest in the central portion of South Arm (Table 3, Figures 10 and 11), reflecting local contaminant sources, as sediments having similar grainsize composition outside South Arm had much lower levels[4]. Relatively high levels were also observed in inner South Arm and at the mouth of Sydney River (Stations 18, 19 and 34, Figures 10 and 11).

Animal Communities

Distribution of softbottom benthic communities reflects both a narrow range of bottom types in Sydney harbour and the effects of contamination in South Arm. The majority of sites sampled had predominately soft (silt/clay) bottom having separate communities in different parts of the harbour, but sandy bottom supporting characteristic communities occurred in the outer harbour. Most soft bottom within South Arm had a community which was reduced in abundance and

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[4] Contaminant levels are presented in this report to aid in interpretation of the biological data. A more definitive presentation of contaminants will be the subject of final reports of other program components.

biomass compared to that outside South Arm (Figures 12 & 13, Table 6). A zone of higher abundance on the northwest side of South Arm and at Station 19 in inner South Arm is due to the presence of a community having high abundance of a small capitellid polychaete (*Mediomastus ambiseta*). Another community dominated by *Mediomastus* but having more species and greater Shannon-Wiener diversity, occurred throughout Northwest Arm and accounted for high abundances observed there (Figure 12, Table 6). High abundances in silty bottom at Station 23 in the outer harbour of several species including *Mediomastus ambiseta* and in particular the polychaete *Owenia fusiformis* resulted in a high abundance at that station. The remaining stations (16, 21 and 22) had sandy bottom, and a separate, more diverse community making up the moderate to high abundance found there.

Biomass was highest in the outer harbour and at the head of Northwest Arm, intermediate in Northwest Arm and lowest in South Arm. Lowest biomass occurred at several stations off Muggah Creek and at Station 34 at the head of South Arm in Sydney River Estuary (Figure 13, Table 6).

Shannon Wiener Diversity was low in both Northwest Arm and South Arm and moderate to high in the outer harbour (Figure 14, Table 6). The community in the vicinity of Muggah Creek and in the Northeast section of South Arm was generally higher in diversity expressed by the Shannon Wiener index than that in the northwest portion of South Arm, and in Northwest Arm.

South Arm (from the vicinity of Muggah Creek to the head of South Arm, and in the northeast portions of South Arm) had the lowest diversity in terms of numbers of species (typically less than 10, Table 6) (although diversity expressed by the Shannon Wiener index at some stations off Muggah Creek and in the northeast portion of South Arm was frequently higher than in other areas (Table 6, Figure 14)). Diversity in terms of number of species was higher in the Northwest Arm and the northwest portion of South Arm (Table 6, 9-27 species), although diversity expressed by the Shannon Wiener Diversity index was frequently lower than at some of the stations off Muggah Creek in South Arm. Lower diversity in Northwest Arm in terms of the Shannon-Wiener index was influenced by high numbers of the capitellid polychaete *Mediomastus ambiseta*, despite moderate numbers of species present. The influence of *Mediomastus* is shown in the low values of Pielou's Evenness (0.19-0.45) for the Northwest Arm stations compared to South Arm stations off Muggah Creek (>0.7) (Table 6). Stations in the outer harbour were highest in diversity, expressed both by number of species (27-44) and Shannon Wiener Diversity (Table 6).

Several groupings of stations having similar composition and abundance of seabed organisms were identified by cluster analysis (Figure 15 mapped in Figure 16 and summarized in Table 7). A community dominated in numbers by the polychaete *Mediomastus ambiseta* (A1, Figures 15 and 16) occurred in Northwest Arm, the northwest portion of South Arm and at Station 19 in mid-South Arm. The group occurs on silty to clayey bottom, depths of 9.5 to 21 m and TOC content of 2.2-4.9 % (7.3% at Station 19 in South Arm). Distribution and abundance of the polychaetes *Ninoe nigripes, Nephtys incisa*, and *Scolelepis squamatus*; the gastropod *Acteocina canaliculata*; the burrowing anemone *Cerianthus borealis*; and the nemertean *Cerebratulus* sp., in addition to *Mediomastus* were most responsible for the clustering of this group.[5] Species

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[5] This was assessed using the ANOSIM module of the PRIMER clustering software.

composition, abundance and relative abundance of organisms are presented in Appendix Tables A1 to A3.

Group A1* contained two stations (23 and 24) which had communities which were in unique situations. Station 24 occurred on a shoal at the mouth of Northwest Arm and had coarser bottom and lower TOC (0.5%) than nearby stations, while Station 23 in the central channel of the outer harbour, although silty, had higher proportions of coarse silt and very fine sand compared with stations in Northwest Arm or South Arm. Species most responsible for clustering of this group were the polychaetes *Mediomastus ambiseta, Ninoe nigripe, Nephtys incisa, Phloe longa* and *Exogone hebes*; and the gastropod *Acteocina canaliculata*. Three stations on sandy bottom in the outer harbour (16, 21 and 22) grouped together forming group A2. An Archiannelid (Protodrilidae sp.1); the bivalve *Tellina agilis*; the New England dog whelk *Nassarius trivittatus*, and the polychaete *Aricidea catherinae* were the species most responsible for this grouping.

The remaining communities in South Arm grouped together, forming groups B1 and B2, the latter including B2* (a closely clustering subgroup of B2) (Figure 15). Group B1 (Stations 13, 30 and 34) were all largely without animals, having only 1-3 species occurring in low abundance. The grouping was mainly due to the common presence of the polychaete *Nephtys incisa*. Other species were the gastropod *Nassarius trivitattus*, and the polychaete *Mediomastus ambiseta* at Station 13; the bivalve *Tellina agilis* and the burrowing anemone *Cerianthus borealis* at Station 30; and the gastropod *Acteocina canaliculata* at Station 34.

A second grouping of stations in South Arm identified by the cluster analysis (B2 including B2*, Figures 15 and 16), occurred in the central harbour off Muggah Creek, in the northeast sector of South Arm, and at one station (Station 18) in the inner harbour (Figure 16). Within this group, six stations in the northeast section of Sydney Harbour, Station 1, and one sample at Station 29 formed cluster B2* and supported a similar community (Figure 16). Species most responsible for this grouping were the burrowing anemone *Cerianthus borealis*; the polychaete *Nephtys incisa* and the nemertean *Cerebratulus* sp. Stations in this group had 4-6 species, and clustered most closely of any of the major groups of stations. The remaining stations in group B2 occurred in central South Arm off Muggah Creek and in inner South Arm (Station 18) and had 2-8 species. Species most responsible for the similarities among these stations were the polychaetes *Mediomastus ambiseta* and *Nephtys incisa*; and the burrowing anemone *Cerianthus borealis*. Species in several of the communities identified by the cluster analysis are illustrated in Figures 17a-c.

Canonical correspondence analysis (CCA) was applied to the biological and physical data sets to show the relationship of groupings of species and stations to environmental parameters. CCA is a numerical procedure which identifies common patterns of distribution of chemical/physical variables, as well as in abundance of organisms, and the relationship between biological distributions and the physical/chemical environment. It is preferable to principal components analysis (PCA) for biological data, as it can identify non-linear relationships which are more common in biological communities living in and reacting to physical/chemical gradients. The analysis identifies orthogonal components of variability in the data, and, like PCA, produces a hierarchy of axes based on the relative amount of the dispersion of species data relative to contaminant parameters they explain, compared to PCA which identifies factors which account for the majority of the variance. Typically two axes account for the majority of the dispersions (CCA) and correlations or scores of 1) physical/chemical parameters; 2) stations; and 3) species from the analysis on the first two axes can be used to generate two-dimensional representations of the relationships.

The first CCA analysis included all stations, and a second only stations having silt/clay bottom (and thus mainly stations in the inner harbour, Northwest Arm and South Arm were included). The first analysis was intended to reveal the more general pattern of communities expected to be strongly influenced by the sharp gradients between the presence of sandy, low contaminant communities in the outer harbour; and contaminated, silty communities in the inner harbour; while the second analysis was intended to look at more subtle patterns in factors when sediment type was more uniform. A third analysis of silty stations was also conducted which focused on particular representative environmental variables, rather than the environmental data set in its entirety. The results of the three CCA analyses are presented in Figures 18 to 20 and Tables 9 & 10.

The success of the CCA in explaining the patterns in the data is expressed by the percentage of the variance in the data that the solved axes explain. The three CCA analyses showed a comparatively low percentage of the variance accounted by the first two axes, indicating that weak relationships occur between biological communities and physical/chemical parameters. In the first CCA (all stations) the first axis accounted for 21% of the variance (Table 9a) and represented a sediment grainsize gradient. The sand fractions (medium, fine and very fine sand) had higher positive correlations with Axis 1 (Table 10a) while silt and clay had high negative correlations with it. Owing to the positive correlations of contaminants (PAHs), and water content with the fine fraction, these parameters also had negative correlations with the first axis of the CCA. Sandy stations all grouped to the right in the CCA diagram (Figure 18a).

The second axis of the first CCA (in which all stations were included), accounted for only a small percentage (10.3%) of the variance and none of the environmental variables showed high correlations with it, the highest being fine sand and depth (r=0.32 and 0.29 respectively) (Table 9a). The separation of silty stations along Axis 2 into South Arm and Northwest Arm (those above the x-axis on the left of Figure 18a are mainly South Arm; those below it are mainly Northwest Arm) is likely related to some other variable not included in the analysis but which relates to location (e.g. hydrodynamic regime, which differs between Northwest Arm and South Arm). The third and fourth axes of the analysis represent influence of PAHs and TOC, and coarse sediment grainsize fractions respectively (Tables 9a & 10a).

The second and third CCAs (stations having predominately fine (silt/clay) sediments (Figures 19 and 20)) showed a similar influence of a range of factors, with the first axis accounting for only 16.2 and 15.2% of the variance for the separate analyses which considered all environmental variables and selected ones respectively, and the second axis only 10.3 and 10.9 % respectively). Median grainsize was most highly correlated with Axis 1 (r=0.78 and 0.87 respectively) and distance from Muggah Creek showed a moderate correlation (r = 0.45, Table 10b).[6] Station 23, the station with the highest median grainsize of those included, had a high score on Axis 1,

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[6] Distance from Muggah Creek and PCB concentrations were included in this CCA but not in the analysis of all stations.

grouping it apart from the rest (Figure 19a). Stations 23 and 35, which had high positive scores on Axis 1, were also the furthest from Muggah Creek, and is the reason for the moderate correlation of distance with Axis 1. Depth, PCB, water content and clay content all had strong negative correlations with Axis 1 (Table 10c). Where grainsize and distance from Muggah Creek is comparable, as in South Arm and outer Northwest Arm, the stations in Central South Arm where all of these parameters tend to be higher, group more to the left of the CCA diagram (Figures 19a and 20a) than do the stations from Northwest Arm and northwestern South Arm.

TPAH and TOC had strong positive correlations, and distance a strong negative correlation with Axis 2 in the CCA in which only key environmental variables were selected (Table 10c, Figure 20b). Station scores in the CCA, which gave stations in central and northeast South Arm high scores on Axis 2 and Northwest Arm and Northwest South Arm low scores on that axis, suggests that the axis is a gradient in particular of TOC and PAH. The low scores of distance on the axis similarly reflects that TOC and PAH are highest in the central South Arm and decline with distance away from it. Axes 3 and 4 accounted for a low percentage of the variance. PCB had a moderate positive correlation (0.37) and depth a negative correlation (-0.40) with Axis 3; and depth had a moderate negative correlation (-0.53) with the fourth axis (Table 10c). The relationships of several chosen environmental variables to the first two axes are presented in Figure 20b, and reflect the correlations with environmental axes discussed above.

Species distributions in relation to stations and environmental variables are shown in the third plot of the first two axes for each CCA (Figures 18c, 19c, and 20c). The scores of each species on the two axes reflect the relative abundance at the station groups identified by CCA (Figures 18a, 19a & 20a respectively) (and further the relation to environmental parameters). For example in Figure 18c, the group of species 2, 10, 29, 50 and 51 in the upper right (listed in Table 8, 2 = *Enis directus*, 10 = *Lunatia triseriata*, 29 = *Paraonis fulgens*, 50 = *Echinarachnius parma*, and 51 = *Strongylocentrotus droebachensis*) all occurred at Station 21 on sandy bottom in the outer harbour (Station 21 shows similar scores on Axis 1 and 2 in Figure 18a) and reflect sandy communities (sand fractions, in particular fine sand, have high correlations with Axis 1 and 2 of this analysis (Table 9a) and plot in the upper right of Figure 18b). Extreme species placements on the plots are not particularly meaningful (e.g. 30, the polychaete *Pherusa affinis*) on Figure 20c). The groups of species including: 4 – the New England Dog Whelk *Nassarius trivittatus;* 8 – unid. Bivalve juvenile; 27 – the polychaete *Nephtys incisa;* 53 – the burrowing anemone *Cerianthus borealis;* 54 – the nemertean *Cerebratulus* sp.; 56 –unidentified Nemertean; and 58 – the Phoronid *Phoronis architecta,* on the left of Figure 20c show the association with stations in central and northeast South Arm, in particular reflecting fine sediments, proximity to Muggah Creek, high PCBs, deeper water and high water content, TOC and TPAH) (Figures 20a and 20b).

DISCUSSION

Animal Communities

The present study examined only subtidal bottoms 8 m and deeper and consequently the communities sampled do not present a complete picture of those present in Sydney Harbour. In South Arm, for example, only silty/clayey bottoms were sampled; shallower areas are expected to have coarser substrate (in one case, Station 15A, a preliminary sample showed sandy/gravely bottom (Table 2)). Different bottom types and depth ranges would support additional communities to those described in this report.

Stations were selected to represent sites of previous sampling in other studies, to provide suitable, relatively homogeneous substrate for the range of testing which was carried out, and to obtain broad coverage of the Sydney Harbour system, which required a well-spaced sampling grid. Consequently the patterns of distribution of communities presented here (e.g. Figure 16) are only approximate. For example the 'tongue' of community A1 extending down the northwest side of South Arm (Figure 16) is based on only three samples over a distance of roughly 3 kilometres. Within this distance there could be variability in bottom type (although in this case bottom type appears to be fairly homogeneous) resulting in community changes. Nonetheless, the presentation provides a useful model of community distribution in the Harbour which can be used as the bases of further studies.

The community on sandy bottom in the outer harbour at the mouth (Group A2, Table 7) contains a range of species typical of shallow sandy bottom environments in Atlantic Canada. The bivalve *Tellina agilis*, the New England Dog Whelk *Nassarius trivittatus* and the polychaete worm *Aricidea catherinae*, some of the species most responsible for clustering of the sandy stations, were among the most abundant and frequently occurring species in open coastal environments in the Gulf of St. Lawrence and Atlantic Nova Scotia (Stewart *et al.* 1999). The fourth species, the Archiannelid, Protodrilidae sp. 1, has not been reported in other studies (probably because of its small size) but we have previously found it in environmental monitoring studies in coastal environments in Placentia Bay, Newfoundland. Abundance was significantly higher and biomass and number of species of these communities were well above those of the majority of communities in the Gulf of St. Lawrence, and above the median value for Shannon Wiener Diversity at a range of sites in Atlantic Canada (Stewart *et al.* 1999).

The community in Northwest Arm and parts of South Arm, dominated by the polychaete *Mediomastus ambiseta,* also supported a high abundance of organisms, significant numbers of species, and moderate biomass despite the high abundance of *Mediomastus* which led to the Shannon-Wiener diversity being low. *Mediomastus*, a species typically found on predominantly silt/clay sediments is a 'colonist' species, which can develop high populations in disturbed areas (e.g. after die-off of fauna due to seasonal anoxia, or storm disturbance) (Santos and Simon 1980; Starczak *et al.* 1992;Hughes 1996; Chang *et al. 1992*). Abundances of *Mediomastus* observed here, ranging from 7,000 to 114,000 in areas where it was most dominant (Table A3) are not as great as have been reported in other locations—densities of 180,000-720,000 per square metre were observed in a US harbour (Fuller *et al.* 1988) and 10^3 to 10^6 per square metre have been reported from a range of estuaries in the eastern coastal US (Starczak *et al.* 1992). In the eastern US, highest abundances of *Mediomastus ambiseta* are observed in late summer to fall during the major period of post-larval settlement (Starczak *et* al 1992; Grassle and Grassle (1984) from Hughes (1996)). *Mediomastus* can be a sporadic inhabitant of bottom habitat; in a Florida estuary, while having typically high abundances, it was also typically absent for periods of time (Santos and Simon 1980). Absence of *Mediomastus* in previous studies (Wendland 1979; P. Lane and Associates 1988, 1989, but particularly the P. Lane studies as it sampled Northwest Arm) is suspected to be due to the sample processing approach and not to the periodic absence of the species. *Mediomastus* was also observed in various locations in the most recent sampling of Sydney Harbour, carried out in July 2000, as part of the current TSRI project.

Despite dominance by *Mediomastus*, the community in Northwest Arm and northwest South Arm was relatively rich in species. Several species which occur in this area are characteristic of disturbed communities, although they are not typically colonist species. These include the burrowing anemone *Cerianthus borealis*, the polychaetes *Nephtys incisa* and *Ninoe nigripes*, *Nassarius trivittatus,* the nemertean *Cerebratulus* sp. and the phoronid *Phoronis architecta.* These species also occurred in parts of South Arm most showing elevated organic content and contaminant levels, where they were the chief components of the seabed biological community, but were less abundant. All the species in this group (including *Mediomastus ambiseta*) were found in a 'contaminant insensitive' community in areas exposed to dredge spoil and sewage dumping in New York Bight (Chang *et al.* 1992)

Biology of many of the species in this community has been documented in previous studies. *Nephtys incisa* is a common species in silty to sandy bottoms all along the North American east coast (Zajac and Whitlatch 1988; Chang *et al.* 1992). The species has been characterized as a late-successional or equilibrium species (Zajac and Whitlatch 1988), showing relatively slow return to population levels after disturbance. *N. incisa* typically burrows in the top 10 cm of the sediments and ingests sediment and small infauna. In estuaries in the eastern United States, it produces two cohorts a year (Zajak and Whitlatch 1989).

Cerianthus borealis is a burrowing anemone which anchors itself in soft bottom sediments in a tube formed from mucus and speacialized nematocysts from the body wall, which extends into the substrate. The felt-like, iridescent purplish tubes of *C. borealis* were seen frequently during sampling in South Arm, and subsequent processing, and made sample processing difficult as they formed a slimy matrix in which organisms were embedded. Ceriantharian anemone tubes extending into the sediment have been suggested to be an adaptation to exploit extremely soft, unstable substrate where secure anchorage is important (Frey 1970a from Jensen 1992), and also shield the anemone from the sediment. Ceriantharian anemones including *C. borealis,* occur widely on soft bottom to sandy sediments in Eastern North America, and have been previously found in communities which are impacted by organic loading. Pearce *et al.* (1976) from Shepard *et al.* (1986) noted high abundances near a sewage sludge/dredge spoil disposal area. *Cerianthus borealis* was a minor constuent of the 'contaminant-insensitive' community observed by Chang *et al.* (1992), but another cerianthid, *Cerianteopsis americanus* was a dominant species. These anemones are carnivores—feeding on benthic animals and their pelagic stages, as well as zooplankton (Langton and Robinson 1990). Their feeding influences the character of the surrounding community, as they capture stages of all types of animals, including pelagic juveniles.

The phoronid *Phoronis architecta* is found on a range of sediments and commonly on anoxic ones where it builds sand grain tubes which can extend 5 to 20 cm into the bottom (Vandergon and Calacino 1989). The species can survive sustained periods of anoxia (more than 18 hours) and may also have biochemical defences against sulfide which can reach high levels in the species' tubes (Vandergon and Calacino, 1989, 1990). *P. architecta* is a common component of biological communities along the US East Coast where it is part of the 'contaminant insensitive' community in New York Bight described by Chang *et al.* (1992). Occurrence in Canadian waters is uncommon, reported from the Bay of Fundy (Bromley and Bleakney 1984) and phoronids as a group have been sampled in the Baie des Chaleurs (Brunel 1961). Some Phoronids are commensals in ceriantharian tubes (e.g. *Phoronis australis* in tubes of *Cerianthus maui*) (Emig *et al.* 1972 from Shepard *et al.* 1986) where the authors conjectured that the anemone tentacles acted as baffles, causing the waterborne particles to settle out and become available to the Phoronid, which is a suspension feeder. Given the co-occurrence observed here between *P. architecta* and *Cerianthus borealis,* a commensal relationship is a possible interpretation, although we did not make observations to that effect.

Several of the other species occurring with *Mediomastus* in the Northwest Arm and the South Arm, including the polychaete *Pherusa affinis* and *Ninoe nigripes*, and the nemertean *Cerebratulus* sp, were also part of Chang *et al.* (1992)'s contaminant insensitive community. *Cerebratulus* lives in the upper few centimetres of the sediments, and is a carnivore, capable of eating a wide range of organisms including molluscs (Kalin 1984).

The communities in Northwest Arm and South Arm are not like those shallow communities impacted by organic enrichment from fish pens and blue mussel aquaculture sites in Atlantic Canada (Pocklington *et al.* 1995; Grant *et al.* 1995) or in the heavily impacted Halifax Inlet (Hargrave *et al.* 1989). No other studies of shallow softbottom communities in coastal inlets in Atlantic Canada were available for comparison with the communities observed here.

Comparison with Previous Studies

Stations were located both to match those from earlier studies, in particular those used repeatedly in a series of Environment Canada studies (See Methods), and at locations chosen for coring as part of the chemistry program. Lack of precise positioning information for most of the previous studies is a source of error in comparison with the present data. Of the previous studies, only Zajdlik *et al.* (2000) listed the coordinates of the stations, and the positions for the other studies were determined from maps provided in the reports. Wendland (1979) used a grid in South Arm which overlaps the Environment Canada stations while P. Lane and Associates' (1988 & 1989) closely match the station grid.

Lack of consistent taxonomy was a major problem in making comparisons between studies. To illustrate, species listed in the Wendland (1979), P. Lane and Associates (1989 and 1989) and the present study are presented in Table 11. In this table, only two species (the polychaetes *Lumbrineris fragilis* and *Ninoe nigripes*) occurred in all three studies. Some groups were treated with different levels of precision in the different studies. In the P. Lane and Associates' studies, nemerteans were separated into different species in considerable detail (*Lineus arenicola, Cerebratulus marginatus, Lineus ruber, Lineus* sp., *Malacobdella grossa*, *Micrura leidyi*, *Nematostella vertens*, *Procephalothrix spiralis*). These groups are difficult to identify and it is not clear whether the P. Lane and Associates' study used specialists to identify them. We found four types (*Cerebratulus* sp., *Amphiporus* sp. 1 & 2, and Nemertean sp. 3) and Wendland (1979) only identified them to phylum. The present study showed more agreement with species composition from Wendland (1979) and Zajdlik *et. al* (2000) than with the P. Lane and Associates' studies.

Stations from the various studies were grouped geographically for comparison of biological measures (Table 12). Because the community analysis in the present study showed that communities in northwest South Arm were different than those in inner, central and northeast South Arm, and had much higher abundances, the stations of all studies on the western ends of transects of these areas were grouped separately (as 'Northwest and Outer South Arm') for comparison with other studies (Table 12).

Communities in South Arm observed in Wendland (1979) show similarities to those in the current study in abundance and genus level identifications of organisms despite taxonomic differences at the species level (Table 7 for the present study and Table 13 for Wendland (1979))[7], although the comparison must be limited to South Arm since Wendland (1979) only sampled there (one non-quantitative station was taken in Northwest Arm). All the Wendland (1979) stations appear to have been taken on soft bottom. Identifications in the P. Lane and Associates study differed significantly from both these studies, and only the summary data has been used in comparisons. Wendland (1979) showed dominance of a sea anemone (probably the burrowing anemone *Cereanthus borealis*) several *Nephtys* and *Nereis* species, and the polychaete *Ninoe nigripes* and Nemertea (Table 13), all of which occurred in the same areas of Sydney Harbour in 1999. Community composition and dominance in Wendland (1979) was similar between stations in the inner as well as central and northeastern South Arm.

Zajdlik *et al.* (2000) assessed the benthic community at five stations extending from the mouth of Muggah Creek to a reference station (the same one used in the present study) in the Outer Harbour [8], but did not sample in Northwest Arm. Because of the limited sampling effort in that study, only a limited comparison of community types and measures with other studies can be made. Communities in samples by Zajdlik *et al.* in South Arm resembled to those in the present study and in Wendland (1979). The Zajdlik *et al.* study showed a *Nephtys* species (*Nephtys ciliata)* to be one of the dominants in South Arm and showed the presence of Nemertea and the polychaete *Ninoe nigripes* which occurred in Wendland (1979) and the present study. Unlike the other studies, the Zajdlik *et al.* study showed the polychaete *Polydora quadrilobata* to be a dominant in South Arm, and Zajdlik *et al.* did not find the burrowing anemone *Cerianthus borealis* which was commonly found in the area in the present study and in Wendland (1979). In the present study *Nephtys incisa* was a dominant and *Polydora concharum* occurred occasionally in South Arm (*P. quadrilobata* was common elsewhere in the Harbour). We suspect that *Nephtys ciliata* was misidentified as it is similar to *N. incisa*, and in particular could be mistaken if they were small (many of the individuals found in South Arm in the present study were small, but we had several larger specimens which enabled us to confirm that *Nephtys incisa* was indeed present in the area). The remaining stations sampled by Zajdlik *et al.* (in the outer harbour) shared many

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[7] Identifications and composition of communities in the P. Lane & Associates (1988 & 1989) studies differed so markedly from the other studies that they couldn't be compared. Apart from the taxonomic differences, some of the communities appear to be from coarser bottom than sampled in the Wendland (1979) and current studies, although at the same stations. A summary of the species composition of communities from the P. Lane and Associates' studies is presented in Appendix Table A4.

[8] One station was off Muggah Creek; two stations were in mid-harbour between the present transects containing Stations 15 & 32 and Stations 6 & 7; the fourth was off the tip of South Bar, north of the junction between Northwest and South Arm; and the fifth was the reference station from the present study.

similar species to those observed in the present study, but dominance and number of species, as well as the identity of some species, differed from the present study (Table 14).

Abundance of organisms was much greater in the current study than in the Wendland (1979) and P. Lane & Associates' (1988-89) studies, while the Zajdlik *et al.* (2000) study (sampled in 1997) showed higher abundance in South Arm, and lower abundance in other areas, than in the present study (Table 12). None of the earlier studies indicated the presence of the small capitellid polychaete (*Mediomastus ambiseta*) which accounted for the largest numbers in the present study. Both the Wendland (1979) study and Zajdlik *et al.* should have recovered the species if it were present (both used a sieve 0.5 mm in preparing the samples). This may suggest that the sorting procedure used in the earlier studies focused on the larger, readily visible organisms or were otherwise incomplete, but it does not rule out that the species was indeed absent.

In contaminated areas of central and northeast South Arm, where *Mediomastus* only occasionally occurred, abundance measured in the current study was roughly twice that in Wendland (1979) though smaller by a factor of three than found by Zajdlik *et al.* (2000) (Table 11). Since the P. Lane and Associates (1988, 1989) study did not state the area sampled and did not present the data as an estimate per unit area, and abundance cannot be directly compared. However, photographs of the Van Veen Grab sampler used in that study (presented in the report) suggest that it was 0.05-0.07 m^2 (smaller than in the current study). If we make a conservative assumption that the sampler was equivalent to that in the present study (0.1 m^2), the abundances from the P. Lane and Associates' study for central and northeast South Arm are comparable to those in the present study (e.g. 206 /m^2, Table 12). A less conservative assumption would make the value from the P. Lane and Associates' study larger, though still comparable to that determined from the present study. In the central channel of the outer harbour, abundance in the present study was comparable to that in the Zajdlik *et al.* study, and much higher than in the P. Lane and Associates' study. Abundance at the reference site in the outer harbour was higher in the present study than in Zajdlik *et al.* (Table 12).

Number of species found is sensitive to sampling approach, in particular to the size range of organisms examined, and to area sampled. Some of the species captured on an 0.5 mm mesh are extremely small and would be overlooked if care was not taken to remove them from samples. As well, the number of species found typically increases asymptotically as the area sampled for a particular type of bottom in a given area increases (the so-called species-area relationship) (Holme and McIntyre 1971). Because it appears that the Wendland (1979) and P. Lane & Associates (1988 & 1989) studies may have focused on the more visible organisms, the number of species found is expected (on equal terms) to be less than in the present study. Wendland (1979) used the total number of species in 3 replicate, 0.05 m^2 grabs per station (an overall area of 0.15 m^2/station) and would be expected to have a slightly higher number of species (all else being equal) than most stations in the present study (sampled by a single grab of 0.1 m^2). Zajdlik *et al.* (2000) used an 0.1 m^2 Van Veen grab sampler (five replicates) and averaged the number of species per sample, and consequently the results would be directly comparable to the present study. The P. Lane & Associates' study appears to have sampled less area than the current study (one replicate of an estimated 0.05-0.07 m^2) and its estimates of number of species based on area considerations would be expected to be lower (all else being equal) than the present study.

Number of species found in South Arm in the present study was comparable to that obtained in the earlier studies (Inner South Arm and central and northeast South Arm) (Table 12). Outside South Arm, the number of species was higher in the present study than in both the P. Lane and Associates (1988, 1989) and the Zajdlik *et al.* studies, although the latter had more taxa at one station in outer South Arm (off South Bar) than in the present study (no stations outside South Arm were sampled quantitively by Wendland (1979)).

Shannon-Wiener diversity was comparable in the current study to that obtained by Wendland (1979) and Zajdlik *et al.* (2000) in South Arm. In both cases, and in the present study, Shannon-Wiener diversity was low to moderate in these areas (Table 12). Diversity at the reference station in outer Sydney Harbour, was higher in the present study than observed by Zajdlik *et al.* (2000). Wet weight biomass in the South Arm in the present study is higher than in Wendland (1979) (150 to 400 %) but the difference may be too small to be statistically significant (Table 12).

Impact or Recovery of Seabed communities

Only a limited assessment of changes in biological communities which could illustrate recovery (or lack of recovery) after the cessation of coke oven operations in the early 1980s can be made. For most areas of Sydney Harbour, method differences between early studies and the present one, could have resulted in differences observed, the present study having higher abundances and numbers of species than earlier studies by Wendland (1979) and P. Lane and Associates (1988 and 1989), and in parts of the harbour in Zajdlik *et al.* (2000), although some values were lower than in the latter study. The difference with Wendland (1979) and P. Lane and Associates' is suggested to be due in part to the exclusion of smaller species (in particular an abundant capitelled polychaete, *Mediomastus ambiseta*), which may have been overlooked in the earlier studies in areas outside South Arm. The species occurring in communities observed in the current study over much of Sydney Harbour outside South Arm, are generally widespread in coastal areas of Atlantic Canada. The Phoronid (*Phoronis architecta*) found commonly in Sydney Harbour has rarely been found in Atlantic Canada, although its absence may more reflect the limited number of benthic studies carried out in softbottom communities in Atlantic Canada inlets.

The current study showed a comparatively reduced community in most areas of South Arm, dominated by the polychaete *Nephtys incisa* and the burrowing anemone *Cerianthus borealis*[9] (Table 7), a finding most comparable to Wendland's study in 1978. In contrast to 1978, a greater diversity of organisms and dominance by additional species occurred in 1999 (Table 7, Groups B2 and B2*), although most of the taxa from 1978 continued to be present (e.g. *Cerianthus borealis, Nephtys* species, Nemertea, *Ninoe nigripes, Cerebratulus* sp.). The Phoronid *Phoronis architecta* found in 1999 was not detected in previous studies. The Zajdlik *et al.* survey in 1997 had less data by comparison but a *Nephtys* species, probably *N. incisa* (as noted earlier), was a dominant species and several of the species from that community also were found in the current study. Although the study did not find *Cerianthus borealis*, sampling intensity was probably too low to determine for certain if other members of the community were present. Communities within South Arm, in particular in inner central and northeast South Arm, thus appear to have

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[9] The Wendland (1979) study only noted 'sea anemone', which has been inferred to be *Cerianthus borealis*, the only distinctive burrowing anemone likely to have occurred.

been comparable in the late 1970s and even in the late 1990s to those observed at present. In addition to dominant species, the overall abundance, biomass and number of species observed in Wendland (1979) is comparable though lower, than at present, while Shannon-Wiener diversity, which is a measure of the overall complexity of the biological community, was comparable to that observed at present.

Another feature of the biological community in South Arm in the present study is that the community often included several size classes of individual species, possibly representing different year classes. Some of the *Nephtys incisa* captured in South Arm in the present study were at least one year old (established by measuring the width of the tenth segment and using size categories from Zajac and Whitlatch (1988)). The largest *Cerianthus borealis* observed had a retracted body length of 5-6 cm long exclusive of tentacles, also indicating an advanced age. Conditions in parts of the South Arm thus are stable enough to support at least some individuals of these species for prolonged periods. A more detailed assessment would have to be carried out, however, to determine if this is the case.

Severely disturbed bottoms frequently have exceptional abundance of a few 'colonist' species which become abundant in areas opened up by disturbance, when competition from other species is reduced (Santos and Simon 1980). Colonists in these situations are commonly small polychaete worms (often of the family Capitellidae). The occurrence of these species leads to a reduced Shannon-Wiener measure of diversity and low biomass (Gray and Pearson 1982). As the length of time from disturbance increases, the colonists become less abundant and the community more balanced, leading to a higher Shannon-Wiener diversity. This type of disturbance is characterized by oil spills and upheavals such as storm events which disturb surficial sediments (Sanders 1977; Santos and Simon 1980). In Sydney Harbour, a colonist species, *Mediomastus ambiseta*, occurs over much of the Northwest Arm and northwestern South Arm. The presence of this community could reflect periodic disturbance such as seasonal anoxia in bottom waters. The community containing *Mediomastus*, however, also includes several species known to be equilibrium species, capable of existing in contaminated environments, and which make up the community living in the most 'contaminated' areas of the Harbour in South Arm (Inner, Central and northeastern) which have highest TOC in sediments, and highest contaminant levels. This community appears to be relatively stable, having a low to moderate diversity and in which small colonist organisms are not predominant and in which certain animals may survive on the order of a year or more. Many of these species occur in 'contaminant insensitive communities' elsewhere (e.g. Chang *et al.*1992). It appears that prolonged exposure to contaminants, although constituting a stressed environment, appear to enable stable communities of organisms to development which are different than, and may even coexist with, 'colonist' communities that respond to short-term disturbance. Determining the relation of these communities to the contamination and to natural cycles of disturbance was beyond the scope of the current project, and will be an interesting focus of further efforts to understand the benthic communities in Sydney Harbour.

The larger question of what factors are causing the distribution of communities of South Arm (e.g. contamination from Muggah Creek, sewage and industrial contamination from the City of Sydney, or factors relating to natural organic input from Sydney River), can only be partially answered at this time. Organic loading appears to be a significant factor in South Arm of Sydney

Harbour. Levels of TOC observed, particularly off Muggah Creek are in the range reported for sediments in harbours in Nova Scotia (Loring *et al.* 1996) and comparable to concentrations in Halifax Inlet (typically less than 10%) (extreme values in Halifax Inlet of 12.5 % in open waters and up to 15.9 % in the highly contaminated Tufts Cove (Buckley and Hargrave 1989)). Levels of TOC at the head of the South Arm in Sydney Harbour and in other areas of Sydney Harbour, appear to be comparable to those which might be expected in uncontaminated inlets in other areas. High organic loading of sediments such as occurs in parts of Sydney Harbour, can lead to a higher oxygen flux into sediments and periodic anoxia which may be a contributing factor in accounting for the nature of the biological community which occurs there.

Contaminant levels, in particular PCB and PAH continue to be high in South Arm (measured in 1995, Ernst *et al.* 1999), the latter representing among the highest levels measured in harbour sediments in the world (Buckley *et al.* 1995; Gearing *et al.* 1991). Ernst *et al.* (1999) noted that the PCB and PAH levels in sediments in Sydney Harbour exceeded ecotoxicological guidelines for health of aquatic communities. The prolonged presence of these levels could thus be a determining factor in distribution of benthic communities. The community appears, however, to be uniform over large areas of South Arm, despite sharp PAH and PCB gradients. For example, Stations 6 & 7, which support the characteristic community for central and northeast South Arm, have lower levels of PAHs (though comparable levels of PCBs) than the remaining stations. These stations are (along with Station 31) the deepest (≈18 m) in South Arm, and had an identical biological community to that in the rest of northeast and central South Arm, yet had much lower TOC and TPAH levels than in those other areas (Figures 6, 10 and 11). Stations 6 & 7 also had the finest sediments of any station (highest clay content and smallest median grainsize, Table 3) reflecting the greater depth of these stations. The similarities in biological communities despite differences in physical/chemical and contaminant factors, suggests that a single common factor (e.g. periodic low nearbottom oxygen levels or common watermass characteristics in a basin) might be more important than contaminant concentrations in determining the biological community in the area. However there is insufficient information to assess the existance and extent of low oxygen conditions, or the combination of these with other possible influences in the present study.

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FIGURES

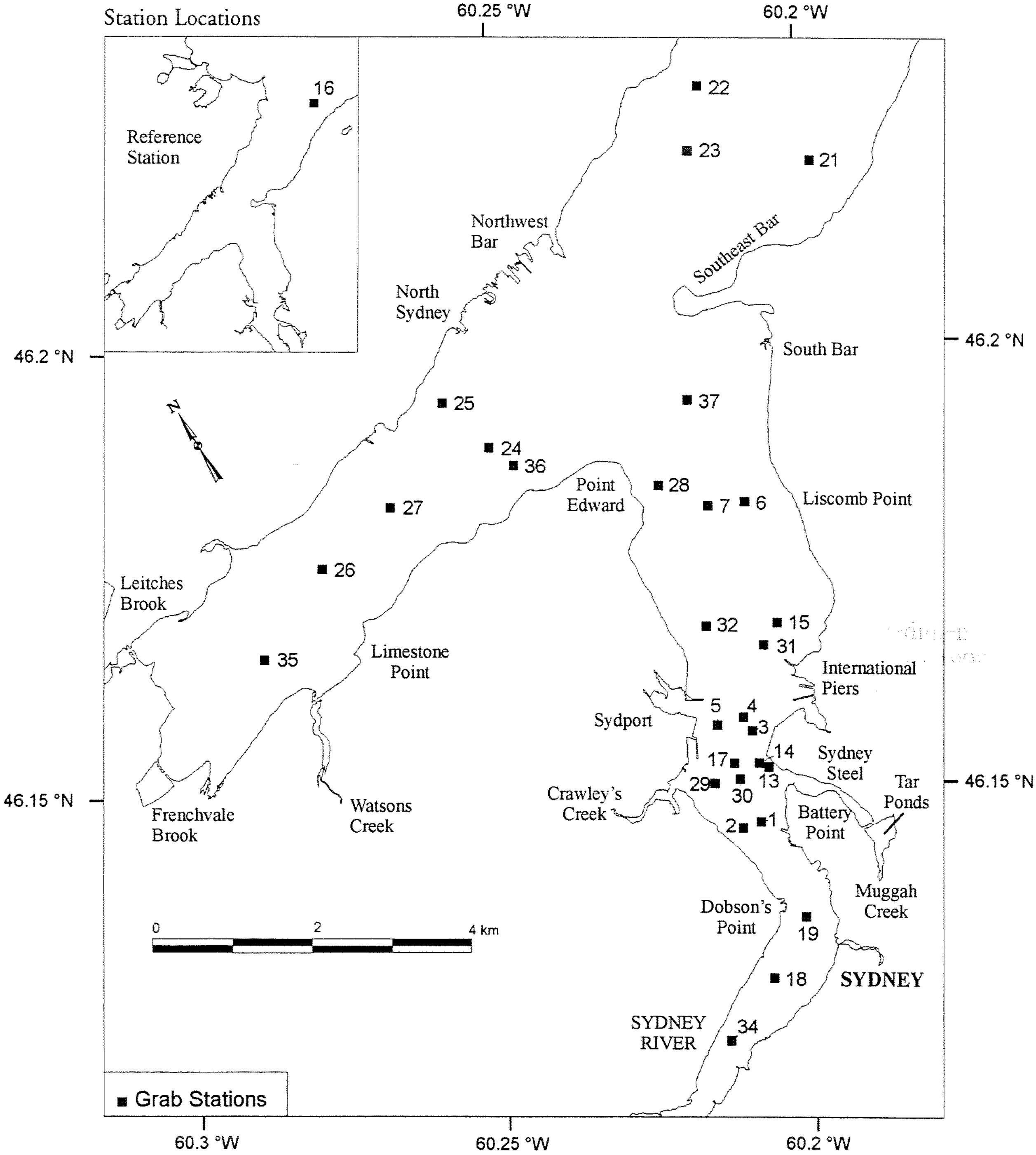


Figure 1. Station locations in Sydney Harbour, MV Navicula Cruise 99-072, October 1999.

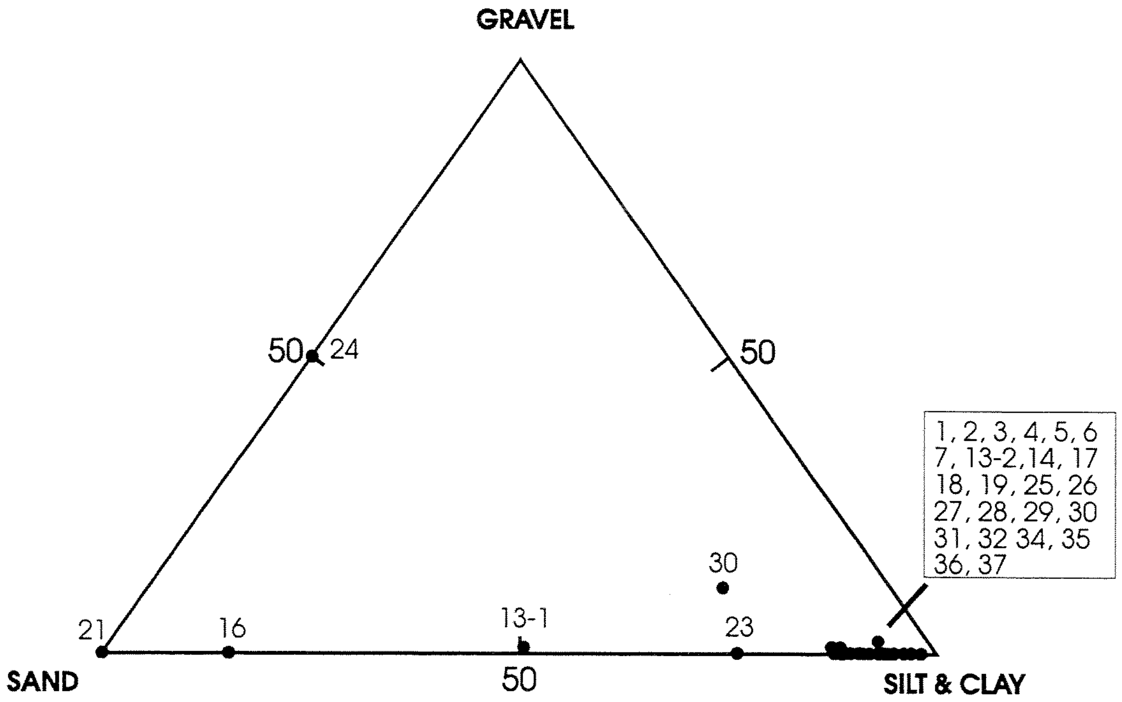


Figure 2. Ternary diagram of grainsize distribution for Sydney Harbour sediments, October 1999. Numbers represent consecutive stations. Station 13-1 is from the subsurface deposit encountered at Station 13 and 13-2 is the typical surface sediment.

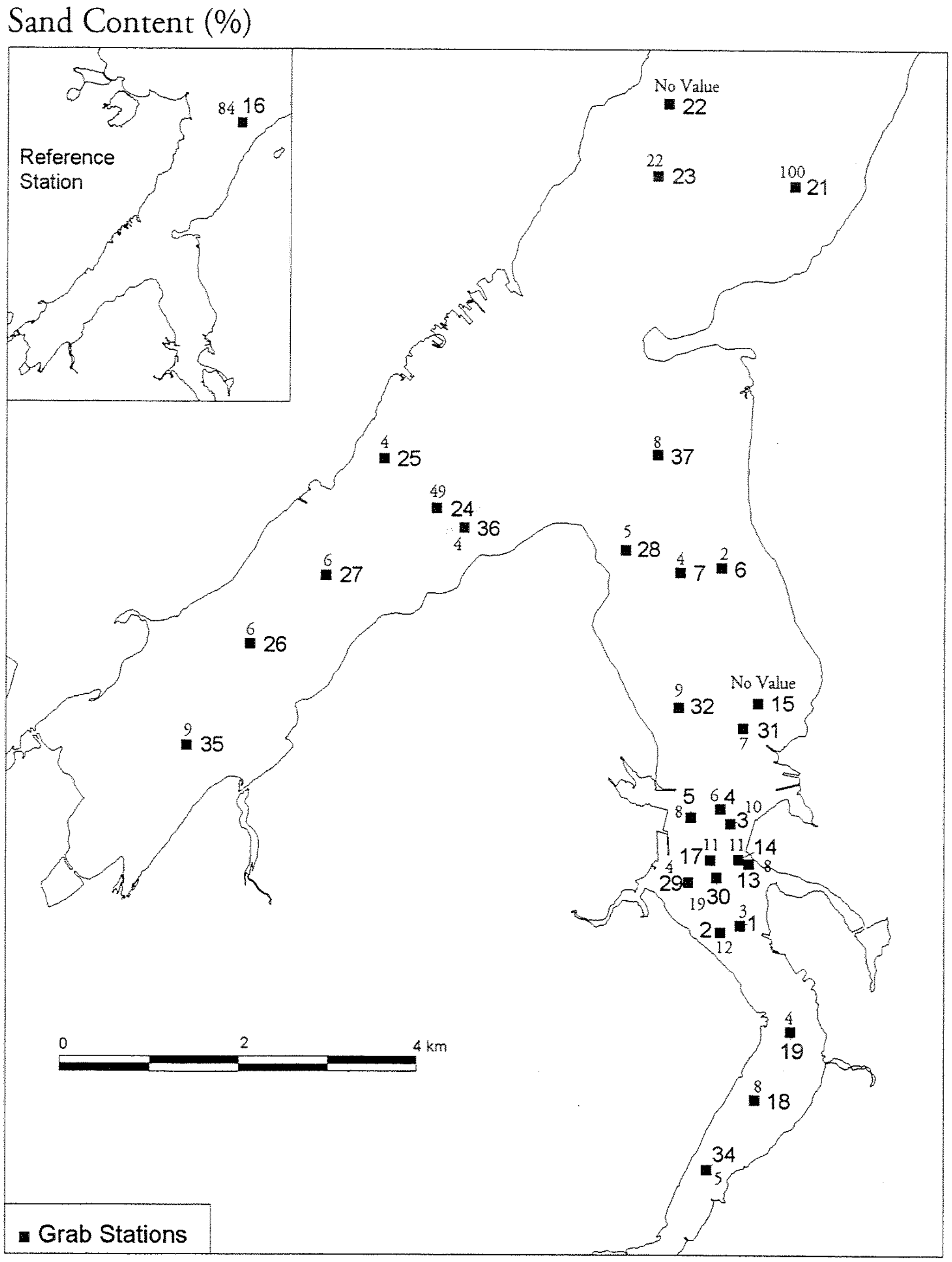


Figure 3. Sand content (%) in Sydney Harbour sediments, October 1999.

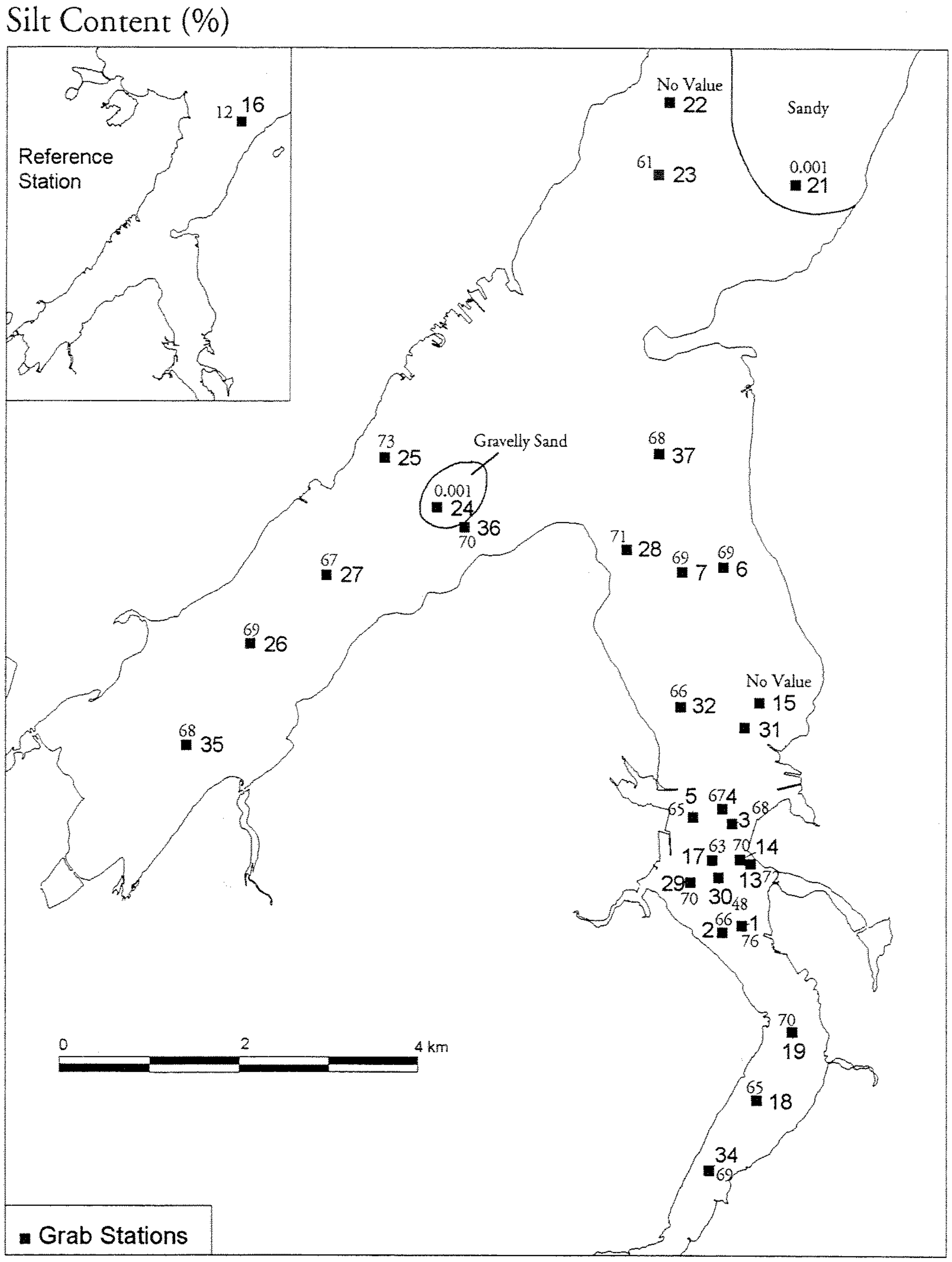


Figure 4. Silt content (%) in Sydney Harbour sediments, October 1999.

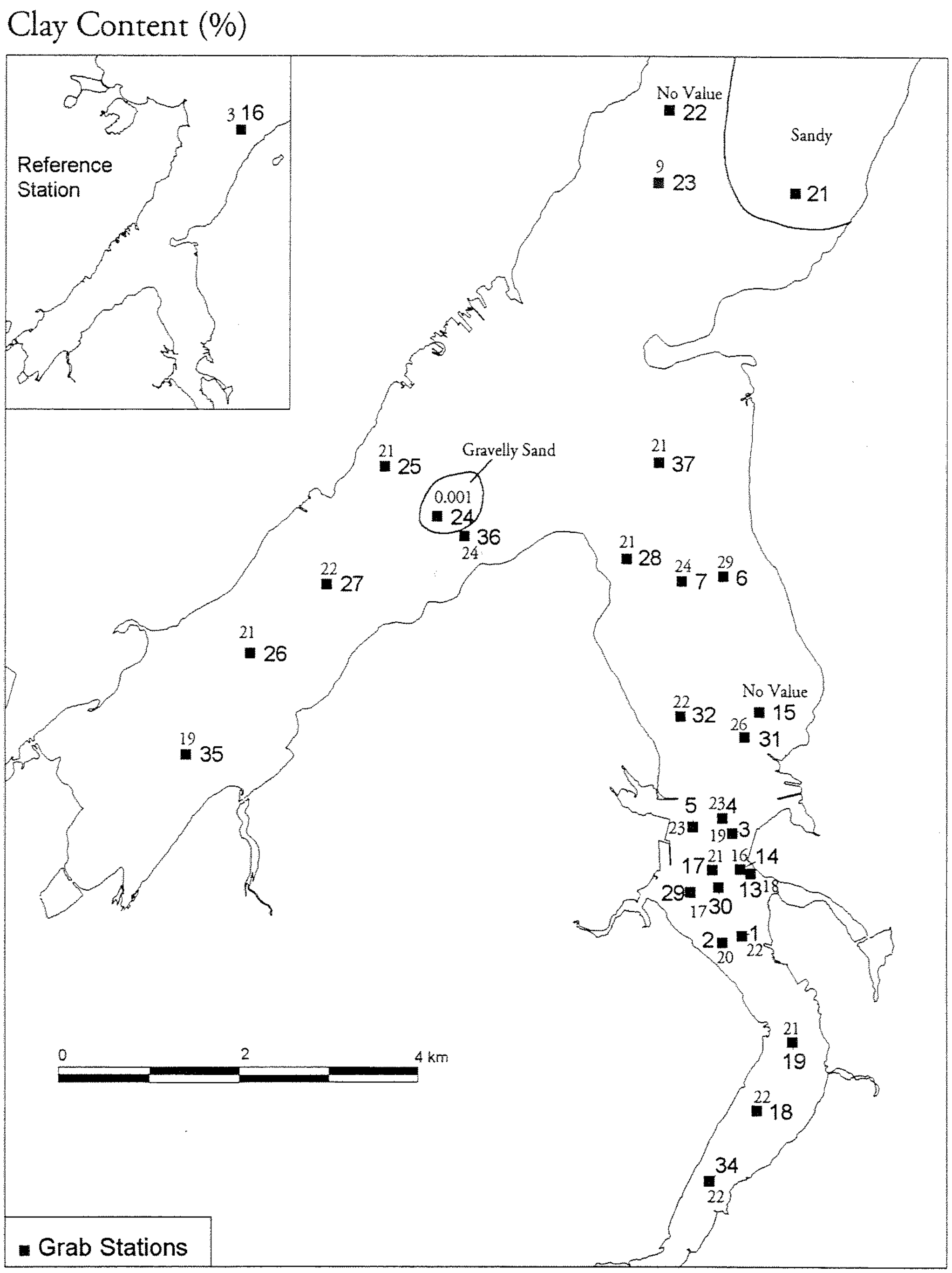


Figure 5. Clay content (%) in Sydney Harbour sediments, October 1999.

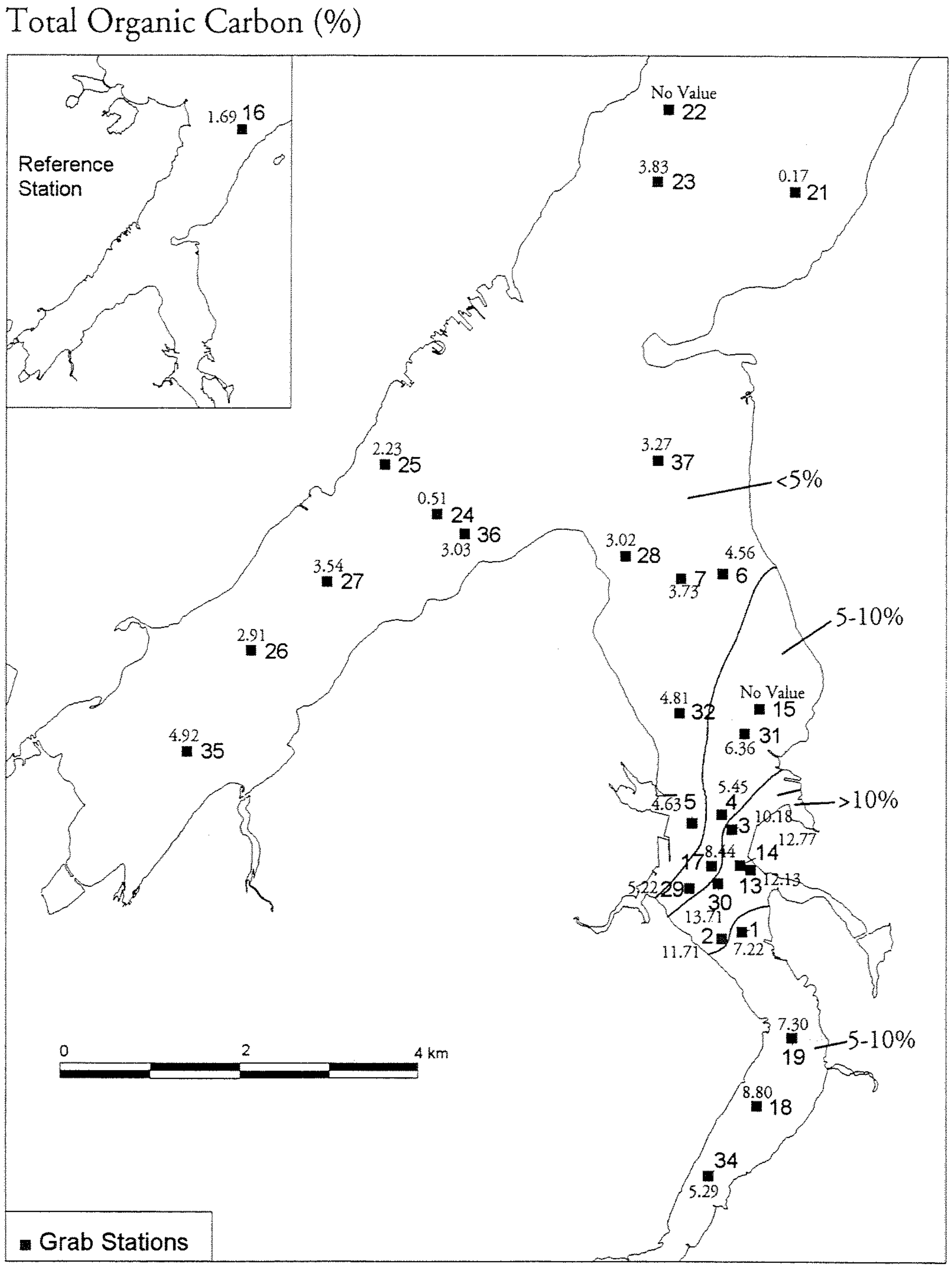


Figure 6. Total organic Carbon (TOC) content (%) in Sydney Harbour sediments, October 1999.

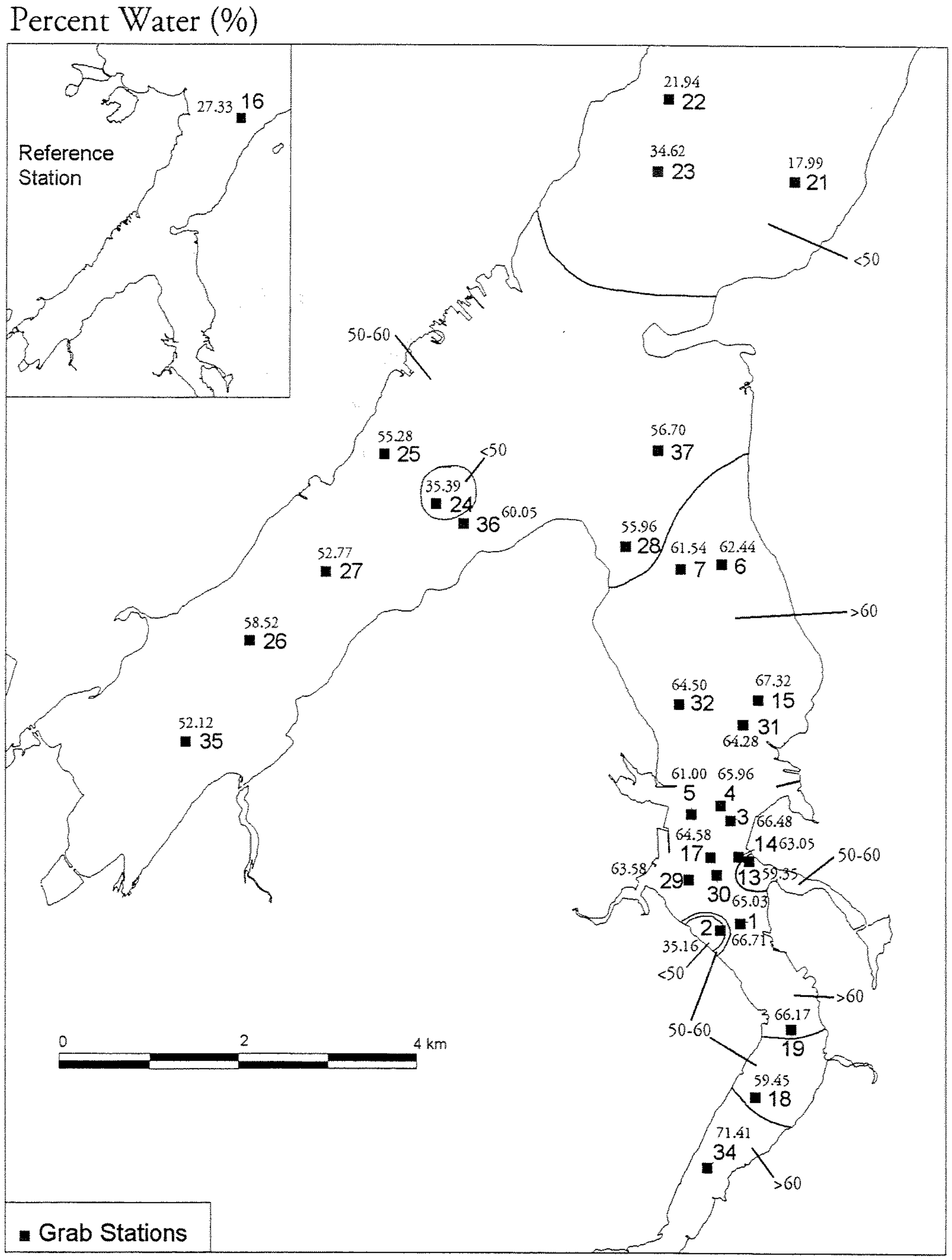


Figure 7. Water content (%) in Sydney Harbour sediments, October 1999.

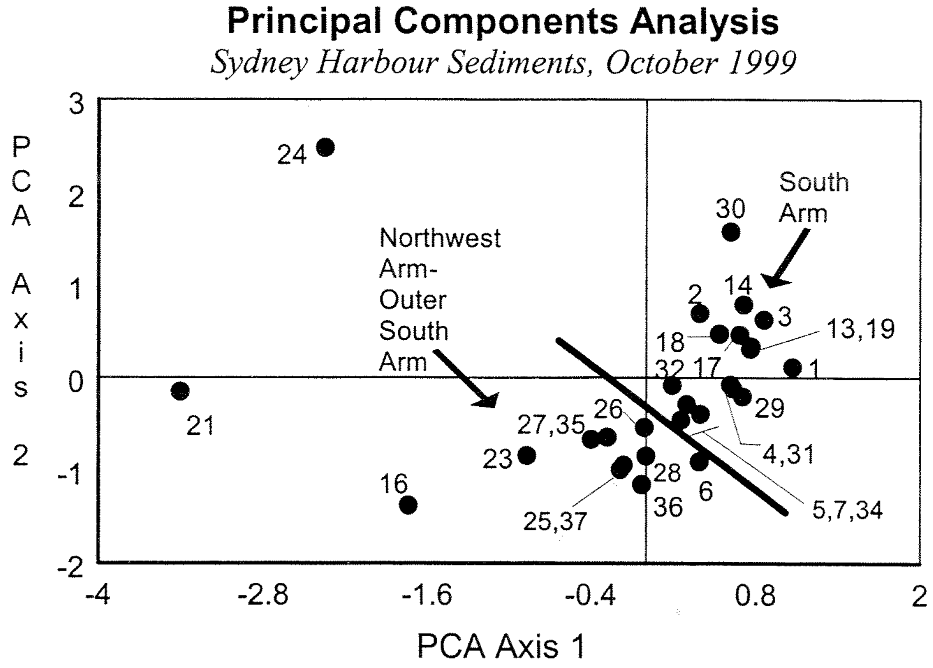
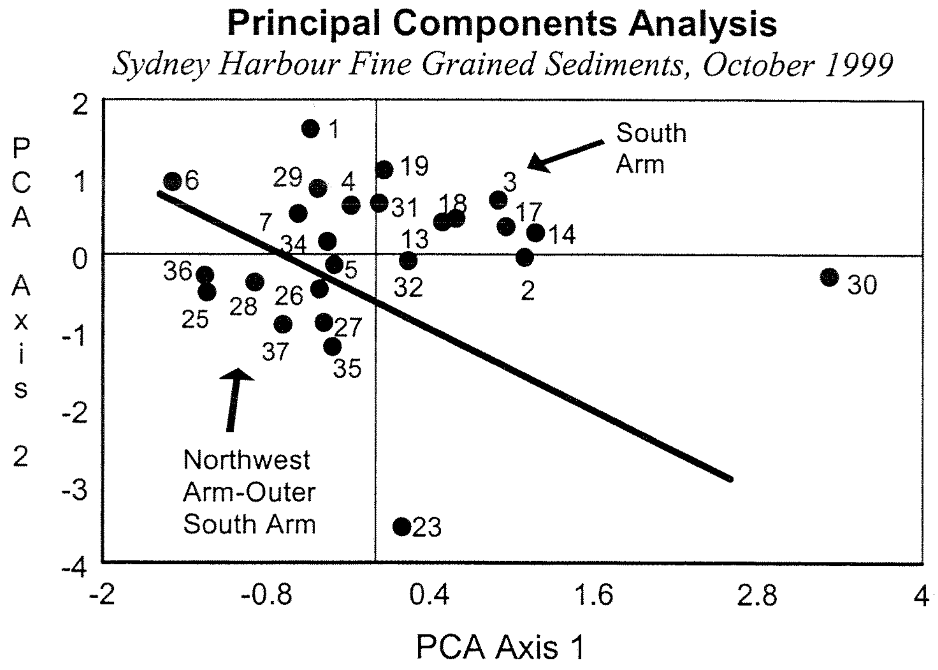


Figure 8. Plot of stations based on first two principal components from analyses of sediment grainsize parameters, TOC and water content of Sydney Harbour, Nova Scotia, October 1999.



Stations 15,16,21,22 & 24 omitted

Figure 9. Plot of stations having fine grained sediments (silt/clay) based on first two principal components from analysis of sediment grainsize parameters, TOC and water content, Sydney Harbour, Nova Scotia, October 1999. Stations having significant content of sand and gravel (Stations 15, 16, 21, 22 and 24) were not included.

TPAH (ug/g)

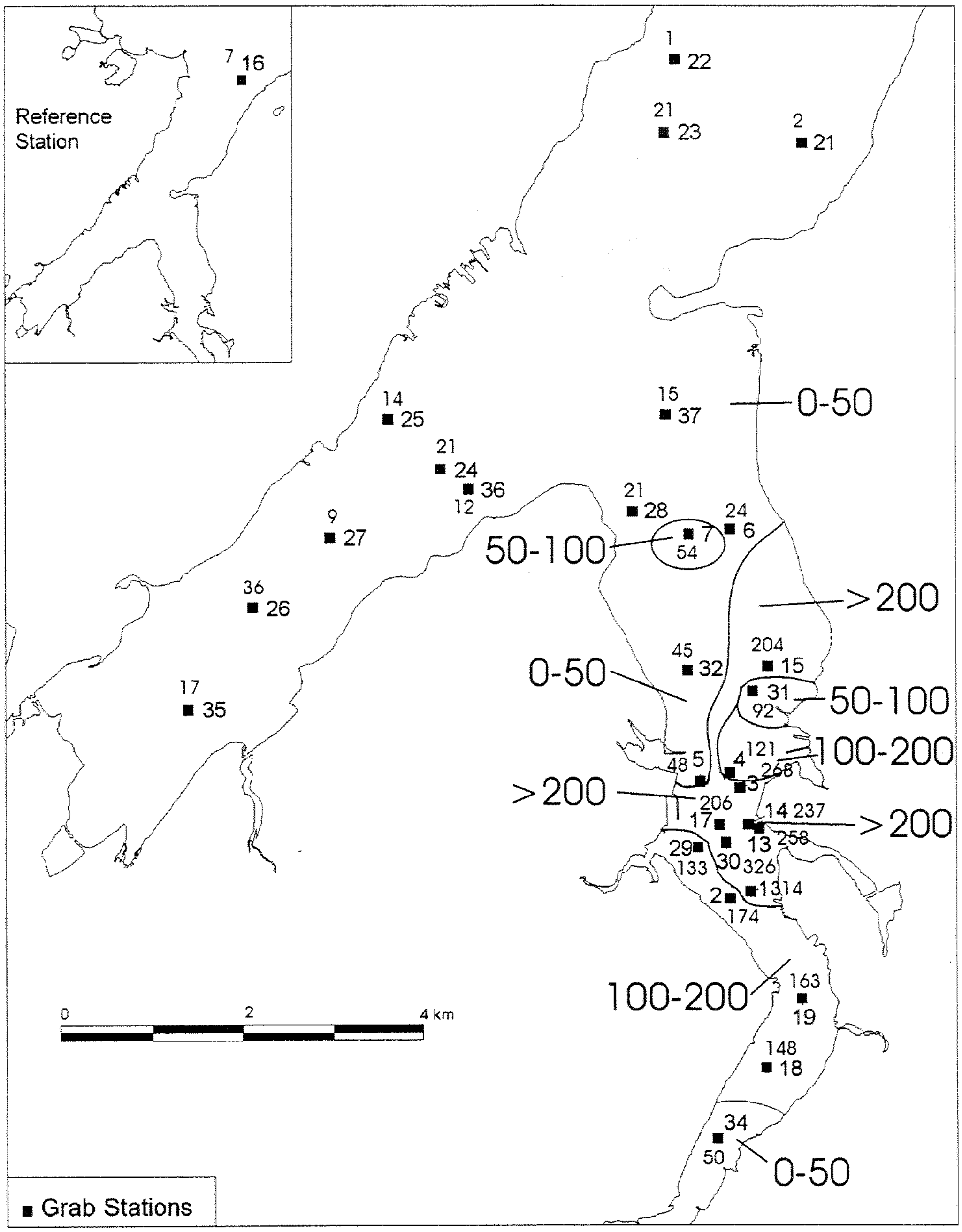


Figure 10. Concentrations of total polycyclic aromatic hydrocarbons (TPAH) (μg/g) in Sydney Harbour sediments, October 1999.

PCB's (ng/g)

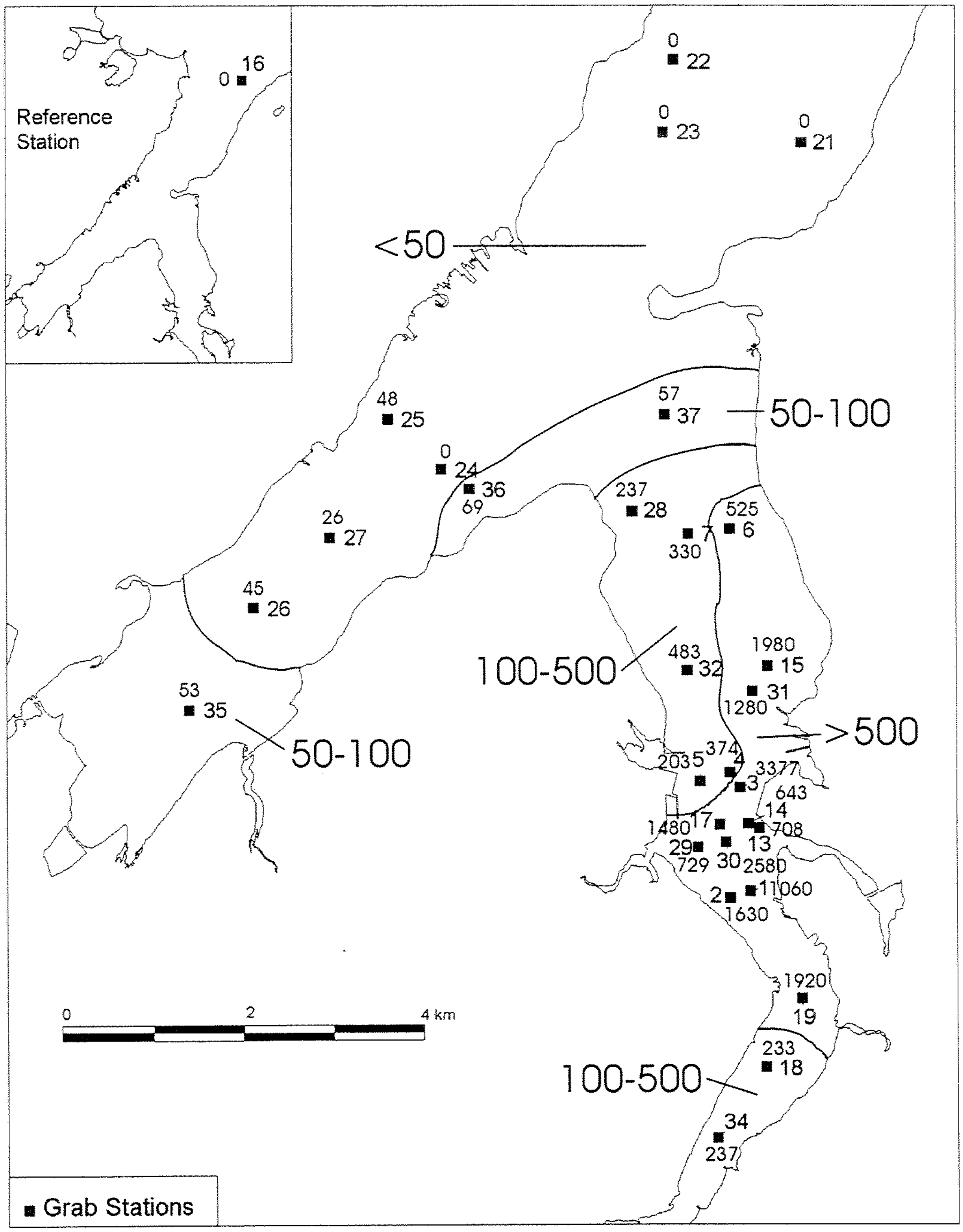


Figure 11. Concentration of polychlorinated biphenyls (PCBs) (ng/g) in Sydney Harbour sediments, October 1999.

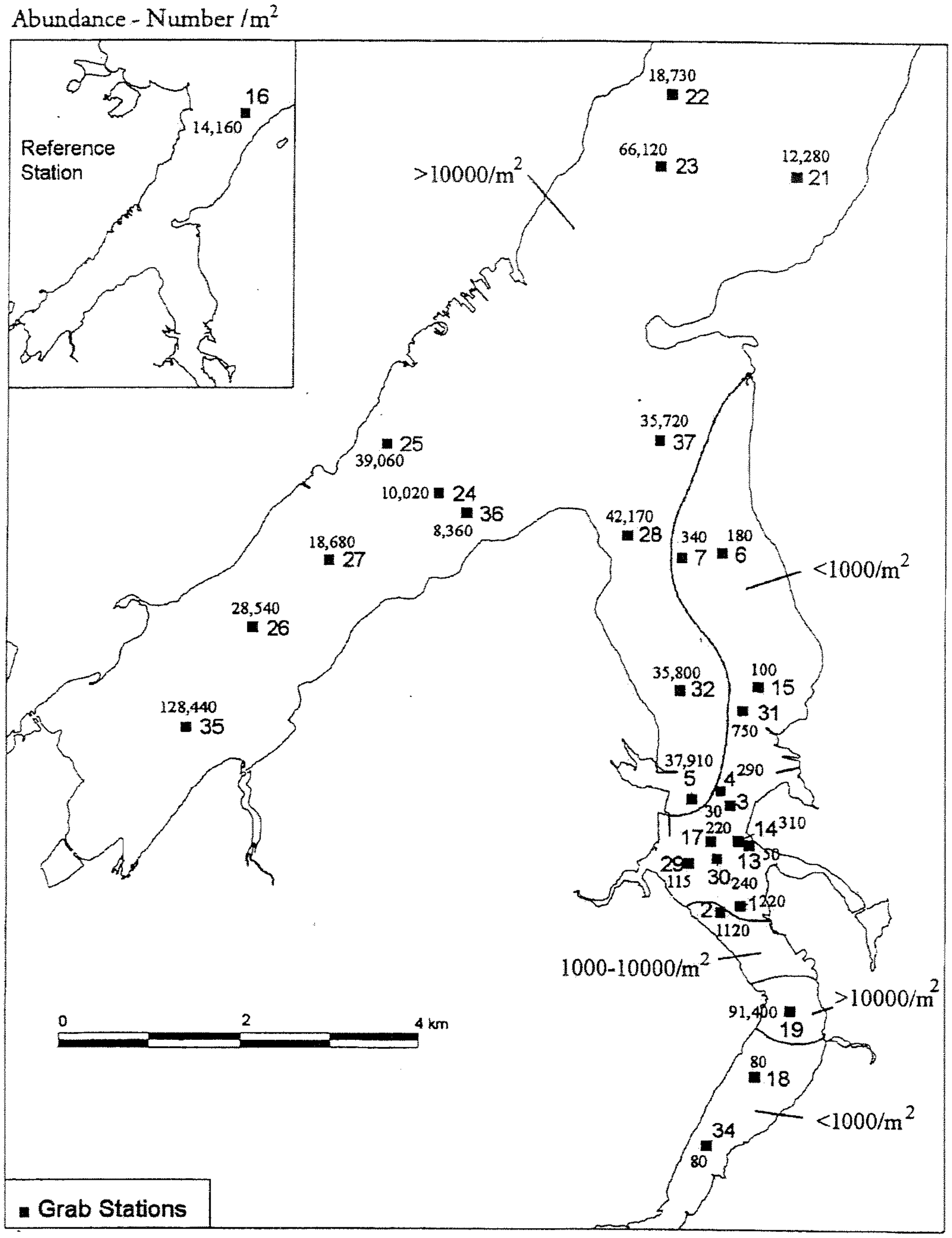


Figure 12. Abundance (number of organisms/m^2) of seabed communities in Sydney Harbour sediments, Cruise 99-072, October 1999.

Biomass (wet weight-grams/m²)

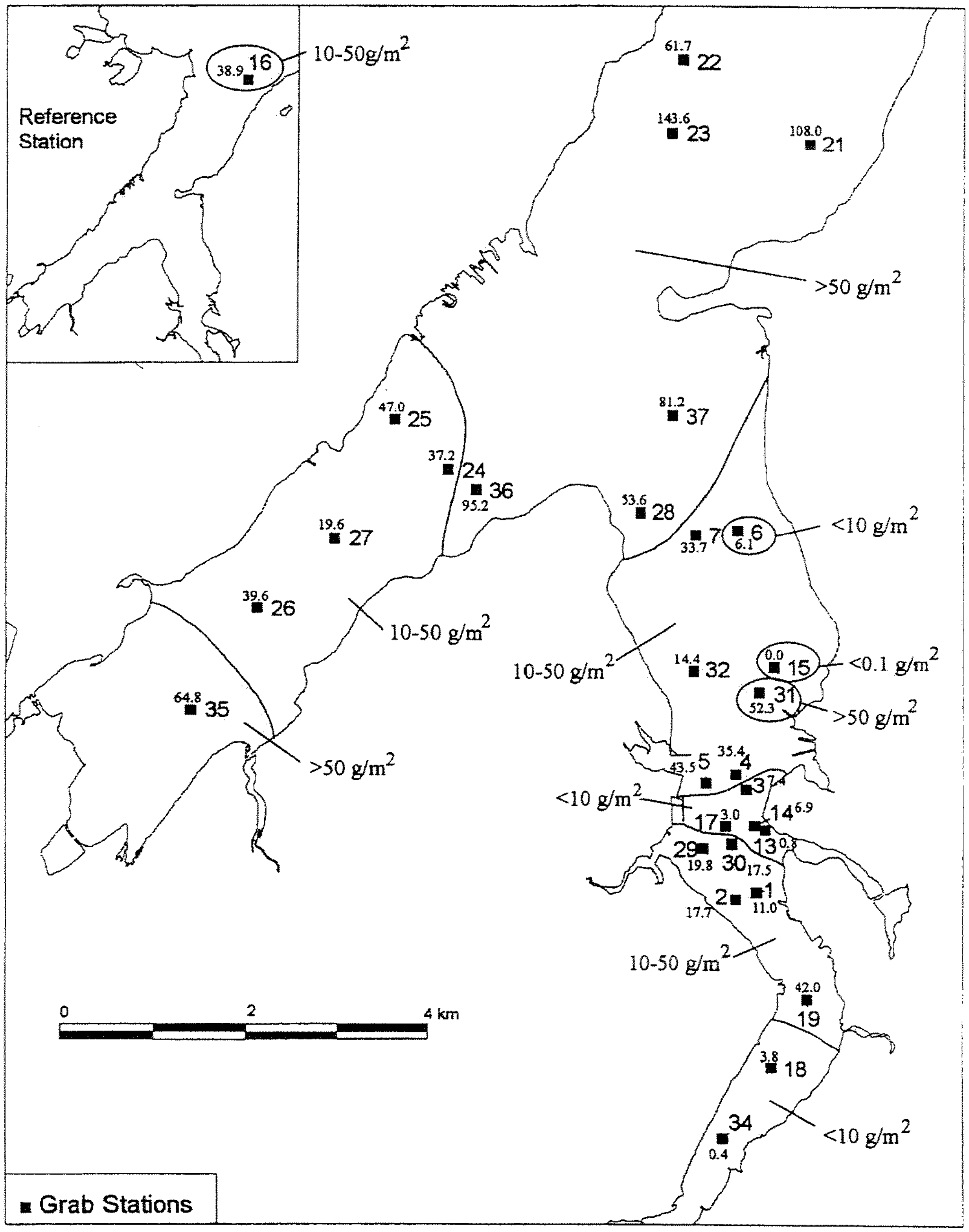


Figure 13. Biomass of seabed communities (g/m²) in Sydney Harbour Sediments, Cruise 99-072, October 1999.

Shannon-Wiener Diversity

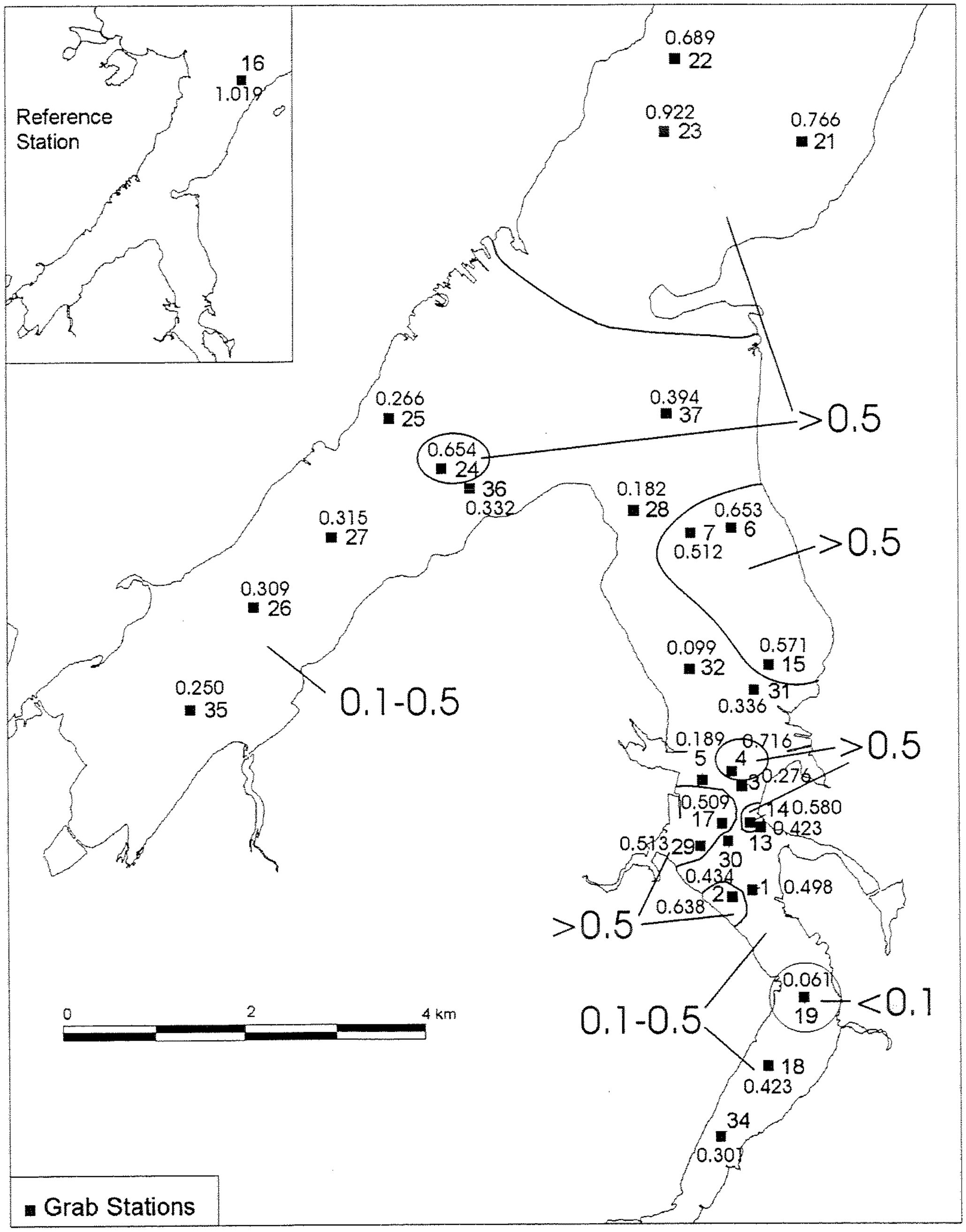


Figure 14. Shannon-Wiener Diversity ($\log_{10}$) of seabed communities in Sydney Harbour sediments, Cruise 99-072, October 1999.

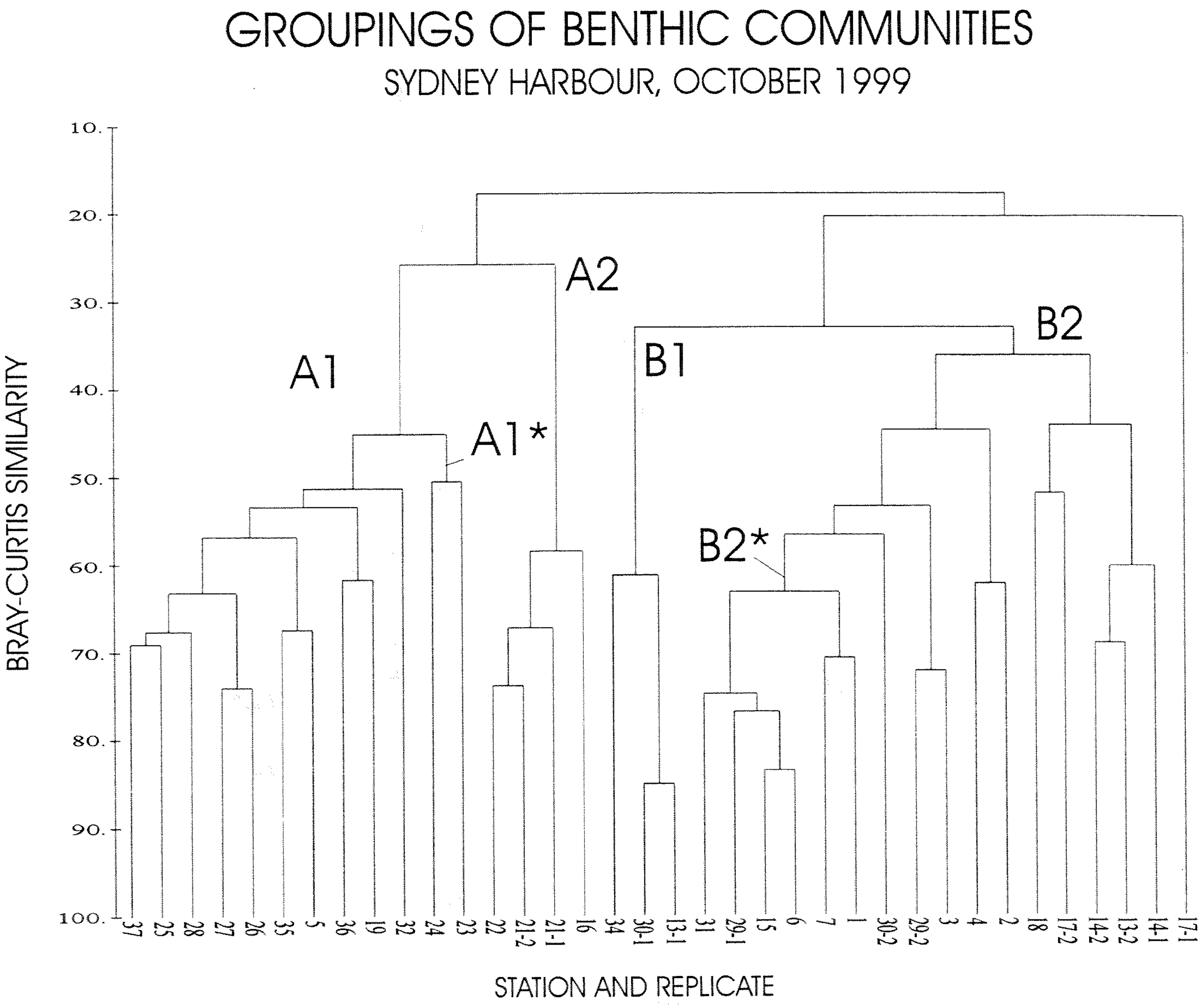


Figure 15. Similarity of seabed communities based on Bray Curtis Index of Similarity, Sydney Harbour, October 1999.

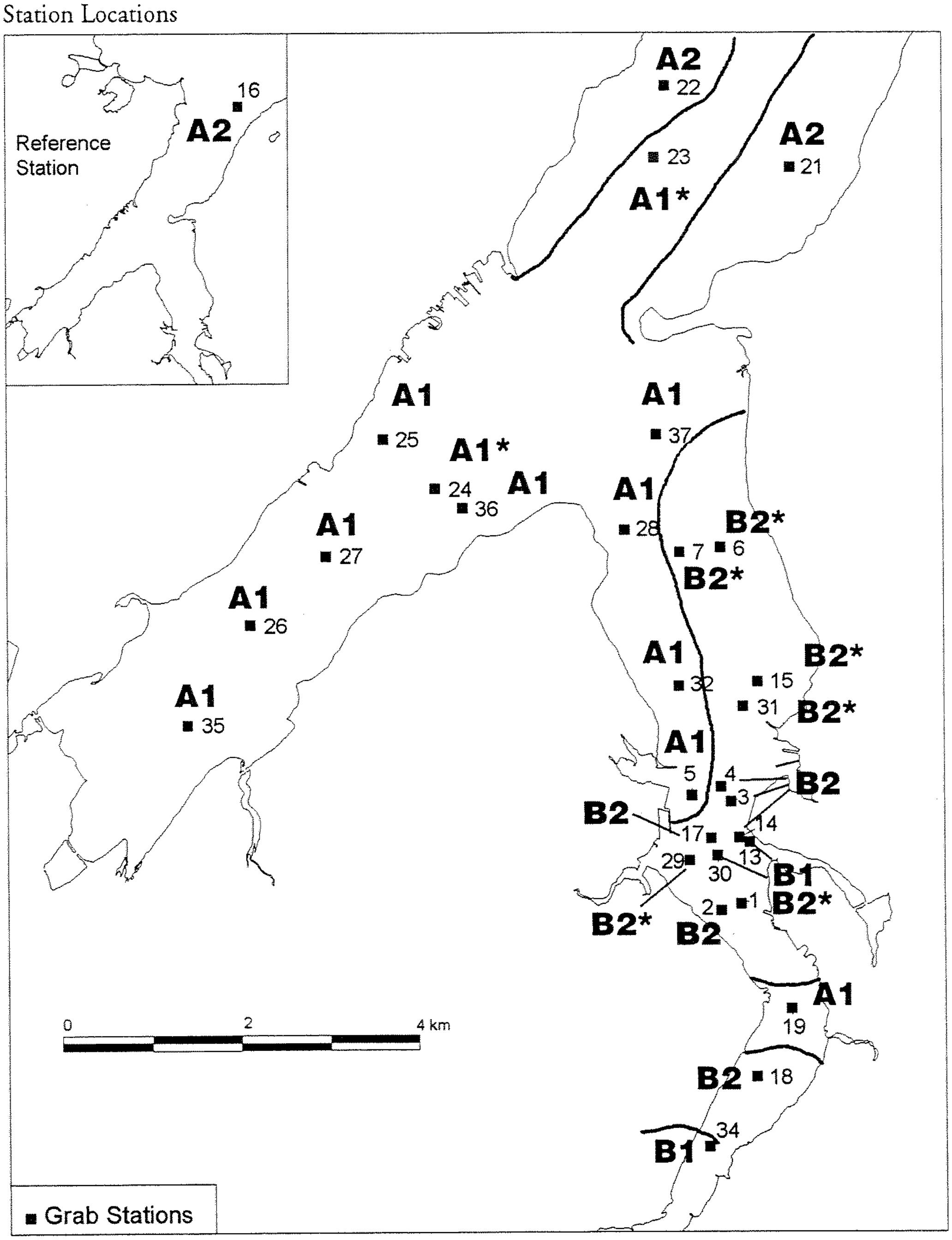


Figure 16. Distribution of biological communities in Sydney Harbour, Nova Scotia, based on Bray Curtis Index of Similarity. Letters indicate similar biological communities from cluster analysis in Figure 15.

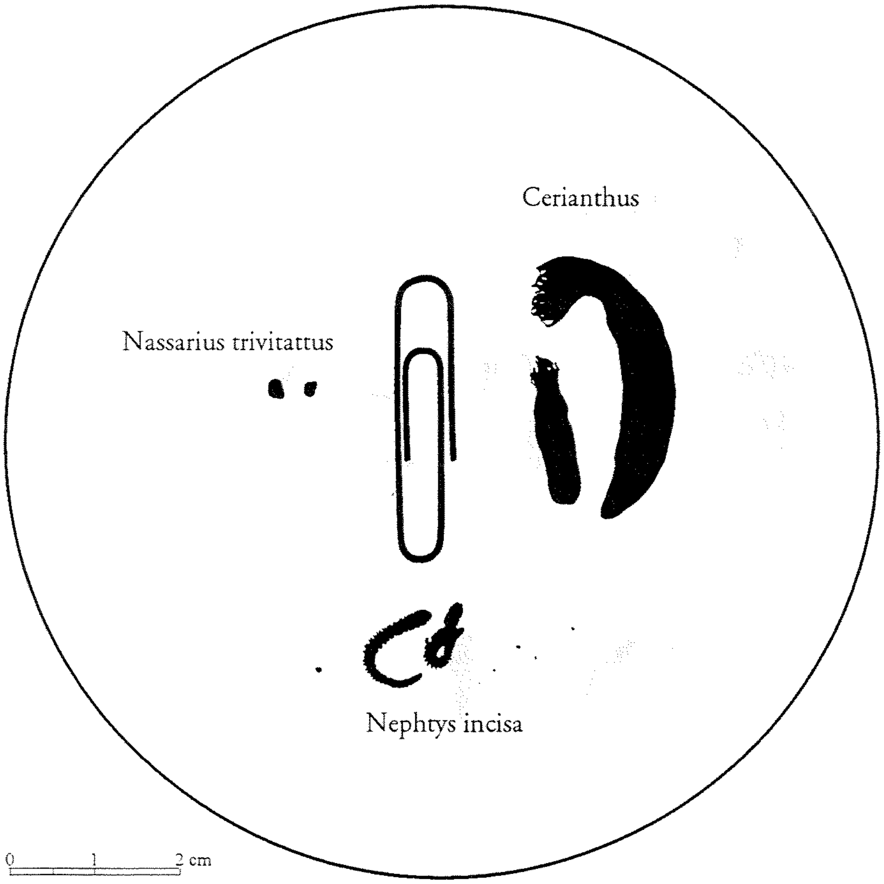


Figure 17a. Biological community at Station 14, off Muggah Creek, South Arm, Sydney Harbour, NS, October 1999.

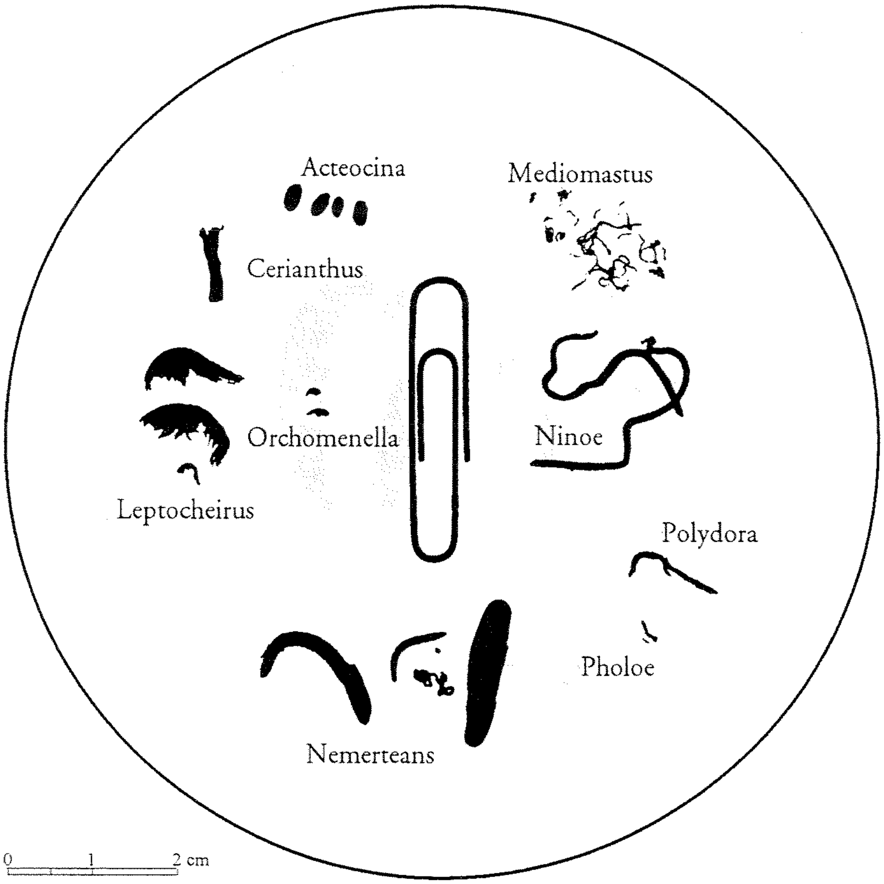


Figure 17b. Biological community at Station 5, South Arm, Sydney Harbour, NS, October 1999.

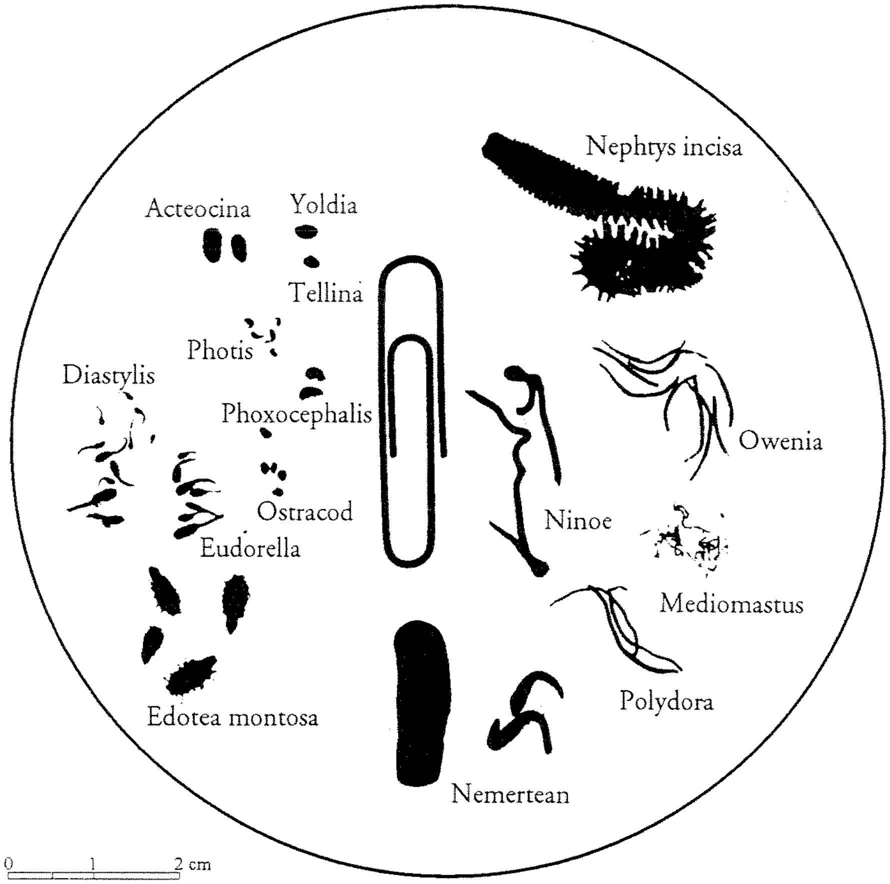


Figure 17c. Biological community at Station 23, Outer Sydney Harbour, Sydney Harbour, NS, October 1999.

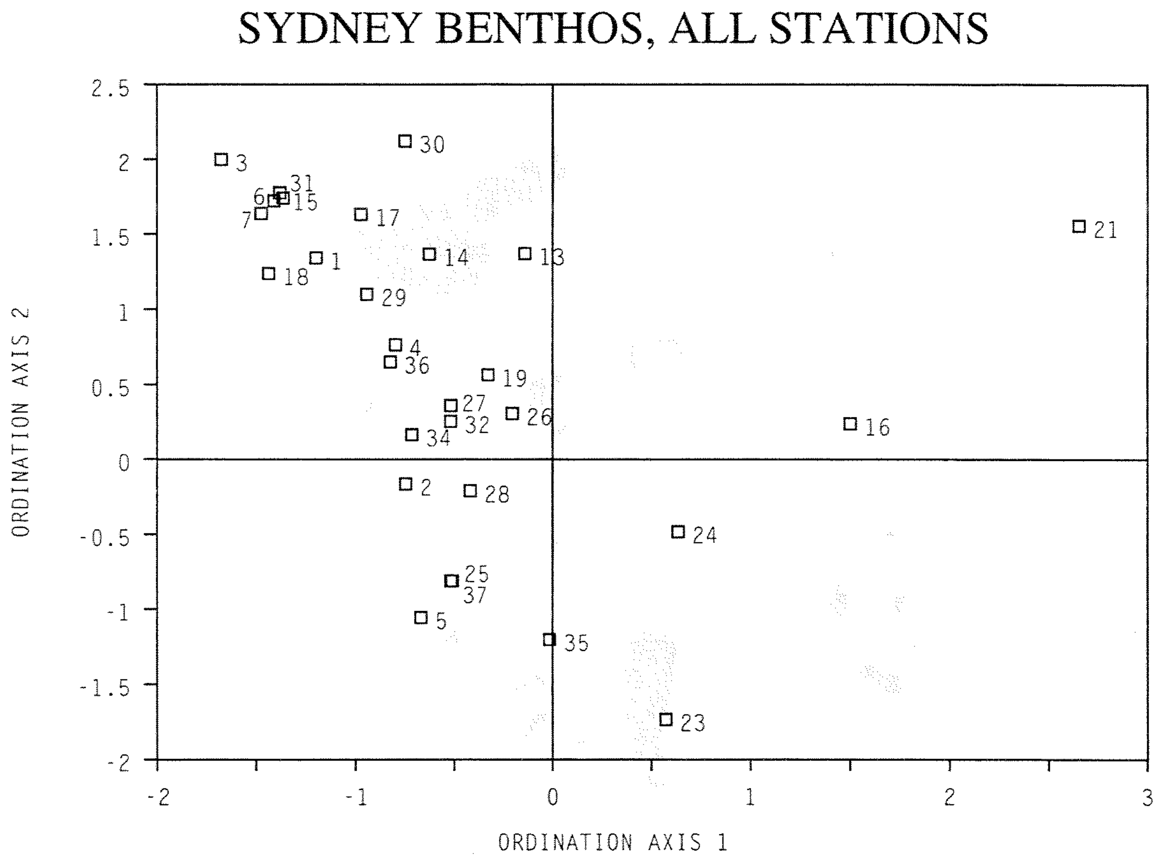


Figure 18a. Plot of stations on the first two axes of a canonical correspondence analysis (CCA), Sydney Harbour, NS, October 1999.

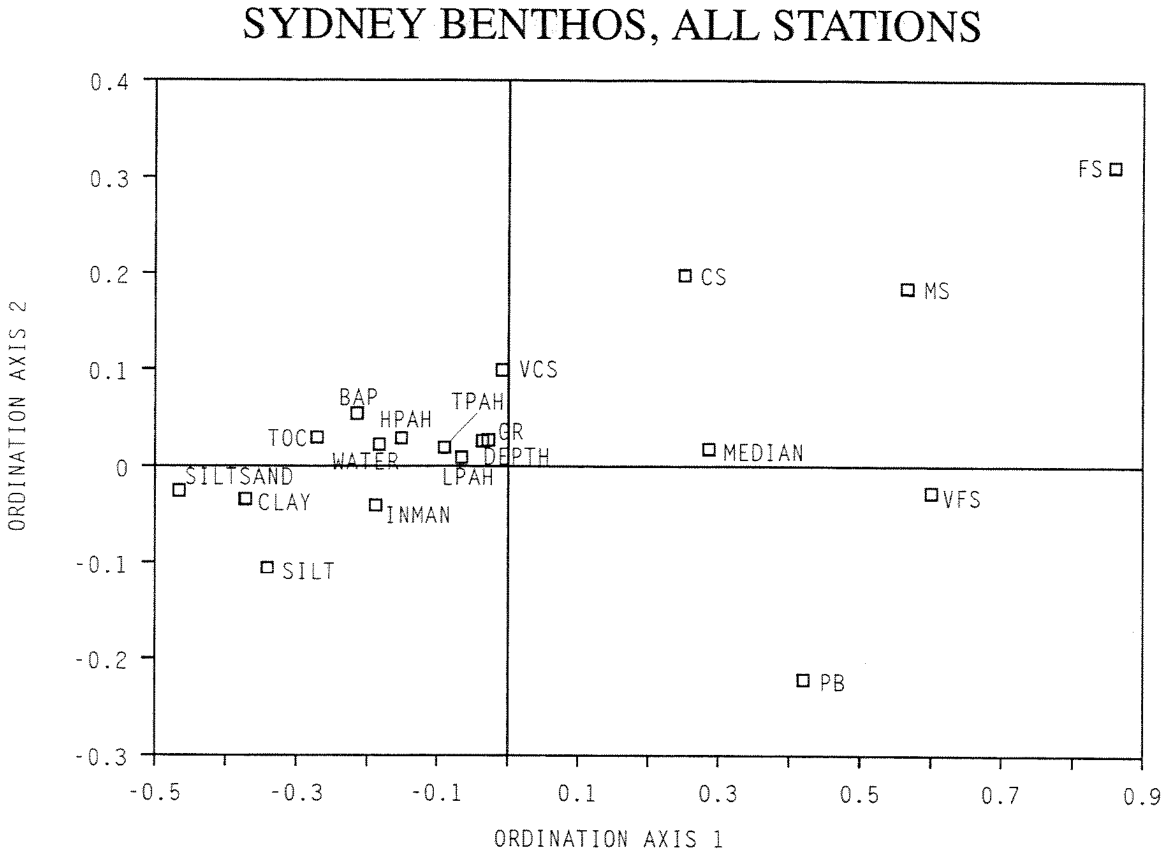


Figure 18b. Plot of environmental variables on the first two axes of a canonical correspondence analysis (CCA), Sydney Harbour, NS, October 1999.

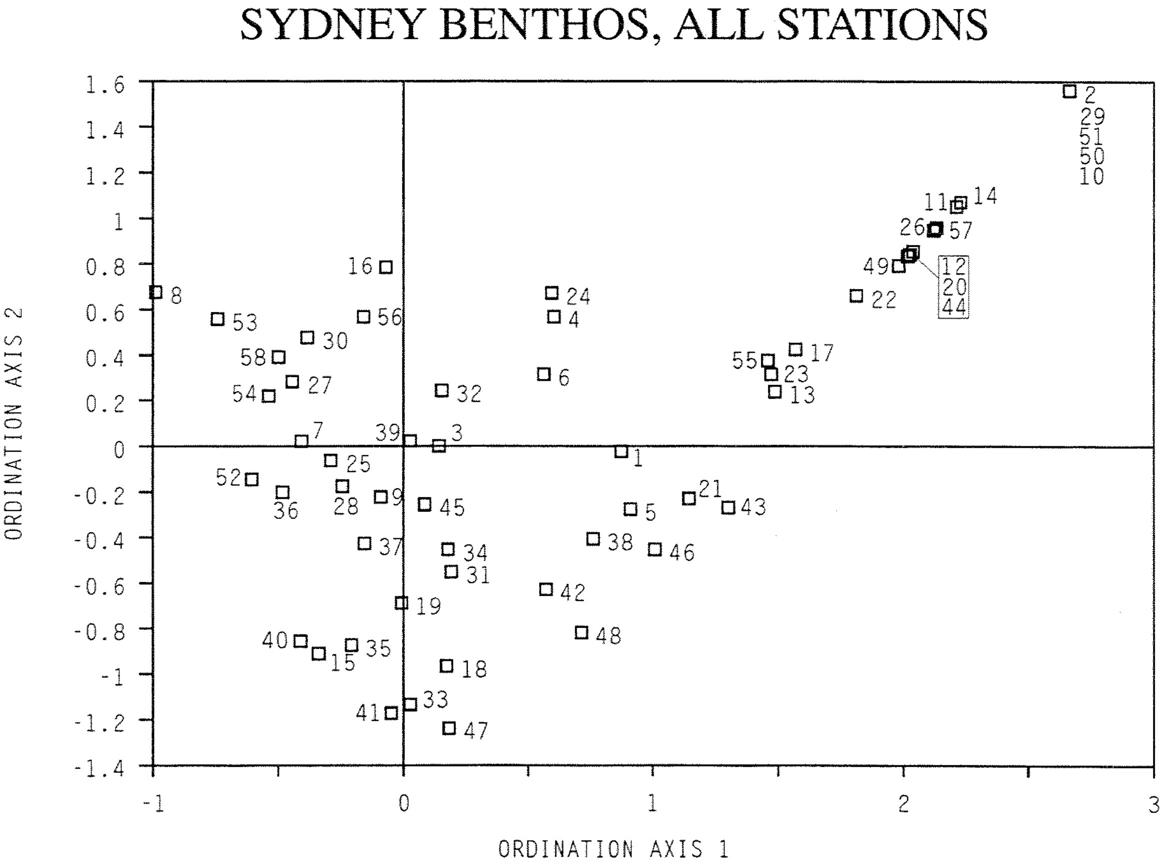


Figure 18c. Plot of species on the first two axes of a canonical correspondence analysis (CCA), Sydney Harbour, NS, October 1999.

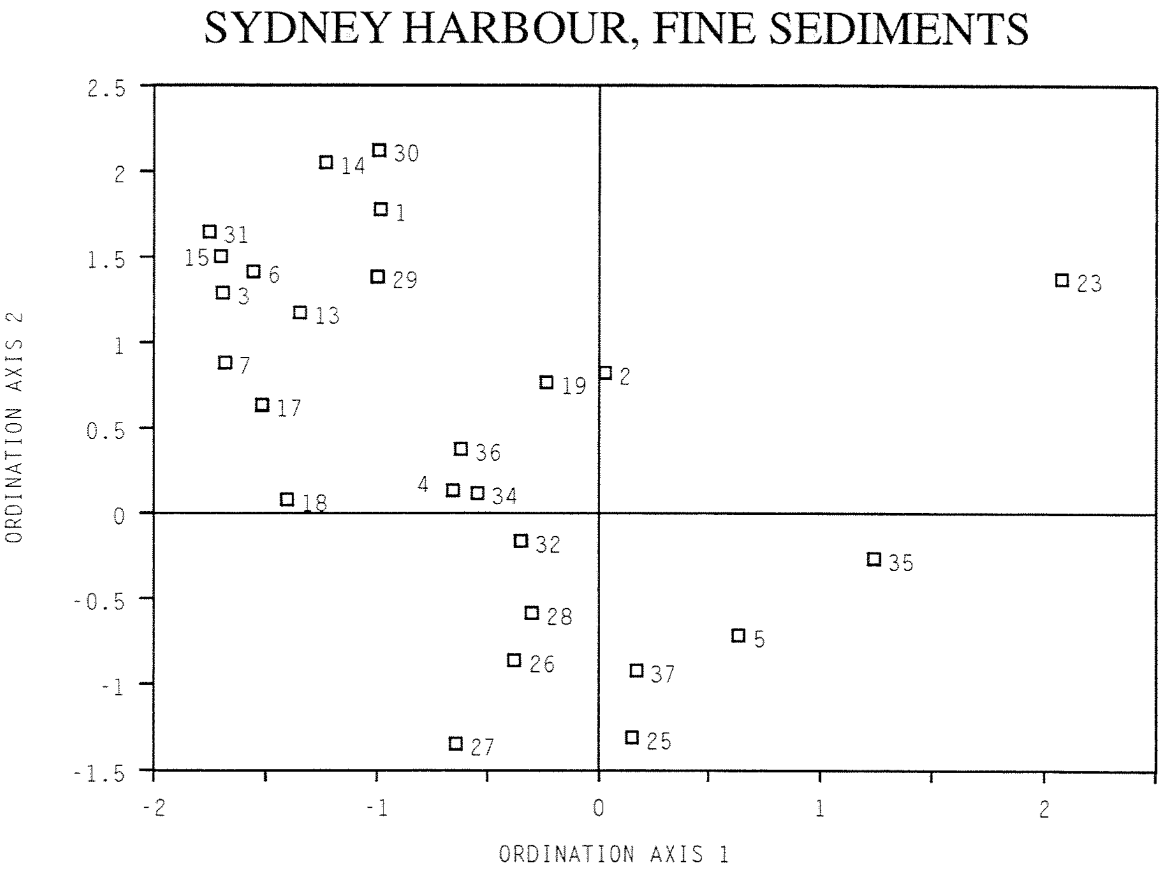


Figure 19a. Plot of stations on the first two axes of a canonical correspondence analysis (CCA), on stations having fine sediments (silt-clay only), Sydney Harbour, NS, October 1999.

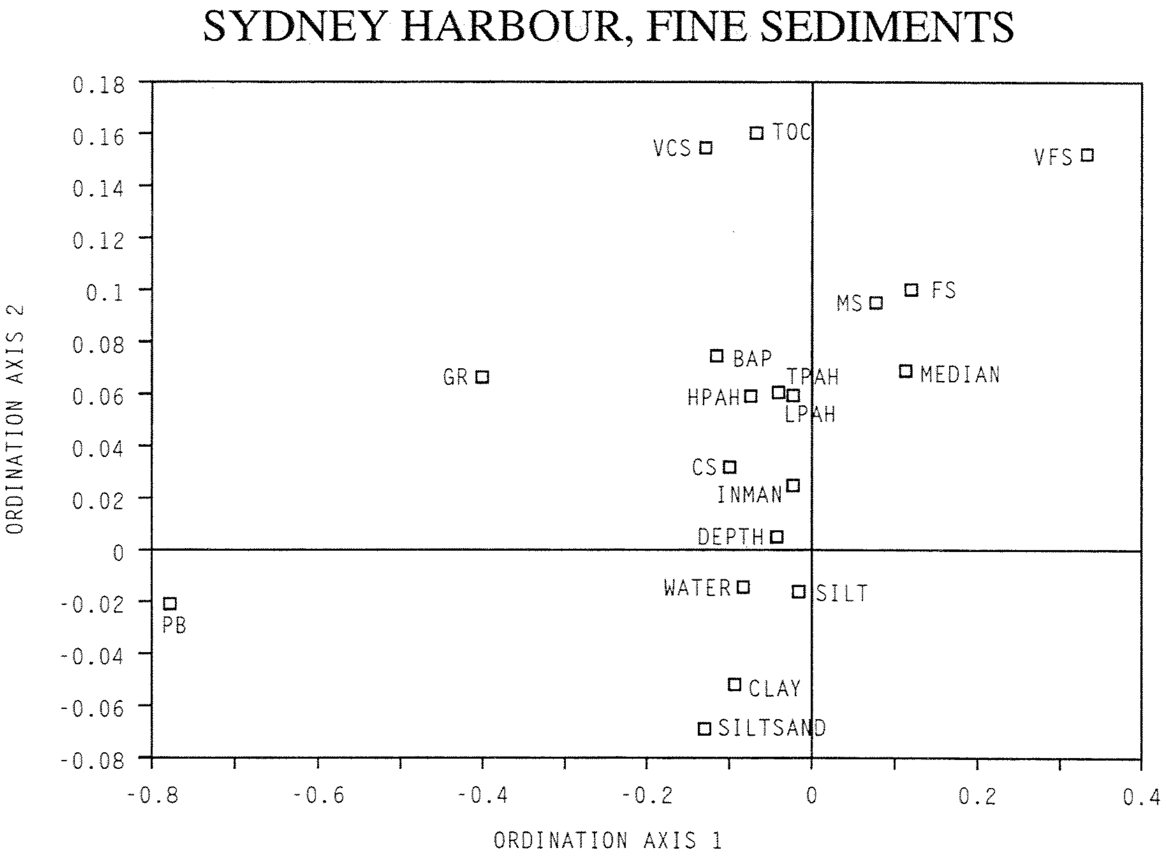


Figure 19b. Plot of environmental variables on the first two axes of a canonical correspondence analysis (CCA), on stations having fine sediments (silt-clay only), Sydney Harbour, NS, October 1999.

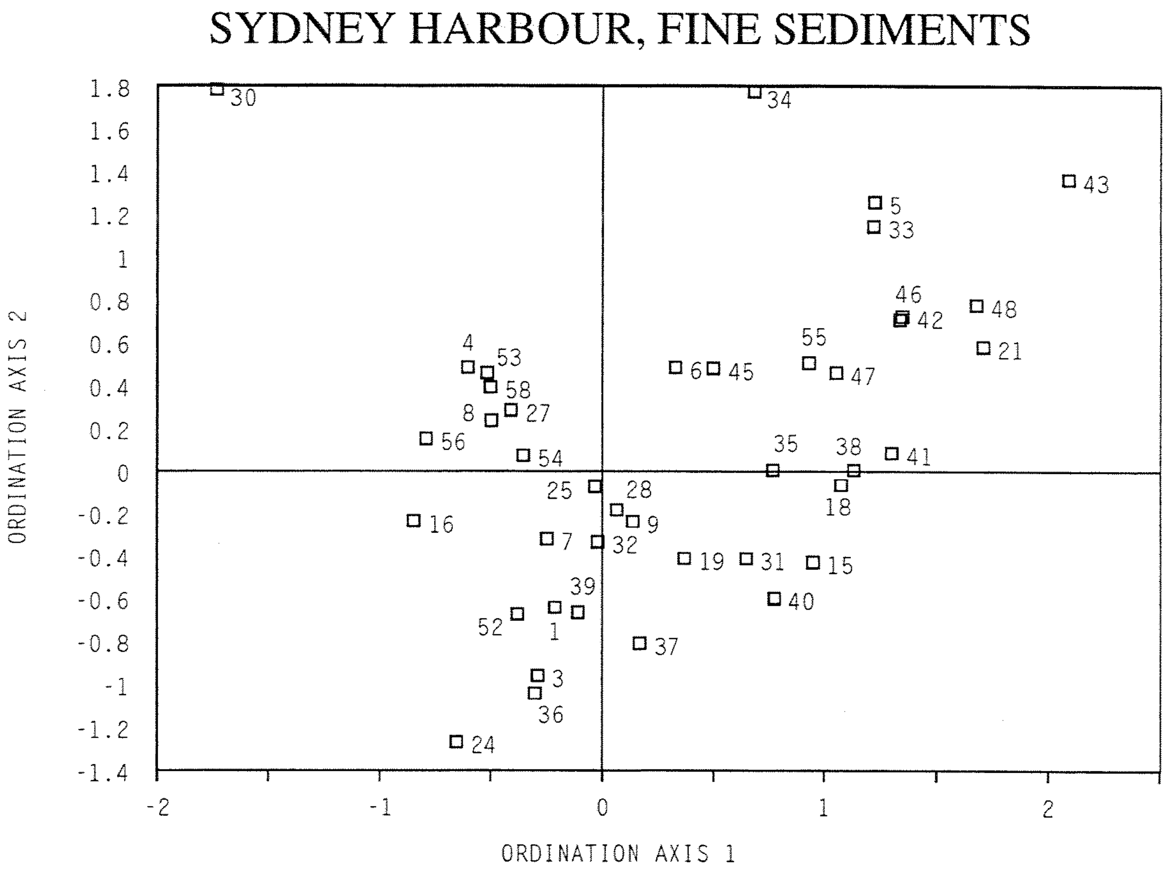


Figure 19c. Plot of species on the first two axes of a canonical correspondence analysis (CCA), on stations having fine sediments (silt-clay only), Sydney Harbour, NS, October 1999.

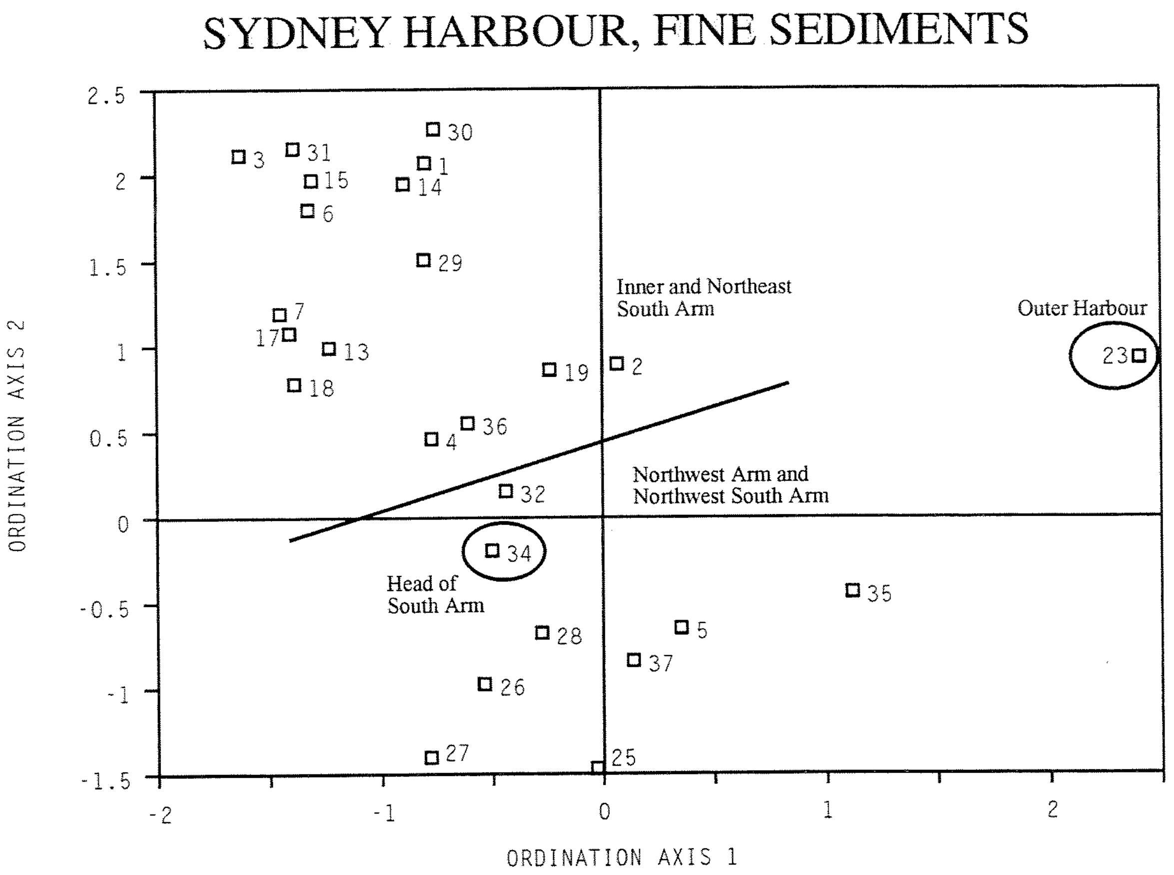


Figure 20a. Plot of stations on the first two axes of a canonical correspondence analysis (CCA) on stations having fine sediments (silt/clay) only, Sydney Harbour, NS, October 1999. In comparison to Figure 19a, this analysis used a reduced set of representative environmental variables (see Figure 20b).

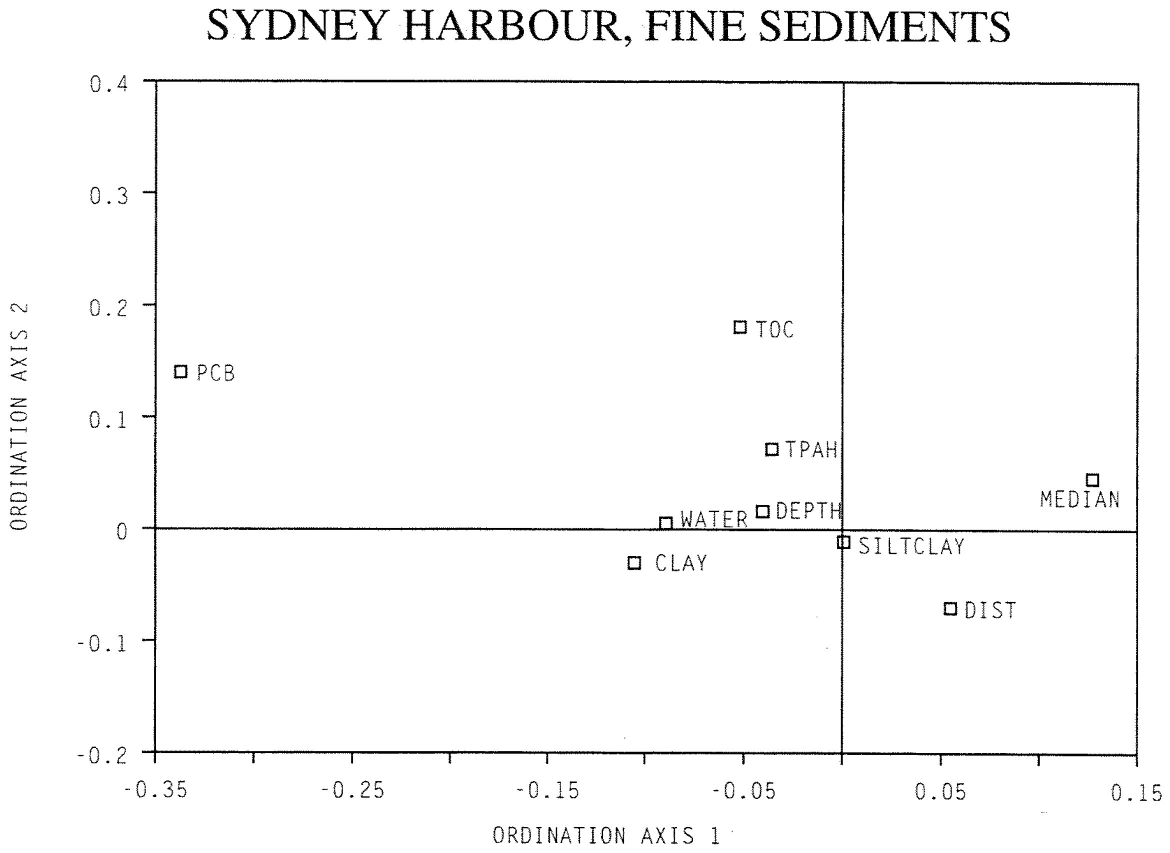


Figure 20b. Plot of environmental variables on the first two axes of a canonical correspondence analysis (CCA) on stations having fine sediments (silt/clay) only, Sydney Harbour, NS, October 1999. In comparison to Figure 19b, this analysis used a reduced set of representative environmental variables.

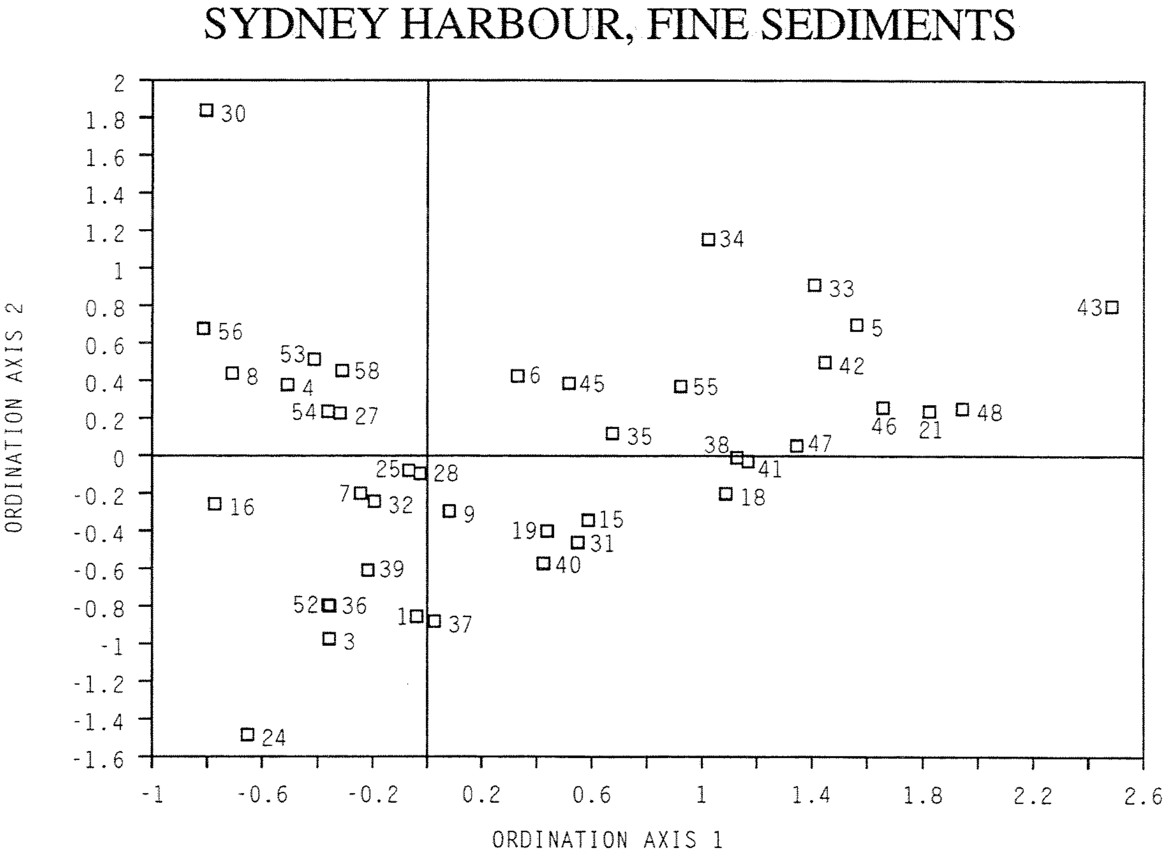


Figure 20c. Plot of species on the first two axes of a canonical correspondence analysis (CCA) on stations having fine sediments (silt/clay) only, Sydney Harbour, NS, October 1999. In comparison to Figure 19c, this analysis used a reduced set of representative environmental variables.

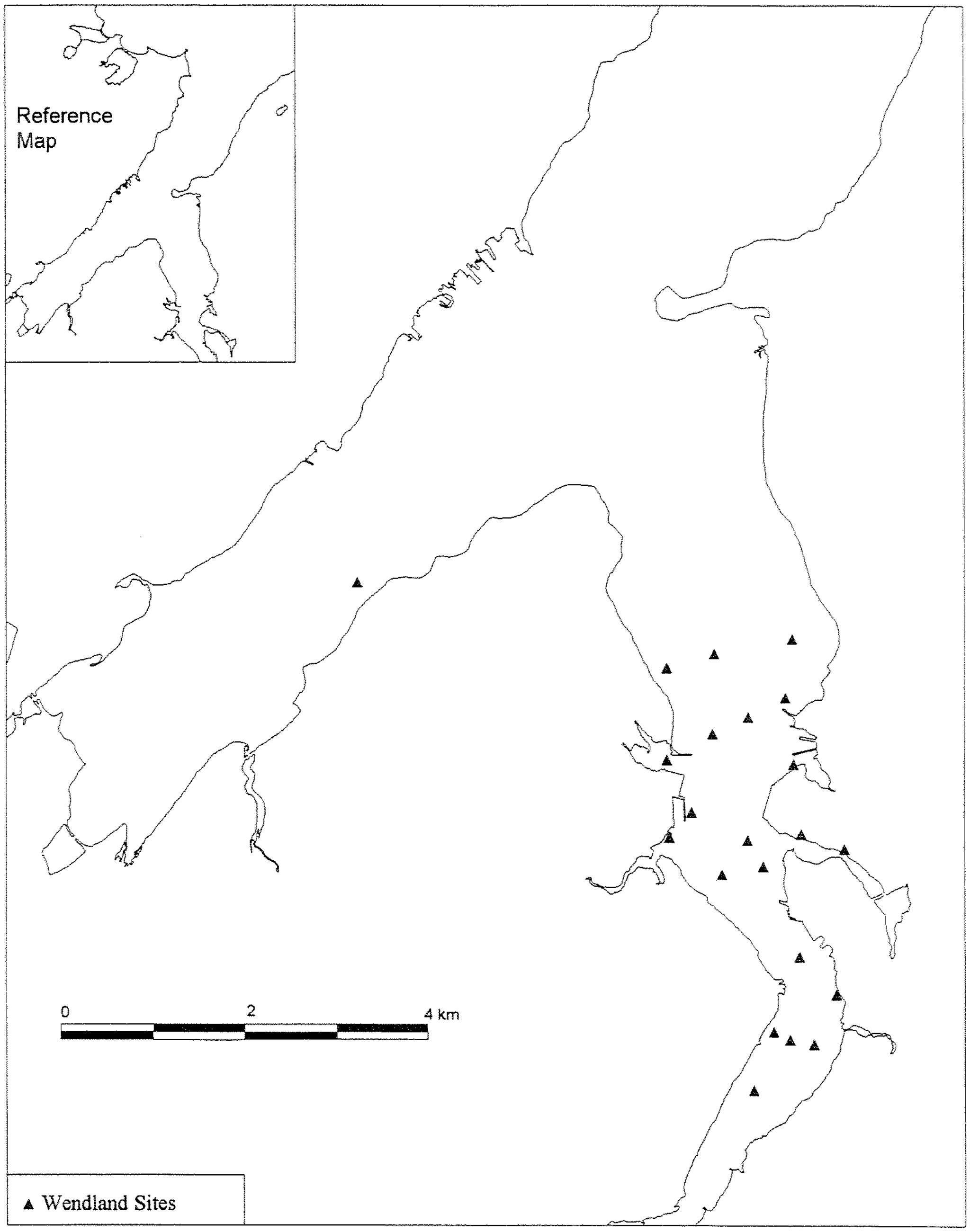


Figure 21. Stations assessed for biological communities in Sydney Harbour, November 1978, by Wendland (1979).

TABLES

Table 1. Station data for biological samples, Sydney Harbour, October 1999.

Station	Location		Distance from Mouth of Muggah Creek (km) [1]	Depth (m)
	Latitude	Longitude		
1	46 08.787	60 12.449	0.62	15.0
2	46 08.748	60 12.626	0.81	9.8
3	46 09.405	60 12.504	0.73	15.0
4	46 09.496	60 12.586	0.93	16.0
5	46 09.452	60 12.842	1.08	14.0
6	46 10.954	60 12.505	3.57	18.0
7	46 10.934	60 12.862	3.59	18.0
13	46 09.156	60 12.354	0.24	10.5
14	46 09.185	60 12.446	0.37	14.0
15	46 10.130	60 12.233	2.06	17.0
15A	46 10.036	60 12.057	2.06	—
16	46 14.986	60 10.609	12.14	16.0
17	46 09.189	60 12.868	0.65	16.0
18	46 07.730	60 12.373	2.52	12.0
19	46 08.136	60 12.045	1.79	12.0
21	46 13.254	60 11.768	8.75	9.2
22	46 13.778	60 12.836	8.93	8.0
23	46 13.343	60 12.950	8.15	12.0
24	46 11.374	60 14.971	6.20	9.0
25	46 11.687	60 15.409	6.86	12.0
26	46 10.585	60 16.641	8.59	13.0
27	46 10.987	60 15.950	7.61	14.0
28	46 11.082	60 13.337	4.02	13.0
29	46 09.057	60 12.881	0.87	14.0
30	46 09.082	60 12.641	0.56	16.0
31	46 09.981	60 12.365	1.77	18.0
32	46 10.119	60 12.913	2.14	15.0
34	46 07.320	60 12.810	3.44	8.0
35	46 09.987	60 17.222	9.84	9.5
36	46 11.249	60 14.737	5.95	21.0
37	46 11.655	60 13.024	4.98	16.0

[1] Measured by GIS on a digital hydrographic chart as the shortest distance by water using straight line segments.

Table 2. Sediment Grainsize Composition[1], Sydney Harbour, October 1999.

Station	Composition (%)												
	Pebble	Granule	Sand					Silt				Clay	
			Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Very Fine	Coarse	Medium
1	0.00	0.00	0.45	0.30	0.20	0.20	2.29	6.53	22.79	36.01	9.63	7.33	14.26
2	0.00	0.61	2.14	2.14	1.43	1.02	5.87	4.95	23.63	24.76	12.97	8.83	11.64
3	0.00	0.21	1.19	1.40	1.40	1.45	4.66	6.26	22.76	33.52	7.71	5.79	13.66
4	0.00	0.00	0.42	0.74	0.63	0.58	3.75	8.87	20.49	26.87	14.04	8.87	14.73
5	0.00	0.05	0.31	0.52	0.63	0.73	6.03	11.17	20.56	23.02	13.32	8.50	15.15
6	0.00	0.00	0.20	0.15	0.20	0.25	0.86	2.02	17.71	29.40	19.94	10.93	18.32
7	0.00	0.21	0.42	0.52	0.73	0.57	1.87	4.94	20.47	28.00	17.35	10.34	14.60
13-1 [2]	0.00	1.11	1.36	1.87	9.84	13.98	22.16	9.99	12.01	9.49	6.61	3.43	8.13
13-2 [3]	0.00	0.00	0.40	0.80	1.15	1.49	4.65	6.55	31.53	28.95	6.38	4.82	13.27
14-1	0.00	1.38	1.69	1.18	1.69	1.54	5.12	5.12	30.71	28.30	6.60	4.91	11.77
15 [4]	Not Determined												
15A [5]	69.44	13.92	6.96	4.39	2.87	1.21	1.21	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.05	0.05	0.51	9.22	75.24	6.78	3.29	1.47	0.76	0.51	2.13
17	0.00	0.16	0.64	1.91	2.22	1.69	5.13	5.56	21.86	26.47	11.96	8.26	14.13
18	0.00	0.48	1.80	1.54	1.01	0.74	2.86	3.50	21.36	35.98	7.90	6.36	16.48
19	0.00	0.27	0.90	0.80	0.59	0.74	0.69	9.41	25.85	30.64	7.93	6.44	15.74
21	0.00	0.00	0.70	7.12	25.38	46.14	20.66	0.00	0.00	0.00	0.00	0.00	0.00
22 [6]	Not Determined												
23	0.00	0.00	0.27	0.44	1.98	2.14	19.45	32.09	19.95	8.41	5.00	3.35	6.92
24	31.41	18.79	7.88	10.10	21.62	8.59	1.62	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.05	0.31	0.26	0.36	0.51	2.57	7.67	25.84	26.66	14.51	8.75	12.51
26	0.00	0.00	0.26	1.09	1.51	1.04	2.71	4.17	25.91	28.52	12.72	7.35	14.70
27	0.79	0.89	0.84	1.47	1.10	0.73	1.84	4.56	22.23	26.95	15.63	10.17	12.79
28	0.00	0.00	0.21	0.31	0.57	0.83	3.64	7.39	23.53	28.06	13.95	8.17	13.33
29	0.00	0.00	0.21	0.36	0.46	0.62	2.88	5.25	23.30	31.74	10.75	7.41	17.03
30	8.78	3.05	4.31	3.52	3.68	3.00	5.89	3.94	18.35	21.14	6.99	5.57	11.78
31	0.00	0.05	0.65	0.85	1.05	1.15	3.06	5.01	17.13	29.76	15.48	8.82	16.98
32	0.00	0.57	0.63	1.83	1.77	1.15	3.55	4.33	20.51	31.32	12.06	7.72	14.56
34	0.00	0.05	0.42	0.52	0.63	0.78	3.28	6.41	27.11	30.45	7.61	6.20	16.53
35	0.00	0.05	0.42	0.79	1.11	1.16	5.54	10.08	29.29	20.63	11.56	6.75	12.61
36	0.00	0.00	0.10	0.36	0.57	0.57	2.53	8.01	22.16	24.79	16.58	10.18	14.15
37	0.00	0.05	0.16	0.41	0.88	1.14	5.85	7.92	25.04	25.30	12.26	9.00	12.00

1. Wentworth Scale
2. Brownish, cohesive, silty mud at about 5 cm below surface
3. Surface layer (0-5 cm)
4. Bottom was a black ooze similar to other stations in the vicinity
5. Sample taken east of Station 15
6. Bottom was silty sand similar to that at Station 21

Table 3. Sediment Grainsize Parameters, Sydney Harbour, October 1999. N.D.= below detection limit. Benzo-pyrene (BaP); low molecular weight PAH (LMW); high molecular weight PAH (HMW); total PAH (TPAH).

Station	Median Grain Size (mm)	Inman Sorting	TOC (%)	Water Content (%)[3]	PAH (μg/g dry weight)[3]				PCB (ng/g dry weight)[4]
					BaP	LMW	HMW	TPAH	
1	0.011	1.69	7.22	66.71	30.73	75.31	238.65	313.95	1060
2	0.012	2.27	11.71	35.16	17.15	45.74	128.28	174.02	1630
3	0.013	1.99	10.18	66.48	24.65	78.43	189.66	268.09	3377
4	0.011	1.86	5.45	65.96	10.65	38.07	82.55	120.62	374
5	0.012	1.99	4.63	61.00	4.20	14.35	33.39	47.74	203
6	0.008	1.56	4.56	62.44	1.88	7.58	15.97	23.56	525
7	0.009	1.72	3.73	61.54	3.88	20.51	33.36	53.87	330
13-1[1]	0.063	2.56	Not Determined						
13-2[2]	0.014	1.82	12.13	59.35	22.47	76.77	181.43	258.20	708
14	0.015	2.10	12.77	63.05	18.66	93.42	143.05	236.47	643
15	4.857	1.08	5.65	67.32	19.62	51.14	152.50	203.64	1980
16	0.086	0.75	1.69	27.33	0.10	5.71	1.15	6.87	ND
17	0.012	2.15	8.44	64.58	19.25	64.41	142.01	206.42	1480
18	0.011	2.09	8.80	59.45	11.80	55.25	92.43	147.68	233
19	0.012	1.81	7.30	66.17	17.22	38.86	124.44	163.30	1920
21	0.194	0.95	0.17	17.99	0.02	1.37	0.21	1.59	ND
22	Not Determined			21.94	0.02	1.04	0.14	1.18	ND
23	0.036	1.78	3.83	34.62	0.24	17.57	3.66	21.23	ND
24	2.015	1.88	0.51	35.39	1.31	8.04	12.44	20.48	ND
25	0.011	1.69	2.23	55.28	0.66	7.44	6.26	13.70	48
26	0.011	1.85	2.91	58.52	1.96	15.89	19.80	35.69	45
27	0.010	2.04	3.54	52.77	0.44	5.31	4.13	9.43	26
28	0.011	1.76	3.02	55.96	1.42	8.42	12.34	20.76	237
29	0.011	1.80	5.22	63.58	12.82	38.16	95.02	133.18	729
30	0.019	3.89	13.71	65.03	32.01	94.36	231.63	326.00	2580
31	0.010	1.91	6.36	64.28	8.23	26.75	65.15	91.90	1280
32	0.011	2.06	4.81	64.50	3.93	12.93	32.06	44.99	483
34	0.012	1.87	5.29	71.41	4.28	16.53	33.38	49.91	237
35	0.015	1.91	4.92	52.12	0.85	8.42	8.63	17.05	53
36	0.010	1.75	3.03	60.05	0.59	6.95	5.21	12.16	69
37	0.012	1.84	3.27	56.70	0.76	8.48	6.81	15.29	57

1. Brownish, cohesive, silty mud at about 5 cm below surface.
2. Surface layer (0-5 cm).
3. Bulk water content determined during organic contaminant analysis, supplied by G. Tremblay, DFO, IML.
4. Data from T. King.

Table 4a. Pearson correlations between sediment characteristics, contaminants and depth, Sydney Harbour, October, 1999. N=28. Bold correlations are significant ($p<0.05$).

	PB	GR	VCS	CS	MS	FS	VFS	SILT	CLAY	TOC	MEDIAN	INMAN	SILT/ SAND RATIO	WATER	BAP	LMW	HMW	TPAH	PCB	DEPTH
PB	1.000																			
GR	**0.933**	1.000																		
VCS	**0.839**	**0.916**	1.000																	
CS	**0.710**	**0.743**	**0.807**	1.000																
MS	**0.611**	**0.584**	**0.592**	**0.917**	1.000															
FS	0.230	0.165	0.205	**0.632**	**0.842**	1.000														
VFS	-0.114	-0.185	-0.221	-0.091	0.126	**0.513**	1.000													
SILT	**-0.583**	**-0.511**	**-0.445**	**-0.711**	**-0.866**	**-0.874**	**-0.500**	1.000												
CLAY	**-0.522**	**-0.469**	**-0.407**	**-0.654**	**-0.841**	**-0.858**	**-0.562**	**0.946**	1.000											
TOC	-0.188	-0.067	0.186	-0.172	**-0.441**	**-0.504**	-0.269	**0.585**	**0.535**	1.000										
MEDIAN	**0.724**	**0.668**	**0.557**	**0.716**	**0.846**	**0.717**	**0.376**	**-0.933**	**-0.946**	**-0.540**	1.000									
INMAN	0.363	0.370	**0.541**	0.238	-0.068	-0.354	**-0.429**	0.300	0.338	**0.642**	-0.242	1.000								
SILT/SAND	**-0.461**	**-0.477**	**-0.508**	**-0.687**	**-0.722**	**-0.712**	**-0.574**	**0.765**	**0.806**	0.180	**-0.734**	-0.039	1.000							
WATER	-0.212	-0.169	-0.136	**-0.414**	**-0.622**	**-0.759**	**-0.644**	**0.762**	**0.823**	**0.558**	**-0.704**	**0.446**	**0.662**	1.000						
BAP	0.000	0.107	0.291	-0.073	-0.373	**-0.581**	**-0.516**	**0.538**	**0.555**	**0.852**	**-0.442**	**0.597**	0.300	**0.725**	1.000					
LMW	-0.047	0.052	0.268	-0.099	-0.349	**-0.488**	-0.283	**0.482**	**0.416**	**0.897**	**-0.374**	**0.569**	0.130	**0.574**	**0.927**	1.000				
HMW	0.003	0.108	0.289	-0.087	**-0.385**	**-0.598**	**-0.502**	**0.546**	**0.551**	**0.857**	**-0.438**	**0.598**	0.295	**0.718**	**0.998**	**0.939**	1.000			
TPAH	-0.026	0.074	0.283	-0.084	-0.358	**-0.527**	**-0.386**	**0.503**	0.476	**0.887**	**-0.400**	**0.580**	0.209	**0.643**	**0.978**	**0.982**	**0.984**	1.000		
PCB	-0.279	-0.181	0.017	-0.255	**-0.522**	**-0.598**	**-0.556**	**0.692**	**0.762**	**0.807**	**-0.707**	**0.532**	**0.512**	**0.797**	**0.883**	**0.741**	**0.866**	**0.819**	1.000	
DEPTH	-0.224	-0.266	-0.327	**-0.434**	**-0.452**	-0.353	-0.011	0.335	**0.449**	0.128	**-0.433**	0.089	0.371	**0.392**	0.143	0.140	0.142	0.135	0.307	1.000

Table 4b. Pearson correlations between sediment characteristics, contaminants and depth for stations having predominantly silty sediment, Sydney Harbour, October, 1999, N=25.

	PB	GR	VCS	CS	MS	FS	VFS	SILT	CLAY	TOC	MEDIAN	INMAN	SILT/ SAND RATIO	WATER	BAP	LMW	HMW	TPAH	PCB	DEPTH
PB	1.000																			
GR	**0.708**	1.000																		
VCS	**0.668**	**0.893**	1.000																	
CS	**0.588**	**0.806**	**0.845**	1.000																
MS	**0.559**	**0.656**	**0.642**	**0.840**	1.000															
FS	**0.510**	**0.515**	**0.527**	**0.659**	**0.930**	1.000														
VFS	0.085	0.033	0.093	0.161	**0.551**	**0.671**	1.000													
SILT	**-0.759**	**-0.620**	**-0.624**	**-0.685**	**-0.781**	**-0.726**	**-0.461**	1.000												
CLAY	-0.193	-0.229	-0.271	-0.255	**-0.596**	**-0.706**	**-0.821**	0.349	1.000											
TOC	0.345	**0.570**	**0.781**	**0.645**	**0.497**	**0.488**	0.137	-0.335	-0.272	1.000										
MEDIAN	0.276	0.182	0.252	0.219	**0.589**	**0.731**	**0.877**	**-0.495**	**-0.946**	0.259	1.000									
INMAN	**0.906**	**0.811**	**0.835**	**0.802**	**0.747**	**0.675**	0.228	**-0.847**	-0.274	**0.572**	0.347	1.000								
SILT/SAND	-0.371	**-0.554**	**-0.584**	**-0.765**	**-0.897**	**-0.877**	**-0.673**	**0.675**	**0.649**	**-0.473**	**-0.634**	**-0.623**	1.000							
WATER	0.083	0.033	-0.004	-0.026	-0.202	-0.209	**-0.582**	0.135	**0.515**	0.130	**-0.463**	0.051	0.293	1.000						
BAP	0.169	0.332	**0.568**	**0.456**	0.190	0.148	-0.189	-0.098	0.095	**0.828**	-0.093	0.377	-0.182	**0.480**	1.000					
LMW	0.202	0.353	**0.614**	**0.490**	0.386	0.377	0.133	-0.211	-0.273	**0.876**	0.257	**0.417**	-0.389	0.261	**0.906**	1.000				
HMW	0.167	0.323	**0.571**	**0.459**	0.215	0.176	-0.145	-0.109	0.045	**0.838**	-0.043	0.377	-0.205	**0.450**	**0.998**	**0.926**	1.000			
TPAH	0.182	0.331	**0.594**	**0.474**	0.293	0.271	-0.006	-0.163	-0.110	**0.867**	0.111	**0.396**	-0.290	0.359	**0.972**	**0.976**	**0.984**	1.000		
PCB	0.169	0.322	**0.476**	0.378	0.043	-0.001	**-0.447**	-0.025	0.401	**0.669**	-0.391	0.325	0.028	**0.573**	**0.883**	**0.645**	**0.858**	**0.771**	1.000	
DEPTH	0.141	0.013	-0.111	-0.069	-0.044	-0.125	-0.229	-0.109	0.383	-0.161	-0.329	0.036	0.239	0.305	-0.010	-0.054	-0.025	-0.042	0.156	1.000

Table 5a. Principal component loadings sediment and for physical environmental variables, Sydney Harbour, Nova Scotia, October 1999.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
PB	-0.458	0.722	0.364	-0.272	0.168
GR	-0.386	0.798	0.326	-0.192	0.192
VCS	-0.266	0.929	0.123	-0.047	0.051
CS	-0.601	0.705	0.093	0.175	-0.284
MS	-0.818	0.441	0.039	0.186	-0.287
FS	-0.853	0.045	-0.287	0.160	-0.371
VFS	-0.518	-0.329	-0.669	-0.347	0.157
SILT	0.928	-0.235	0.106	0.087	0.092
CLAY	0.932	-0.211	0.221	0.012	-0.064
BAP	0.777	0.575	-0.148	0.055	0.008
TOC	0.750	0.439	-0.399	0.028	0.000
MEDIAN	-0.884	0.362	-0.008	-0.072	0.154
INMAN	0.425	0.673	0.106	-0.171	-0.129
SILTSAND	0.715	-0.402	0.435	0.112	0.029
WATER	0.870	0.117	0.255	-0.034	-0.086
LMW	0.698	0.549	-0.397	-0.031	0.079
HMW	0.779	0.573	-0.159	0.040	0.044
TPAH	0.739	0.571	-0.301	0.018	0.048
DEPTH	0.412	-0.257	0.069	-0.742	-0.406
PCB	0.878	0.287	-0.067	0.100	-0.250
% of VARIANCE	50.82	26.55	7.92	4.73	3.46

Table 5b. Principal component loadings for physical environmental variables, silt/clay sediments. Sydney Harbour, Nova Scotia, October 1999.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
PB	0.648	-0.110	0.586	0.037	0.424
GR	0.770	0.005	0.438	-0.277	0.011
VCS	0.888	0.129	0.194	-0.291	0.070
CS	0.870	-0.004	0.256	-0.198	-0.312
MS	0.839	-0.397	0.119	0.098	-0.264
FS	0.790	-0.470	-0.040	0.189	-0.121
VFS	0.372	-0.747	-0.400	0.247	-0.014
SILT	-0.726	0.361	-0.409	-0.183	-0.054
CLAY	-0.479	0.679	0.445	-0.034	-0.173
BAP	0.615	0.733	-0.270	0.040	0.006
TOC	0.833	0.358	-0.271	-0.098	0.027
MEDIAN	0.495	-0.691	-0.389	0.164	0.277
INMAN	0.863	-0.071	0.423	-0.008	0.184
SILTSAND	-0.784	0.449	0.089	0.013	0.332
WATER	0.011	0.720	0.200	0.311	0.119
LMW	0.737	0.451	-0.438	0.144	0.055
HMW	0.632	0.701	-0.308	0.054	0.014
TPAH	0.690	0.591	-0.386	0.104	0.044
DEPTH	-0.106	0.234	0.490	0.714	-0.160
PCB	0.434	0.842	0.015	0.002	-0.078
% of VARIANCE	45.38	26.17	11.91	5.12	3.36

Table 6. Biological community measures for Sydney Harbour stations, October 1999.

Station & Replicate	Abundance (No/m^2)	Biomass g/m^2	Species/Station	Shannon Wiener Diversity (log$_{10}$)	Pielou's Evenness
1	220	11.0	4	0.498	0.827
2	1120	17.7	8	0.638	0.707
3	30	7.4	2	0.276	0.918
4	290	35.4	7	0.716	0.847
5	37910	43.5	14	0.189	0.165
6	180	6.1	6	0.653	0.839
7	340	33.7	6	0.512	0.658
13-1	20	0.4	1	0.000	—
13-2	80	1.2	3	0.423	0.887
14-1	470	3.7	8	0.554	0.613
14-2	150	10.1	5	0.606	0.867
15	100	0.0	4	0.571	0.948
16	14160	38.9	44	1.019	0.620
17-1	200	5.6	4	0.579	0.961
17-2	240	0.4	3	0.439	0.921
18	80	3.8	3	0.423	0.887
19	91400	42.0	12	0.061	0.057
21-1	5750	57.4	27	0.802	0.560
21-2	18810	158.6	31	0.729	0.489
22	18710	61.7	35	0.689	0.450
23	66120	143.6	29	0.922	0.631
24	10020	37.2	27	0.654	0.457
25	39060	47.0	18	0.266	0.212
26	28540	39.6	14	0.309	0.269
27	18680	19.6	16	0.315	0.262
28	42170	53.6	20	0.182	0.140
29-1	190	37.9	5	0.573	0.820
29-2	40	1.7	3	0.452	0.946
30-1	60	0.6	1	0.000	—
30-2	420	34.4	3	0.434	0.909
31	750	52.3	6	0.336	0.431
32	35800	14.4	10	0.099	0.099
34	80	0.4	2	0.301	1.000
35	128440	64.8	21	0.250	0.189
36	8360	95.2	9	0.332	0.347
37	35720	81.2	18	0.394	0.314

Table 7. Dominance (relative abundance) of seabed organisms in communities identified by cluster analysis, Sydney Harbour, Nova Scotia, October 1999. Includes species present in greater than 0.1% abundance for each cluster group.

A1

Species	Abundance	%
Mediomastus ambiseta	42140	89.6
Acteocina canaliculata	704	1.5
Ostracods	556	1.2
Scolelepis squamata	546	1.2
Ninoe nigripes	521	1.1
Edotea montosa	465	1.0
Nephtys incisa	345	0.7
Cerebratulus sp.	314	0.7
Phoronis architecta	278	0.6
Euchone elegans	153	0.3
Cerianthus borealis	152	0.3
Phloe minuta	146	0.3
Tharyx acutus	111	0.2
Mercenaria mercenaria	98	0.2
Polydora quadrilobata	97	0.2
Yoldia limatula	80	0.2
Tellina agilis	64	0.1
Leptocheirus pinguis	59	0.1
Phyllodoce arenae	50	0.1
Eteone longa	43	0.1
Photis reinhardi	40	0.1
Capitellidae	32	0.1
Orchomenella minuta	29	0.1
Spiophanes bombyx	24	0.1

A1*

Species	Abundance	%
Mediomastus ambiseta	2560	32.7
Owenia fusiformis	1256	16.1
Photis reinhardi	916	11.7
Protodrilidae sp. 1	780	10.0
Edotea montosa	496	6.3
Eudorella truncatula	494	6.3
Ninoe nigripes	197	2.5
Ostracods	193	2.5
Polydora quadrilobata	140	1.8
Polydora cornuta	130	1.7
Cerebratulus sp.	130	1.7
Eteone longa	68	0.9
Nucula delphinodonta	65	0.8
Nephtys incisa	53	0.7
Diastylis polita	52	0.7
Tellina agilis	40	0.5
Phloe minuta	35	0.4
Acteocina canaliculata	29	0.4
Phoxocephalus holbolli	25	0.3
Exogone hebes	16	0.2
Capitata capitella	16	0.2
Harpacticoidea	16	0.2
Crenella decussata	16	0.2
Phyllodoce sp.?	16	0.2
Yoldia limatula	9	0.1
Astarte undata	8	0.1
Nassarius trivittatus	8	0.1
Clymenella torquata	5	0.1
Ampelisca vadorum	5	0.1
Cerastoderma pinnulatum	5	0.1
Phyllodoce maculata	4	0.1
Cerianthus borealis	4	0.1
Strongylocenttrotus droebachensis	4	0.1
Diastylis sculpta	4	0.1
Laonome kroyeri	4	0.1
Spiophanes bombyx	4	0.1
Euchone elegans	4	0.1
Scolelepis squamata	4	0.1
Orchomenella minuta	4	0.1

A2

Species	Abundance	%
Protodrilidae sp. 1	2583	45.1
Tellina agilis	1022	17.9
Mediomastus ambiseta	364	6.4
Cirratulidae	257	4.5
Acteocina canaliculata	209	3.7
Aricidea catherinae	205	3.6
Exogone hebes	153	2.7
Nassarius trivittatus	148	2.6
Spiophanes bombyx	68	1.2
Nephtys longosetosa	51	0.9
Tharyx acutus	46	0.8
Ninoe nigripes	44	0.8
Glycera capitata	40	0.7
Phyllodoce arenae	37	0.6
Sayella ? fusca	37	0.6
Diastylis polita	33	0.6
Pseudoleptocuma minor	33	0.6
Eudorella truncatula	33	0.6
Echinarachnius parma	33	0.6
Clymenella torquata	29	0.5
Paraonis fulgens	24	0.4
Phoxocephalus holbolli	23	0.4
Mercenaria mercenaria	22	0.4
Phoronis architecta	22	0.4
Tanaidacea	21	0.4
Unicola irrorata	20	0.3
Nucula delphinodonta	20	0.3
Eusthenelais limicola	16	0.3
S. droebachensis	16	0.3
Lunatia sp.	13	0.2
Phloe minuta	12	0.2
Photis reinhardi	11	0.2
Ensis directus	10	0.2
Glycera dibranchiata	10	0.2
Edotea montosa	6	0.1
Turbonilla interrupta	6	0.1
Prionispio sp.	6	0.1
Bivalve juv.	5	0.1
Scolelepis squamata	4	0.1
Maldanidae	4	0.1
Cerastoderma pinnulatum	4	0.1
Ampharete lindstroemi	4	0.1
Pherusa affinis	3	0.1
Eteone longa	3	0.1

B1

Species	Abundance	%
Nephtys incisa	29	43.9
Cerianthus borealis	20	30.3
Tellina agilis juveniles	6	9.1
Acteocina canaliculata	4	6.1
Mediomastus ambiseta	4	6.1
Nassarius trivittatus	3	4.5

B2

Species	Abundance	%
Acteocina canaliculata	54	19.2
Ninoe nigripes	38	13.5
Nephtys incisa	38	13.5
Mediomastus ambiseta	29	10.3
Polydora cornuta	29	10.3
Cerianthus borealis	25	8.9
Cerebratulus sp.	19	6.8
Phoronis architecta	11	3.9
Edotea montosa	9	3.2
Nemertean unid	8	2.8
Capitellidae	5	1.8
Nassarius trivittatus	4	1.4
Yoldia limatula	4	1.4
Phyllodoce sp.?	3	1.1
Tharyx acutus	2	0.7
Phyllodoce arenae	1	0.4
Nucula delphinodonta	1	0.4
Nemertean sp 3	1	0.4

B2*

Species	Abundance	%
Phoronis architecta	67	42.1
Cerianthus borealis	46	28.9
Nephtys incisa	27	17.0
Cerebratulus sp.	9	5.7
Mediomastus ambiseta	3	1.9
Edotea montosa	2	1.3
Amphiporus sp 1	2	1.3
Yoldia limatula	1	0.6
Edwardsia elegans	1	0.6
Pherusa affinis	1	0.6

Table 8. Species identification number for canonical correspondence analysis (See Figures 18c, 19c and 20c).

Number	Species
1	Cerastoderma pinnulatum
2	Ensis directus
3	Mercenaria mercenaria
4	Nassarius trivittatus
5	Nucula delphinodonta
6	Tellina agilis
7	Yoldia limatula
8	Bivalve juv.
9	Acteocina canaliculata
10	Lunatia triseriata
11	Lunatia sp.
12	Sayella ? fusca
13	Turbonilla interrupta
14	Aricidea catherinae
15	Brada villosa
16	Capitellidae
17	Clymenella torquata
18	Eteone longa
19	Euchone elegans
20	Eusthenelais limicola
21	Exogone hebes
22	Glycera capitata
23	Glycera dibranchiata
24	Lumbrineris fragilis
25	Mediomastus ambiseta
26	Nephtys longosetosa
27	Nephtys incisa
28	Ninoe nigripes
29	Paraonis fulgens
30	Pherusa affinis
31	Pholoe minuta
32	Phyllodoce arenae
33	Phyllodoce sp.?
34	Polydora cornuta
35	Polydora quadrilobata
36	Sabellidae unid
37	Scolelepis squamata
38	Spiophanes bombyx
39	Tharyx acutus
40	Leptocheirus pinguis
41	Orchomenella minuta
42	Photis reinhardi
43	Phoxocephalus holbolli

Table 8 (continued). Species identification number for canonical correspondence analysis (See Figures 18c, 19c and 20c).

44	Unciola irrorata
45	Edotea montosa
46	Diastylis polita
47	Diastylis sculpta
48	Eudorella truncatula
49	Pseudoleptocuma minor
50	Echinarachnius parma
51	Strongylocentrotus droebachensis
52	Edwardsia elegans
53	Cerianthus borealis
54	Cerebratulus sp.
55	Protodrilidae sp. 1
56	Nemertean unid
57	Tanaidacea
58	Phoronis architecta

Table 9a. Partitioning of the variance in species data explained for CCA analysis of all Sydney Harbour stations, October 1999.

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalue	.0375	0.184	0.156	0.110
Species – Environment Correlations	.0992	0.972	0.976	0.937
Cumulative % Variance				
- of species data	21.0	31.3	40.1	46.2
- of species environment relation	26.6	39.7	50.7	58.5
Total inertia	1.784			

Table 9b. Partitioning of the variance in species data explained for CCA analysis of Stations on silt/clay sediments, Sydney Harbour, October 1999.

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalue	0.253	0.189	0.148	0.141
Species – Environment Correlations	0.992	0.986	0.968	0.982
Cumulative % Variance				
- of species data	16.2	28.3	37.8	46.8
- of species environment relation	18.8	33.0	44.0	54.6
Total inertia	1.561			

Table 9c. Partitioning of the variance in species data explained for CCA analysis of stations on silt/clay sediments using selected environmental variables, Sydney Harbour, October 1999.

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalue	0.238	0.17	0.118	0.093
Species – Environment Correlations	0.973	0.940	0.888	0.873
Cumulative % Variance				
- of species data	15.0	26.1	33.6	39.6
- of species environment relation	28.0	48.0	61.8	72.8
Total inertia	1.561			

Table 10a. Correlations of environmental variables with axes in Canonical Correspondence Analysis (CCA), of all Sydney Harbour stations, October 1999.

Axis 1		Axis 2		Axis 3		Axis 4	
Variable	r	Variable	r	Variable	r	Variable	r
FS	0.89	FS	0.32	LPAH	0.49	PB	0.56
VFS	0.69	Depth	0.29	TPAH	0.40	GR	0.50
Median	0.62	CS	0.26	TOC	0.32	VCS	0.40
MS	0.61		⋮	Median	0.26	Median	0.35
CS	0.33	Silt	-0.24	HPAH	0.25		⋮
	⋮			VCS	0.22	TOC	-0.30
Depth	-0.41				⋮		
LPAH	-0.66			Clay	-0.22		
Inman	-0.70						
TOC	-0.70						
TPAH	-0.73						
Silt	-0.77						
Silt/sand	-0.78						
BAP	-0.81						
HPAH	-0.81						
Clay	-0.84						
Water	-0.92						

FS = Fine Sand; VFS = Very Fine Sand; MS = Medium Sand; CS = Coarse Sand; VCS = Very Coarse Sand; Median = Median Grainsize; Inman = Inman sorting Coefficient; PB = Pebble; GR = Gravel; TOC = Total Organic Carbon; BAP = Benzo(*a*)pyrene; TPAH = Total PAH; LPAH = Low Molecular Weight PAH; HPAH = High Molecular Weight PAH.

Table 10b. Correlations of environmental variables with axes in Canonical Correspondence Analysis (CCA) of analysis of stations on silt/clay sediments, Sydney Harbour, October 1999.

Axis 1		Axis 2		Axis 3		Axis 4	
Variable	r	Variable	r	Variable	r	Variable	r
Median	0.78	LPAH	0.72	BAP	0.43	PB	0.23
VFS	0.76	TOC	0.64	HPAH	0.42		⋮
FS	0.49	TPAH	0.61	TPAH	0.34	Clay	-0.22
MS	0.27	Median	0.48	TOC	0.31	Depth	-0.27
	⋮	HPAH	0.44	Clay	0.30		
TOC	-0.27	FS	0.41	VCS	0.26		
LPAH	-0.28	BAP	0.39		⋮		
CS	-0.28	VFS	0.35	VFS	-0.31		
VCS	-0.29	VCS	0.34	MS	-0.34		
GR	-0.34	MS	0.33	FS	-0.38		
Silt	-0.37		⋮	Depth	-0.39		
TPAH	-0.42	Silt	-0.37				
Silt sand ratio	-0.46	Clay	-0.41				
Depth	-0.55						
HPAH	-0.56						
BAP	-0.60						
Water	-0.74						
Clay	-0.74						

FS = Fine Sand; VFS = Very Fine Sand; MS = Medium Sand; CS = Coarse Sand; VCS = Very Coarse Sand; Median = Median Grainsize; Inman = Inman sorting Coefficient; PB = Pebble; GR = Gravel; TOC = Total Organic Carbon; BAP = Benzo(*a*)pyrene; TPAH = Total PAH; LPAH = Low Molecular Weight PAH; HPAH = High Molecular Weight PAH.

Table 10c. Correlations of environmental variables with axes in Canonical Correspondence Analysis (CCA), of Sydney Harbour stations on silt/clay sediments using selected environmental variables, October 1999.

Axis 1		Axis 2		Axis 3		Axis 4	
Variable	r	Variable	r	Variable	r	Variable	r
Median	0.87	TPAH	0.69	PCB	0.37	TOC	0.31
Distance	0.45	TOC	0.69		⋮	TPAH	0.30
	⋮	Median	0.30	Depth	-0.41		⋮
Depth	-0.52		⋮			Depth	-0.53
PCB	-0.74	Silt/clay	-0.32				
Water	-0.78	Distance	-0.56				
Clay	-0.82						

FS = Fine Sand; VFS = Very Fine Sand; MS = Medium Sand; CS = Coarse Sand; VCS = Very Coarse Sand; Median = Median Grainsize; Inman = Inman sorting Coefficient; PB = Pebble; GR = Gravel; TOC = Total Organic Carbon; BAP = Benzo(*a*)pyrene; TPAH = Total PAH; LPAH = Low Molecular Weight PAH; HPAH = High Molecular Weight PAH.

Table 11. Comparison of lists of taxa from studies of seabed communities found in Sydney Harbour in various studies.

	Studies			
	Wendland (1979)	P. Lane & Associates (1988)	P. Lane & Associates (1989)	Present Study (1999)
Species				
Abra longicallis			*	
Acteocina canaliculata				*
Ampelisca vadorum				*
Ampharete lindstroemi				*
Amphipods	*			
Amphiporus sp 1				*
Amphiporus sp 2				*
Anobothrus gracilis				*
Aphrodita hastate			*	
Arabellidae	*			
Arctica islandica				*
Arenicola marina			*	
Arenicola sp.			*	
Aricidea catherinae				*
Aricidea sp.		*	*	
Astarte sp.		*	*	
Astarte undata				*
Asterias sp.			*	
Athenaria			*	
Barentsia major			*	
Brada villosa				*
Buccinum sp		*	*	
Capitella capitata		*	*	*
Capitellidae				*
Cerastoderma pinnulatum		*		*
Cerebratulus marginatus			*	
Cerebratulus sp.				*
Ceriantharia			*	
Cerianthus borealis		*	*	*
Chiridotea sp.		*		
Chiridotea tuftsi				*
Cirratulus cirratus			*	
Cirratulidae				*
Clymenella sp.			*	
Clymenella torquata				*
Crangon septemspinosa				*
Crenella decussata				*
Diastylis polita				*
Diastylis sculpta				*
Diastylis sp.				*

Table 11 (continued). Comparison of lists of taxa from studies of seabed communities found in Sydney Harbour in various studies.

	Studies			
	Wendland (1979)	P. Lane & Associates (1988)	P. Lane & Associates (1989)	Present Study (1999)
Species				
Echinarachnius parma		*		*
Edotea montosa				*
Edotea triloba		*	*	
Edwardsia elegans		*		*
Ensis directus		*		*
Eteone lactea	*			
Eteone longa				*
Eteone sp.	*			
Euchone elegans				*
Eudorella truncatula				*
Euplana gracilis			*	
Eusthenelais limicola				*
Exogone hebes				*
Flabelligeridae	*			
Gammarus mucronatus		*	*	
Gammarus oceanicus		*	*	
Gammarus sp.			*	
Glycera capitata	*			*
Glycera dibranchiata				*
Glycera sp.	*			
Harmothoe imbricata			*	
Harmothoe sp.			*	
Heteromastus filiformis			*	
Hirudinaea				*
Hydrobia ? totteni				*
Hydroides dianthus		*		
Idotea phosphorea				*
Ischnochiton rubra				*
Lamprops quadriplicata		*	*	
Laonome kroyeri				*
Lepidonotus sp.			*	
Leptocheirus pinguis				*
Limpet	*			
Lineus arenicola		*	*	
Lineus ruber		*		
Lineus sp.			*	
Littorina sp.		*	*	
Lumbrineris fragilis	*	*	*	*
Lumbrineris sp.			*	
Lunatia sp.				*
Lunatia triseriata				*
Malacobdella grossa		*	*	

Table 11 (continued). Comparison of lists of taxa from studies of seabed communities found in Sydney Harbour in various studies.

	Studies			
	Wendland (1979)	P. Lane & Associates (1988)	P. Lane & Associates (1989)	Present Study (1999)
Species				
Maldanidae				*
Marenzellaria viridis			*	*
Mediomastus ambiseta				*
Mercenaria mercenaria				*
Micrura leidyi		*		
Mya arenaria				*
Mysidacea			*	
Mytilus edulis		*	*	
Myxicola infundibulum		*	*	
Myxicola sp.			*	
Naineris quadricuspida		*	*	
Nassarius trivittatus				*
Nematoda			*	
Nematostella vertensis		*		
Nemertea	*			*
Nemertean sp 3				*
Nephtys bucera				*
Nephtys incisa	*			*
Nephtys picta	*			
Nephtys sp.		*	*	
Nereis diversicolor		*	*	
Nereis grayi			*	
Nereis pelagica	*			
Nereis succinea				*
Nereis virens	*	*	*	
Nereis zonata	*			
Nereis sp.			*	
Ninoe nigripes	*	*		*
Notomastus latericeus			*	
Nucula delphinodonta				*
Ophelina acuminata			*	
Orchomenella minuta				*
Owenia fusiformis			*	*
Oxyurostylis smithi				*
Pagurus acadianus		*		
Pagurus sp.	*			
Paraonis fulgens				*
Pectinaria gouldii		*	*	
Pherusa affinis			*	*
Pholoe minuta			*	*
Phoronis architecta				*
Photis reinhardi				*

Table 11 (continued). Comparison of lists of taxa from studies of seabed communities found in Sydney Harbour in various studies.

	Studies			
	Wendland (1979)	P. Lane & Associates (1988)	P. Lane & Associates (1989)	Present Study (1999)
Species				
Phoxocephalus holbolli				*
Phyllodoce arenae				*
Phyllodoce maculata				*
Phyllodoce sp.?				*
Placopecten magellanicus		*	*	
Polycirrus sp.		*	*	
Polydora ligni (=cornuta)		*	*	*
Polydora quadrilobata				*
Polydora sp.		*		*
Priapulus caudatus			*	
Prionospio streenstrupi			*	
Prionispio sp.				*
Procephalothrix spiralis			*	
Protodrilidae sp. 1				*
Pseudoleptocuma minor				*
Sabella sp.			*	
Sabellaria vulgaris			*	
Sabellidae				*
Saccoglossus ?				*
Sayella ? fusca				*
Scolelepis squamata				*
Scoloplos acutus			*	
Scoloplos armiger				*
Scoloplos fragilis [10]			*	
Scoloplos robustus [1]		*	*	
Scypha sp.			*	
Sea Anenome	*			
Sclerocrangon boreas		*		
Spiophanes bombyx				*
Spirorbis sp.			*	
Strongylocentrotus droebachiensis			*	*
Tanaidacea				*
Tellina agilis				*
Tharyx acutus				*
Tharyx sp.			*	
Thenaria			*	
Thyasira flexuosa				*
Turbonilla interrupta				*
Unicola irrorata				*
Yoldia limatula		*	*	*

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[10] Used alternate name Hoploscoloplos.

Table 12. Summary of community measures for the seabed biological community of Sydney Harbour, Nova Scotia, in 1978 – 1999. Geometric means indicated by “$\log_{10}$”.

Study	Number of Samples	Abundance (number/m^2)				Wet Weight Biomass (grams/m^2)				Number of Species		Shannon-Wiener Diversity ($\log_{10}$)	
Present Study (Sampled October 1999)		$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$	SD
1. Inner South Arm	3	30520.0	52723.6	2.93	1.76	15.4	23.1	0.82	0.75	5.7	5.5	0.260	0.180
2. Central & NE South Arm	16	291.9	291.3	2.26	0.47	13.8	16.2	0.87	0.57	4.4	2.3	0.450	0.210
3. Outer & NW South Arm	6	25305.0	19652.1	3.70	1.38	38.7	28.3	1.42	0.54	11.7	6.9	0.310	0.180
4. Northwest Arm	6	38850.0	45388.0	4.39	0.43	50.6	26.3	1.66	0.23	17.5	6.2	0.360	0.150
5. Outer Harbour	5	24714.0	23749.4	4.26	0.38	92.0	54.9	1.91	0.26	33.0	6.7	0.830	0.140
Wendland (1979) (Sampled November 1978)		$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$	SD
1. Inner South Arm	6	149.3	37.8	2.2	0.1	9.8	5.1	1.0	0.2	3.5	1.0	0.397	0.152
2. Central & NE South Arm	8	108.1	70.3	1.9	0.4	9.5	7.4	0.9	0.4	3.6	1.4	0.416	0.192
3. Outer & NW South Arm	4	224.8	125.4	2.3	0.3	9.2	3.0	1.0	0.2	5.0	2.4	0.410	0.198
P. Lane & Associates (1988 & ‘89) (Sampled ‘87 & ’88)		$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$	SD
1. Inner South Arm	3	42.7	47.9	1.5	0.5	—	—	—	—	5.0	2.3	—	—
2. Central & NE South Arm	10	20.6	19.0	1.2	0.3	—	—	—	—	4.9	1.3	—	—
3. Outer & NW South Arm	6	21.4	18.9	1.3	0.3	—	—	—	—	5.0	1.5	—	—
4. Northwest Arm	6	40.7	16.0	1.6	0.2	—	—	—	—	8.3	1.5	—	—
5. Outer Harbour	4	259.6	275.1	2.2	0.4	—	—	—	—	11.4	3.4	—	—
Zajdlik et al. (2000)[2] (Sampled 1997)		$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$ ($\log_{10}$)	SD ($\log_{10}$)	$\bar{x}$	SD	$\bar{x}$	SD
1. Inner South Arm	—	—	—	—	—	—	—			—	—	—	—
2. Central & NE South Arm	3	716[3]	609	2.67	0.565	—	—			4.34[4]	—	0.295[5]	—
3. Outer & NW South Arm	1	29782	—	—	—	—	—			17.8	—	0.330	—
4. Northwest Arm	—	—	—	—	—	—	—			—	—	—	—
5. Outer Harbour	1	3668	—	—	—	—	—			15.8	—	0.622	—

1. Abundance expressed per sample. Area of grab was not stated but appears from photographs to be 0.05 to 0.07 m^2.
2. Five replicate samples (0.1 m^2) were taken per station.
3. Average of 108, 714 and 1326 organisms/m^2, at stations off Muggah Creek, in North Central South Arm and in Northern South Arm respectively.
4. Average of 2.4, 5 and 5.6 species.
5. Average of 0.255, 0.370 and 0.259.
6. Sample= 3 replicates of 0.053 m^2 (0.16 m^2).

Table 13. Dominant species for subdivisions of Sydney Harbour, from Wendland (1979). Inner Harbour stations are landward of Dobson's Point.

Inner Sydney Harbour

Number of Stations=6

Species	Abundance	%
Sea Anemone	384	42.9
Nephtys picta	255	28.5
Eteone sp.	90	10.0
Nemertea	45	5.0
Ninoe nigripes	45	5.0
Glycera capitata	32	3.6
Nereis virens	26	2.9
Eteone lactea	19	2.1

Northeast and Central Sydney Harbour

Number of Stations=8

Species	Abundance	%
Sea Anemone	485	56.1
Ninoe nigripes	160	18.5
Nephtys picta	108	12.5
Nemertea	43	5.0
Nereis virens	38	4.4
Nereis pelagica	19	2.2
Nereis zonata	6	0.7
Arabellidae	6	0.7

Table 14. Biological communities at five stations in Sydney Harbour, Nova Scotia, in July 1997 (Zjadlik *et al.* 2000).

South Arm			Outer Harbour Channel off South Bar (Station 9)			Reference site (Station 12)		
Station 1—Mouth of Muggah Creek								
Taxon	Abundance (number/m^2)	%	Taxon	Abundance (number/m^2)	%	Taxon	Abundance (number/m^2)	%
Nephtys ciliata	8.6	79.6	*Polydora quadrilobata*	2522.4	84.7	*Polydora quadrilobata*	213.0	58.1
Polydora quadrilobata	1.6	14.8	*Stenothoe ? minuta*	106.0	3.6	Nematoda	67.0	18.3
Nematoda	0.4	3.7	*Diastylis polita*	80.6	2.7	*Ninoe nigripes*	14.0	3.8
Harmothoe imbricata	0.2	1.9	Nematoda	67.4	2.3	*Nucula delphinodonta*	13.6	3.7
			Ninoe nigripes	39.2	1.3	*Ilynassa trivittatus*	12.6	3.4
Station 5—Mid South Arm North of Muggah Creek			*Eteone longa*	29.4	1.0	*Spiophanes bombyx*	11.6	3.2
Taxon	Abundance (number/m^2)	%	*Edotea triloba*	25.4	0.9	*Nephtys ciliata*	10.4	2.8
			Orchomenella pinguis	24.8	0.8	*Diastylis polita*	7.2	2.0
Polydora quadrilobata	44.8	62.9	*Nephtys ciliata*	21.4	0.7	*Macoma tenta*	4.2	1.1
Nephtys ciliata	21.6	30.3	*Eudorellopsis deformis*	19.4	0.7	Capitellidae	1.4	0.4
Marine Oligochaete	2.0	2.8	Nemertea	10.0	0.3	*Pholoe minuta*	1.4	0.4
Nemertea	1.4	2.0	*Nucula delphinodonta*	5.4	0.2	*Chiridotea tuftsi*	1.2	0.3
Edwardsia sp.	0.8	1.1	*Anonyx sarsi*	5.2	0.2	*Aricidea suecica*	0.8	0.2
Ninoe nigripes	0.2	0.3	*Edwardsia* sp.	3.8	0.1	*Gammarus* sp.	0.8	0.2
Diastylis polita	0.2	0.3	*Yoldia limatula*	2.4	0.1	Cirratulidae	0.6	0.2
Leptochirus pinguis	0.2	0.3	*Chiridotea tuftsi*	2.2	0.1	*Eteone longa*	0.6	0.2
			Pherusa plumose	2.0	0.1	*Prionospio steenstrupi*	0.6	0.2
Station 6—Northern South Arm			*Cerastoderma pinnulatum*	2.0	0.1	Sabellidae	0.6	0.2
Taxon	Abundance (number/m^2)	%	*Macoma tenta*	1.8	0.1	*Marine Oligochaete*	0.6	0.2
			Sabellidae	1.6	0.1	*Eudorellopsis deformis*	0.6	0.2
Polydora quadrilobata	113.0	85.2	*Phyllodoce mucosa*	1.4	< 0	*Euchone incolor*	0.4	0.1
Nephtys ciliata	13.2	10.0	*Ilynassa trivittatus* [1]	1.0	< 0	Copepoda	0.4	0.1
Nemertea	1.6	1.2	*Harmothoe imbricata*	0.8	< 0	*Edotea triloba*	0.4	0.1
Nematoda	1.2	0.9	*Mya truncata*	0.8	< 0	*Stenothoe ? minuta*	0.4	0.1
Eteone longa	1.0	0.8	Cirratulidae	0.4	< 0	*Macoma balthica*	0.4	0.1
Ninoe nigripes	0.8	0.6	*Cossura longicirrata*	0.4	< 0	*Margarites groenlandica*	0.4	0.1
Leptochirus pinguis	0.4	0.3	*Pholoe minuta*	0.4	< 0	*Exogone hebes*	0.2	0.1
Aricidea suecica	0.2	0.2	*Cylichna gouldi*	0.4	< 0	*Neoleanira tetragona*	0.2	0.1
Exogone hebes	0.2	0.2	*Macoma balthica*	0.2	< 0	*Pherusa plumosa*	0.2	0.1
Pherusa plumosa	0.2	0.2				*Phyllodoce mucosa*	0.2	0.1
Eudorellopsis deformis	0.2	0.2				*Phoxocephalus holbolli*	0.2	0.1
Macoma tenta	0.2	0.2				*Edwardsia* sp.	0.2	0.1
Edwardsia sp.	0.2	0.2				*Echinarachnius parma*	0.2	0.1
						Nemertea	0.2	0.1

[1] *Ilynassa* = *Nassarius*

APPENDICES

Table A1. Dominance and occurrence of seabed organisms from Sydney Harbour based on total number of individuals at 30 stations, October 1999.

	Total # of Individuals	Percent of total	Number of Stations
Species			
Mediomastus ambiseta	45100	76.71	23
Protodrilidae sp. 1	3367	5.73	6
Owenia fusiformis	1256	2.14	1
Tellina agilis	1132	1.93	10
Acteocina canaliculata	1000	1.70	17
Edotea montosa	978	1.66	12
Photis reinhardi	967	1.64	6
Ninoe nigripes	800	1.36	16
Scolelepis squamata	554	0.94	10
Eudorella truncatula	528	0.90	4
Nephtys incisa	492	0.82	28
Cerebratulus sp.	474	0.81	21
Phoronis architecta	378	0.64	13
Cirratulidae	257	0.44	1
Cerianthus borealis	247	0.42	23
Polydora quadrilobata	237	0.40	4
Aricidea catherinae	205	0.35	4
Phloe minuta	193	0.33	11
Nassarius trivittatus	178	0.30	11
Exogone hebes	173	0.29	7
Tharyx acutus	159	0.27	11
Polydora cornuta	159	0.27	4
Euchone elegans	159	0.27	5
Mercenaria mercenaria	121	0.21	8
Eteone longa	114	0.19	6
Spiophanes bombyx	96	0.16	6
Yoldia limatula	94	0.16	9
Phyllodoce arenae	88	0.15	11
Diastylis polita	87	0.15	5
Nucula delphinodonta	86	0.15	5
Leptocheirus pinguis	60	0.10	4
Phoxocephalus holbolli	48	0.08	6
Glycera capitata	41	0.07	5
Capitellidae	39	0.07	5
Sayella ? fusca	37	0.06	4
Clymenella torquata	34	0.06	5
Echinarachnius parma	33	0.06	3
Orchomenella minuta	33	0.06	3
Pseudoleptocuma minor	33	0.06	3
Tanaidacea	21	0.04	3
Strongylocentrotus droebachensis	20	0.03	3
Unicola irrorata	20	0.03	4
Phyllodoce sp.?	19	0.03	2
Paraonis fulgens	24	0.04	2
Bivalve unid.	17	0.03	2
Nemertean unid	17	0.03	3

Table A1 (cont.). Dominance and occurrence of seabed organisms from Sydney Harbour based on total number of individuals at 30 stations, October 1999.

Species	Total # of Individuals	Percent of total	Number of Stations
Capitella capitata	16	0.03	1
Crenella decussata	16	0.03	1
Eusthenelais limicola	16	0.03	4
Glycera dibranchiata	13	0.02	4
Lunatia sp.	13	0.02	4
Cerastoderma pinnulatum	12	0.02	5
Oxyurostylis smithi	12	0.02	1
Sabellidae unid	12	0.02	2
Marenzellaria viridis	11	0.02	1
Nephtys longosetosa	11	0.02	3
Ensis directus	10	0.02	2
Astarte undata	8	0.01	1
Brada villosa	7	0.01	2
Diastylis sculpta	6	0.01	2
Edwardsia elegans	6	0.01	3
Prionispio sp.	6	0.01	1
Turbonilla interrupta	6	0.01	2
Ampelisca vadorum	5	0.01	1
Lumbrineris fragilis	5	0.01	2
Pherusa affinis	5	0.01	2
Ampharete lindstroemi	4	0.01	1
Hydrobia ? totteni	4	0.01	1
Laonome kroyeri	4	0.01	1
Maldanidae	4	0.01	1
Nereis succinea	4	0.01	1
Phyllodoce maculata	4	0.01	1
Saccoglossus ?	4	0.01	1
Amphiporus sp 1	2	<0.01	1
Anobothrus gracilis	2	<0.01	1
Arctica islandica	2	<0.01	1
Chiridotea tuftsi	2	<0.01	1
Lunatia triseriata	2	<0.01	2
Nephtys caeca	2	<0.01	2
Polychaete unid.	2	<0.01	1
Amphiporus sp 2	1	<0.01	1
Crangon septemspinosus	1	<0.01	1
Diastylis sp.	1	<0.01	1
Hirudinaea	1	<0.01	1
Idotea phosphorea	1	<0.01	1
Ischnochiton rubra	1	<0.01	1
Mya arenaria	1	<0.01	1
Polydora sp. 1	1	<0.01	1
Scoloplos armiger	1	<0.01	1
Thyasira flexuosa	1	<0.01	1

Table A2. Relative abundance of benthic infauna at 30 stations in Sydney Harbour, Nova Scotia, October 1999.

	Total Number of Individuals	Percent of Total	Number of Stations
Species			
BIVALVIA			
Arctica islandica	2	<0.01	1
Astarte undata	8	0.01	1
Cerastoderma pinnulatum	12	0.02	5
Crenella decussata	16	0.03	1
Ensis directus	10	0.02	2
Mercenaria mercenaria	121	0.21	8
Mya arenaria	1	<0.01	1
Nassarius trivittatus	178	0.30	11
Nucula delphinodonta	86	0.15	5
Tellina agilis	1132	1.93	10
Thyasira flexuosa	1	<0.01	1
Yoldia limatula	94	0.16	9
Bivalve juv.	17	0.03	2
GASTROPODA			
Acteocina canaliculata	1000	1.70	17
Hydrobia ? totteni	4	0.01	1
Lunatia triseriata	2	<0.01	2
Lunatia sp.	13	0.02	4
Sayella ? fusca	37	0.06	4
Turbonilla interrupta	6	0.01	2
POLYPLACOPHORA			
Ischnochiton rubra	1	<0.01	1
POLYCHAETA			
Ampharete lindstroemi	4	0.01	1
Anobothrus gracilis	2	<0.01	1
Aricidea catherinae	205	0.35	4
Brada villosa	7	0.01	2
Capitellidae	39	0.07	5
Capitella capitata	16	0.03	1
Cirratulidae	257	0.44	1
Clymenella torquata	34	0.06	5
Eteone longa	114	0.19	6
Euchone elegans	159	0.27	5
Eusthenelais limicola	16	0.03	4
Exogone hebes	173	0.29	7
Glycera capitata	41	0.07	5
Glycera dibranchiata	13	0.02	4
Laonome kroyeri	4	0.01	1

Table A2 (cont.). Relative abundance of benthic infauna at 30 stations in Sydney Harbour, Nova Scotia, October 1999.

	Total Number of Individuals	Percent of Total	Number of Stations
Species			
Lumbrineris fragilis	5	0.01	2
Maldanidae	4	0.01	1
Marenzellaria viridis	11	0.02	1
Mediomastus ambiseta	45100	76.71	23
Nephtys caeca	2	<0.01	2
Nephtys longosetosa	11	0.02	3
Nephtys incisa	492	0.82	28
Nereis succinea	4	0.01	1
Ninoe nigripes	800	1.36	16
Owenia fusiformis	1256	2.14	1
Paraonis fulgens	24	0.04	2
Pherusa affinis	5	0.01	3
Phloe minuta	193	0.33	11
Phyllodoce arenae	88	0.15	11
Phyllodoce maculata	4	0.01	1
Phyllodoce sp.?	19	0.03	2
Polychaete unid.	2	<0.01	1
Polydora cornuta	159	0.27	4
Polydora quadrilobata	237	0.40	4
Polydora sp. 1	1	<0.01	1
Prionispio sp.	6	0.01	1
Sabellidae unid	12	0.02	2
Scolelepis squamata	554	0.94	10
Scoloplos armiger	1	<0.01	1
Spiophanes bombyx	96	0.16	6
Tharyx acutus	159	0.27	11
HIRUDINEA	1	<0.01	1
AMPHIPODA			
Ampelisca vadorum	5	0.01	1
Leptocheirus pinguis	60	0.10	4
Orchomenella minuta	33	0.06	3
Photis reinhardi	967	1.64	6
Phoxocephalus holbolli	48	0.08	6
Unicola irrorata	20	0.03	4
ISOPODA			
Chiridotea tuftsi	2	<0.01	1
Edotea montosa	978	1.66	12
Idotea phosphorea	1	<0.01	1

Table A2 (cont.). Relative abundance of benthic infauna at 30 stations in Sydney Harbour, Nova Scotia, October 1999.

	Total Number of Individuals	Percent of Total	Number of Stations
Species			
CUMACEA			
Diastylis polita	87	0.15	5
Diastylis sculpta	6	0.01	2
Diastylis sp.	1	<0.01	1
Eudorella truncatula	528	0.90	4
Oxyurostylis smithi	12	0.02	1
Pseudoleptocuma minor	33	0.06	3
ECHINODERMATA			
Echinarachnius parma	33	0.06	3
Strongylocentrotus droebachensis	20	0.03	3
Crangon septemspinosa	1	<0.01	1
ANTHOZOA			
Cerianthus borealis	247	0.42	23
Edwardsia elegans	6	0.01	3
NEMERTEA			
Amphiporus sp 1	2	<0.01	1
Amphiporus sp 2	1	<0.01	1
Cerebratulus sp.	474	0.81	21
Nemertean sp 3	1	<0.01	1
Nemertean unid	17	0.03	3
ARCHIANNELID			
Protodrilidae sp. 1	3367	5.73	6
Saccoglossus ?	4	0.01	1
TANAIDACEA	21	0.04	3
PHORONIDA			
Phoronis architecta	378	0.64	13

Table A3. Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	1	2	3	4	5	6	7	13-1	13-2	14-1	14-2	15
Subsample factor					C							
BIVALVIA												
Arctica islandica	0	0	0	0	0	0	0	0	0	0	0	0
Astarte undata	0	0	0	0	0	0	0	0	0	0	0	0
Cerastoderma pinnulatum	0	0	0	0	0	0	0	0	0	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0	0
Ensis directus	0	0	0	0	0	0	0	0	0	0	0	0
Mercenaria mercenaria	0	0	0	0	0	0	0	0	0	0	0	0
Mya arenaria	0	0	0	0	0	0	0	0	0	0	0	0
Nucula delphinodonta	0	0	0	0	0	0	0	0	0	0	0	0
Tellina agilis	0	0	0	0	0	0	0	0	0	0	0	0
Thyasira flexuosa	0	0	0	0	0	0	0	0	0	0	0	0
Yoldia limatula	0	0	0	0	0	0	10	0	0	0	0	0
Bivalve juv.	0	0	0	0	0	0	0	0	0	0	0	0
GASTROPODA												
Acteocina canaliculata	0	540	0	0	160	0	0	0	0	0	0	0
Hydrobia ? totteni	0	0	0	0	0	0	0	0	0	0	0	0
Lunatia triseriata	0	0	0	0	0	0	0	0	0	0	0	0
Lunatia sp.	0	0	0	0	0	0	0	0	0	0	0	0
Nassarius trivittatus	0	0	0	0	0	0	0	0	30	10	30	0
Sayella ? fusca	0	0	0	0	0	0	0	0	0	0	0	0
Turbonilla interrupta	0	0	0	0	0	0	0	0	0	0	0	0
POLYPLACOPHORA												
Ischnochiton rubra	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA												
Ampharete lindstroemi	0	0	0	0	0	0	0	0	0	0	0	0
Anobothrus gracilis	0	0	0	0	0	0	0	0	0	0	0	0
Aricidea catherinae	0	0	0	0	0	0	0	0	0	0	0	0
Brada villosa	0	0	0	0	30	0	0	0	0	0	0	0
Capitellidae	0	0	0	0	0	0	0	0	0	10	0	0
Capitata capitella	0	0	0	0	0	0	0	0	0	0	0	0
Cirratulidae	0	0	0	0	0	0	0	0	0	0	0	0
Clymenella torquata	0	0	0	0	0	0	0	0	0	0	0	0
Eteone longa	0	0	0	0	0	0	0	0	0	0	0	0
Euchone elegans	0	0	0	0	0	0	0	0	0	0	0	0
Eusthenelais limicola	0	0	0	0	0	0	0	0	0	0	0	0
Exogone hebes	0	0	0	0	0	0	0	0	0	0	0	0
Glycera capitata	0	0	0	0	0	0	0	0	0	0	0	0
Glycera dibranchiata	0	0	0	0	0	0	0	0	0	0	0	0
Laonome kroyeri	0	0	0	0	0	0	0	0	0	0	0	0
Lumbrineris fragilis	0	0	0	0	0	0	0	0	0	0	0	0
Maldanidae	0	0	0	0	0	0	0	0	0	0	0	0
Marenzellaria viridis	0	0	0	0	110	0	0	0	0	0	0	0
Mediomastus ambiseta	0	0	0	0	34980	10	0	0	40	100	20	10
Nephtys caeca	0	0	0	0	0	0	0	0	0	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	1	2	3	4	5	6	7	13-1	13-2	14-1	14-2	15
Species												
Nephtys longosetosa	0	0	0	0	0	0	0	0	0	0	0	0
Nephtys incisa	70	110	0	50	120	40	110	20	10	20	20	30
Nereis succinea	0	0	0	0	0	0	0	0	0	0	0	0
Ninoe nigripes	0	280	0	60	870	0	0	0	0	0	0	0
Owenia fusiformis	0	0	0	0	0	0	0	0	0	0	0	0
Paraonis fulgens	0	0	0	0	0	0	0	0	0	0	0	0
Pherusa affinis	0	0	0	0	0	0	0	0	0	0	0	0
Phloe minuta	0	0	0	0	370	0	0	0	0	0	0	0
Phyllodoce arenae	0	0	0	10	50	0	0	0	0	0	0	0
Phyllodoce maculata	0	0	0	0	0	0	0	0	0	0	0	0
Phyllodoce sp.?	0	30	0	0	0	0	0	0	0	0	0	0
Polychaete unid.	0	0	0	0	0	0	0	0	0	0	0	0
Polydora cornuta	0	0	0	0	0	0	0	0	0	280	10	0
Polydora quadrilobata	0	0	0	0	210	0	0	0	0	0	0	0
Polydora sp. 1	0	0	0	0	0	0	0	0	0	0	0	0
Prionispio sp.	0	0	0	0	0	0	0	0	0	0	0	0
Sabellidae unid	0	0	0	0	0	0	0	0	0	0	0	0
Scolelepis squamata	0	0	0	0	30	0	0	0	0	0	0	0
Scoloplos armiger	0	0	0	0	0	0	0	0	0	0	0	0
Spiophanes bombyx	0	0	0	0	0	0	0	0	0	0	0	0
Tharyx acutus	0	0	0	20	0	0	0	0	0	0	0	0
HIRUDINEA sp.	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA												
Ampelisca vadorum	0	0	0	0	0	0	0	0	0	0	0	0
Leptocheirus pinguis	0	0	0	0	460	0	0	0	0	0	0	0
Orchomenella minuta	0	0	0	0	50	0	0	0	0	0	0	0
Photis reinhardi	0	0	0	0	0	0	0	0	0	0	0	0
Phoxocephalus holbolli	0	0	0	0	0	0	0	0	0	0	0	0
Unicola irrorata	0	0	0	0	0	0	0	0	0	0	0	0
ISOPODA												
Chiridotea tuftsi	0	0	0	0	0	0	0	0	0	0	0	0
Edotea montosa	20	80	0	10	0	0	0	0	0	0	0	0
Idotea phosphorea	0	0	0	0	0	0	0	0	0	0	0	0
CUMACEA												
Diastylis polita	0	0	0	0	0	0	0	0	0	0	0	0
Diastylis sculpta	0	0	0	0	0	0	0	0	0	0	0	0
Diastylis sp.	0	0	0	0	0	0	0	0	0	0	0	0
Eudorella truncatula	0	0	0	0	0	0	0	0	0	0	0	0
Oxyurostylis smithi	0	0	0	0	0	0	0	0	0	0	0	0
Pseudoleptocuma minor	0	0	0	0	0	0	0	0	0	0	0	0
ECHINODERMATA												
Echinarachnius parma	0	0	0	0	0	0	0	0	0	0	0	0
S. droebachensis	0	0	0	0	0	0	0	0	0	0	0	0
DECAPODA												
Crangon septemspinosa	0	0	0	0	0	0	0	0	0	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	1	2	3	4	5	6	7	13-1	13-2	14-1	14-2	15
Species												
ANTHOZOA												
Cerianthus borealis	110	40	10	30	90	80	180	0	0	10	70	30
Edwardsia elegans	0	0	0	0	0	0	10	0	0	0	0	0
NEMERTEA												
Amphiporus sp 1	0	0	0	0	0	20	0	0	0	0	0	0
Amphiporus sp 2	0	0	0	0	0	0	0	0	0	0	0	0
Cerebratulus sp.	20	30	20	110	380	10	10	0	0	10	0	0
Nemertean sp 3	0	10	0	0	0	0	0	0	0	0	0	0
Nemertean unid	0	0	0	0	0	0	0	0	0	0	0	0
Protodrilidae sp. 1	0	0	0	0	0	0	0	0	0	0	0	0
Saccoglossus ?	0	0	0	0	0	0	0	0	0	0	0	0
Tanaidacea	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticoidea	0	0	0	0	0	0	0	0	0	0	0	0
Ostracods	0	0	0	0	0	0	0	0	0	0	0	0
Phoronis architechta	0	0	0	0	0	20	20	0	0	30	0	30

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	16	17-1	17-2	18	19	21-1	21-2	22	23	24	25	26	27
Subsample factor	C	4	4		4,C				4,C	C	C	4	4
BIVALVIA													
Arctica islandica	20	0	0	0	0	0	0	0	0	0	0	0	0
Astarte undata	0	0	0	0	0	0	0	0	0	80	0	0	0
Cerastoderma pinnulatum	20	0	0	0	0	0	10	10	0	50	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0	0	160	0	0	0
Ensis directus	0	0	0	0	0	0	40	60	0	0	0	0	0
Mercenaria mercenaria	210	0	0	0	0	0	10	0	0	10	30	420	360
Mya arenaria	10	0	0	0	0	0	0	0	0	0	0	0	0
Nucula delphinodonta	190	0	0	0	0	10	0	0	40	610	0	0	0
Tellina agilis	1150	0	0	0	80	2920	2970	3180	400	0	0	360	0
Thyasira flexuosa	0	0	0	0	0	0	0	0	0	10	0	0	0
Yoldia limatula	0	0	0	40	0	0	0	0	40	50	0	80	200
Bivalve juv.	0	0	0	0	0	0	0	50	0	0	0	0	0
GASTROPODA													
Acteocina canaliculata	0	0	0	0	120	640	810	640	200	90	300	1040	360
Hydrobia ? totteni	0	0	0	0	0	0	0	0	0	0	0	0	40
Lunatia triseriata	0	0	0	0	0	0	10	10	0	0	0	0	0
Lunatia sp.	10	0	0	0	0	40	50	30	0	0	0	0	0
Nassarius trivittatus	430	0	0	0	80	130	490	430	0	80	0	40	0
Sayella ? fusca	150	0	0	0	0	40	120	60	0	0	0	0	0
Turbonilla interrupta	40	0	0	0	0	0	0	20	0	0	0	0	0
POLYPLACOPHORA													
Ischnochiton rubra	10	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA													
Ampharete lindstroemi	40	0	0	0	0	0	0	0	0	0	0	0	0
Anobothrus gracilis	0	0	0	0	0	0	20	0	0	0	0	0	0
Aricidea catherinae	40	0	0	0	0	650	450	910	0	0	0	0	0
Brada villosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Capitellidae	0	40	0	0	0	20	0	0	0	0	0	120	200
Capitata capitella	0	0	0	0	0	0	0	0	160	0	0	0	0
Cirratulidae	0	0	0	0	0	0	2570	0	0	0	0	0	0
Clymenella torquata	60	0	0	0	0	10	70	150	0	50	0	0	0
Eteone longa	20	0	0	0	0	0	0	10	680	0	30	0	0
Euchone elegans	20	0	0	0	0	0	0	0	40	0	10	0	0
Eusthenelais limicola	70	0	0	0	0	10	60	20	0	0	0	0	0
Exogone hebes	20	0	0	0	0	20	410	1080	80	80	0	0	0
Glycera capitata	60	0	0	0	0	110	160	70	0	10	0	0	0
Glycera dibranchiata	60	0	0	0	0	0	20	20	0	30	0	0	0
Laonome kroyeri	0	0	0	0	0	0	0	0	40	0	0	0	0
Lumbrineris fragilis	0	0	0	0	0	10	0	0	0	0	0	0	40
Maldanidae	0	0	0	0	0	40	0	0	0	0	0	0	0
Marenzellaria viridis	0	0	0	0	0	0	0	0	0	0	0	0	0
Mediomastus ambiseta	3540	0	120	10	89520	0	0	100	19240	6360	33290	24400	16000
Nephtys caeca	10	0	0	0	0	0	0	10	0	0	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	16	17-1	17-2	18	19	21-1	21-2	22	23	24	25	26	27
Species													
Nephtys longosetosa	510	0	0	0	0	30	0	40	0	0	0	0	0
Nephtys incisa	0	0	40	30	80	0	0	0	200	330	50	960	800
Nereis succinea	0	0	0	0	0	0	0	0	0	0	0	0	0
Ninoe nigripes	440	40	0	0	400	0	0	0	640	1330	1320	320	320
Owenia fusiformis	0	0	0	0	0	0	0	0	12560	0	0	0	0
Paraonis fulgens	0	0	0	0	0	20	220	0	0	0	0	0	0
Pherusa affinis	30	0	0	0	0	0	0	0	0	10	0	0	0
Phloe minuta	100	0	0	0	0	10	10	0	200	150	40	0	40
Phyllodoce arenae	300	0	0	0	320	20	40	10	0	0	10	40	40
Phyllodoce maculata	0	0	0	0	0	0	0	0	0	40	0	0	0
Phyllodoce sp.?	0	0	0	0	0	0	0	0	160	0	0	0	0
Polychaete unid.	0	0	0	0	0	0	20	0	0	0	0	0	0
Polydora cornuta	0	0	0	0	0	0	0	0	1200	100	0	0	0
Polydora quadrilobata	0	0	0	0	0	0	0	0	1400	0	0	0	0
Polydora sp. 1	0	0	0	0	0	0	0	10	0	0	0	0	0
Prionispio sp.	60	0	0	0	0	0	0	0	0	0	0	0	0
Sabellidae unid	0	0	0	0	0	0	0	0	0	0	0	0	40
Scolelepis squamata	20	0	0	0	0	0	0	20	0	40	3370	600	40
Scoloplos armiger	0	0	0	0	0	0	0	10	0	0	0	0	0
Spiophanes bombyx	480	0	0	0	0	0	30	170	40	0	0	0	0
Tharyx acutus	30	0	0	0	0	160	0	270	0	0	30	80	80
HIRUDINEA sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA													
Ampelisca vadorum	0	0	0	0	0	0	0	0	0	50	0	0	0
Leptocheirus pinguis	0	0	0	0	0	0	0	10	0	0	10	0	0
Orchomenella minuta	0	0	0	0	0	0	0	0	40	0	0	0	0
Photis reinhardi	70	0	0	0	40	10	0	30	9160	0	0	0	0
Phoxocephalus holbolli	120	0	0	0	0	20	40	50	240	10	0	0	0
Unicola irrorata	40	0	0	0	0	10	30	120	0	0	0	0	0
ISOPODA													
Chiridotea tuftsi	0	0	0	0	0	0	20	0	0	0	0	0	0
Edotea montosa	30	0	0	0	80	0	10	20	4920	40	0	40	0
Idotea phosphorea	10	0	0	0	0	0	0	0	0	0	0	0	0
CUMACEA													
Diastylis polita	270	0	0	0	0	20	0	40	520	0	0	0	0
Diastylis sculpta	0	0	0	0	0	0	0	0	40	0	0	0	0
Diastylis sp.	0	0	0	0	0	0	0	0	0	0	10	0	0
Eudorella truncatula	330	0	0	0	0	0	0	0	4760	180	10	0	0
Oxyurostylis smithi	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudoleptocuma minor	230	0	0	0	0	70	30	0	0	0	0	0	0
ECHINODERMATA													
Echinarachnius parma	0	0	0	0	0	140	140	50	0	0	0	0	0
S. droebachensis	0	0	0	0	0	0	50	110	40	0	0	0	0
DECAPODA													
Crangon septemspinosa	0	0	0	0	0	0	0	0	0	10	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	16	17-1	17-2	18	19	21-1	21-2	22	23	24	25	26	27
Species													
ANTHOZOA													
Cerianthus borealis	0	40	0	0	600	0	0	0	40	0	110	0	80
Edwardsia elegans	0	0	0	0	0	0	0	0	0	0	30	0	0
NEMERTEA													
Amphiporus sp 1	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphiporus sp 2	0	0	0	0	0	0	0	0	0	0	10	0	0
Cerebratulus sp.	20	0	0	0	40	0	0	0	1240	60	400	40	0
Nemertean sp 3	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemertean unid	10	0	80	0	0	0	0	0	0	0	0	0	0
Protodrilidae sp. 1	4620	0	0	0	0	490	9830	10890	7800	0	0	0	0
Saccoglossus ?	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanaidacea	40	0	0	0	0	100	70	0	0	0	0	0	0
Harpacticoidea	0	0	0	0	0	0	0	0	160	0	0	0	0
Ostracods	0	0	0	0	0	0	0	0	1920	10	0	0	0
Phoronis architechta	220	80	0	0	40	0	0	0	0	0	0	0	40

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	28	29-1	29-2	30-1	30-2	31	32	34	35	36	37
Subsample factor	C			2	2		4,C	4	4,C	4	4,C
BIVALVIA											
Arctica islandica	0	0	0	0	0	0	0	0	0	0	0
Astarte undata	0	0	0	0	0	0	0	0	0	0	0
Cerastoderma pinnulatum	30	0	0	0	0	0	0	0	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0
Ensis directus	0	0	0	0	0	0	0	0	0	0	0
Mercenaria mercenaria	10	0	0	0	0	0	0	0	0	0	160
Mya arenaria	0	0	0	0	0	0	0	0	0	0	0
Nucula delphinodonta	0	10	0	0	0	0	0	0	0	0	0
Tellina agilis	0	0	0	0	60	0	0	0	160	40	0
Thyasira flexuosa	0	0	0	0	0	0	0	0	0	0	0
Yoldia limatula	320	0	0	0	0	0	0	0	0	160	40
Bivalve juv.	0	0	0	0	0	0	0	0	0	120	0
GASTROPODA											
Acteocina canaliculata	300	0	0	0	0	0	40	40	4520	120	80
Hydrobia ? totteni	0	0	0	0	0	0	0	0	0	0	0
Lunatia triseriata	0	0	0	0	0	0	0	0	0	0	0
Lunatia sp.	0	0	0	0	0	0	0	0	0	0	0
Nassarius trivittatus	30	0	0	0	0	0	0	0	0	0	0
Sayella ? fusca	0	0	0	0	0	0	0	0	0	0	0
Turbonilla interrupta	0	0	0	0	0	0	0	0	0	0	0
POLYPLACOPHORA											
Ischnochiton rubra	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA											
Ampharete lindstroemi	0	0	0	0	0	0	0	0	0	0	0
Anobothrus gracilis	0	0	0	0	0	0	0	0	0	0	0
Aricidea catherinae	0	0	0	0	0	0	0	0	0	0	0
Brada villosa	0	0	0	0	0	0	0	0	40	0	0
Capitellidae	0	0	0	0	0	0	0	0	0	0	0
Capitata capitella	0	0	0	0	0	0	0	0	0	0	0
Cirratulidae	0	0	0	0	0	0	0	0	0	0	0
Clymenella torquata	0	0	0	0	0	0	0	0	0	0	0
Eteone longa	0	0	0	0	0	0	0	0	320	0	80
Euchone elegans	320	0	0	0	0	0	0	0	0	0	1200
Eusthenelais limicola	0	0	0	0	0	0	0	0	0	0	0
Exogone hebes	0	0	0	0	0	0	0	0	40	0	0
Glycera capitata	0	0	0	0	0	0	0	0	0	0	0
Glycera dibranchiata	0	0	0	0	0	0	0	0	0	0	0
Laonome kroyeri	0	0	0	0	0	0	0	0	0	0	0
Lumbrineris fragilis	0	- 0	0	0	0	0	0	0	0	0	0
Maldanidae	0	0	0	0	0	0	0	0	0	0	0
Marenzellaria viridis	0	0	0	0	0	0	0	0	0	0	0
Mediomastus ambiseta	39250	40	0	0	0	10	34480	0	114000	6920	28560
Nephtys caeca	0	0	0	0	0	0	0	0	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A “C” under “subsample factor” indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	16	17-1	17-2	18	19	21-1	21-2	22	23	24	25	26	27
Species													
ANTHOZOA													
Cerianthus borealis	0	40	0	0	600	0	0	0	40	0	110	0	80
Edwardsia elegans	0	0	0	0	0	0	0	0	0	0	30	0	0
NEMERTEA													
Amphiporus sp 1	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphiporus sp 2	0	0	0	0	0	0	0	0	0	0	10	0	0
Cerebratulus sp.	20	0	0	0	40	0	0	0	1240	60	400	40	0
Nemertean sp 3	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemertean unid	10	0	80	0	0	0	0	0	0	0	0	0	0
Protodrilidae sp. 1	4620	0	0	0	0	490	9830	10890	7800	0	0	0	0
Saccoglossus ?	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanaidacea	40	0	0	0	0	100	70	0	0	0	0	0	0
Harpacticoidea	0	0	0	0	0	0	0	0	160	0	0	0	0
Ostracods	0	0	0	0	0	0	0	0	1920	10	0	0	0
Phoronis architechta	220	80	0	0	40	0	0	0	0	0	0	0	40

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	28	29-1	29-2	30-1	30-2	31	32	34	35	36	37
Subsample factor	C			2	2		4,C	4	4,C	4	4,C
BIVALVIA											
Arctica islandica	0	0	0	0	0	0	0	0	0	0	0
Astarte undata	0	0	0	0	0	0	0	0	0	0	0
Cerastoderma pinnulatum	30	0	0	0	0	0	0	0	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0
Ensis directus	0	0	0	0	0	0	0	0	0	0	0
Mercenaria mercenaria	10	0	0	0	0	0	0	0	0	0	160
Mya arenaria	0	0	0	0	0	0	0	0	0	0	0
Nucula delphinodonta	0	10	0	0	0	0	0	0	0	0	0
Tellina agilis	0	0	0	0	60	0	0	0	160	40	0
Thyasira flexuosa	0	0	0	0	0	0	0	0	0	0	0
Yoldia limatula	320	0	0	0	0	0	0	0	0	160	40
Bivalve juv.	0	0	0	0	0	0	0	0	0	120	0
GASTROPODA											
Acteocina canaliculata	300	0	0	0	0	0	40	40	4520	120	80
Hydrobia ? totteni	0	0	0	0	0	0	0	0	0	0	0
Lunatia triseriata	0	0	0	0	0	0	0	0	0	0	0
Lunatia sp.	0	0	0	0	0	0	0	0	0	0	0
Nassarius trivittatus	30	0	0	0	0	0	0	0	0	0	0
Sayella ? fusca	0	0	0	0	0	0	0	0	0	0	0
Turbonilla interrupta	0	0	0	0	0	0	0	0	0	0	0
POLYPLACOPHORA											
Ischnochiton rubra	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA											
Ampharete lindstroemi	0	0	0	0	0	0	0	0	0	0	0
Anobothrus gracilis	0	0	0	0	0	0	0	0	0	0	0
Aricidea catherinae	0	0	0	0	0	0	0	0	0	0	0
Brada villosa	0	0	0	0	0	0	0	0	40	0	0
Capitellidae	0	0	0	0	0	0	0	0	0	0	0
Capitata capitella	0	0	0	0	0	0	0	0	0	0	0
Cirratulidae	0	0	0	0	0	0	0	0	0	0	0
Clymenella torquata	0	0	0	0	0	0	0	0	0	0	0
Eteone longa	0	0	0	0	0	0	0	0	320	0	80
Euchone elegans	320	0	0	0	0	0	0	0	0	0	1200
Eusthenelais limicola	0	0	0	0	0	0	0	0	0	0	0
Exogone hebes	0	0	0	0	0	0	0	0	40	0	0
Glycera capitata	0	0	0	0	0	0	0	0	0	0	0
Glycera dibranchiata	0	0	0	0	0	0	0	0	0	0	0
Laonome kroyeri	0	0	0	0	0	0	0	0	0	0	0
Lumbrineris fragilis	0	0	0	0	0	0	0	0	0	0	0
Maldanidae	0	0	0	0	0	0	0	0	0	0	0
Marenzellaria viridis	0	0	0	0	0	0	0	0	0	0	0
Mediomastus ambiseta	39250	40	0	0	0	10	34480	0	114000	6920	28560
Nephtys caeca	0	0	0	0	0	0	0	0	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	28	29-1	29-2	30-1	30-2	31	32	34	35	36	37
Species											
Nephtys longosetosa	0	0	0	0	0	0	0	0	0	0	0
Nephtys incisa	480	90	20	60	160	20	160	40	40	560	200
Nereis succinea	0	0	0	0	0	0	0	0	40	0	0
Ninoe nigripes	340	0	0	0	0	0	160	0	640	280	560
Owenia fusiformis	0	0	0	0	0	0	0	0	0	0	0
Paraonis fulgens	0	0	0	0	0	0	0	0	0	0	0
Pherusa affinis	0	0	0	0	0	10	0	0	0	0	0
Phloe minuta	10	0	0	0	0	0	0	0	880	0	120
Phyllodoce arenae	0	0	0	0	0	0	0	0	40	0	0
Phyllodoce maculata	0	0	0	0	0	0	0	0	0	0	0
Phyllodoce sp.?	0	0	0	0	0	0	0	0	0	0	0
Polychaete unid.	0	0	0	0	0	0	0	0	0	0	0
Polydora cornuta	0	0	0	0	0	0	0	0	0	0	0
Polydora quadrilobata	0	0	0	0	0	0	40	0	0	0	720
Polydora sp. 1	0	0	0	0	0	0	0	0	0	0	0
Prionispio sp.	0	0	0	0	0	0	0	0	0	0	0
Sabellidae unid	0	0	0	0	0	0	0	0	0	0	80
Scolelepis squamata	100	0	0	0	0	0	0	0	1280	0	40
Scoloplos armiger	0	0	0	0	0	0	0	0	0	0	0
Spiophanes bombyx	0	0	0	0	0	0	0	0	200	0	40
Tharyx acutus	400	0	0	0	0	0	320	0	80	0	120
HIRUDINEA sp.	10	0	0	0	0	0	0	0	0	0	0
AMPHIPODA											
Ampelisca vadorum	0	0	0	0	0	0	0	0	0	0	0
Leptocheirus pinguis	0	0	0	0	0	0	0	0	120	0	0
Orchomenella minuta	0	0	0	0	0	0	0	0	240	0	0
Photis reinhardi	0	0	0	0	0	0	0	0	360	0	0
Phoxocephalus holbolli	0	0	0	0	0	0	0	0	0	0	0
Unicola irrorata	0	0	0	0	0	0	0	0	0	0	0
ISOPODA											
Chiridotea tuftsi	0	0	0	0	0	0	0	0	0	0	0
Edotea montosa	10	0	0	0	0	0	0	0	4520	0	0
Idotea phosphorea	0	0	0	0	0	0	0	0	0	0	0
CUMACEA											
Diastylis polita	20	0	0	0	0	0	0	0	0	0	0
Diastylis sculpta	20	0	0	0	0	0	0	0	0	0	0
Diastylis sp.	0	0	0	0	0	0	0	0	0	0	0
Eudorella truncatula	0	0	0	0	0	0	0	0	0	0	0
Oxyurostylis smithi	0	0	0	0	0	0	0	0	120	0	0
Pseudoleptocuma minor	0	0	0	0	0	0	0	0	0	0	0
ECHINODERMATA											
Echinarachnius parma	0	0	0	0	0	0	0	0	0	0	0
S. droebachensis	0	0	0	0	0	0	0	0	0	0	0
DECAPODA											
Crangon septemspinosa	0	0	0	0	0	0	0	0	0	0	0

Table A3 (cont.). Abundance (number/m^2) of seabed organisms at Sydney Harbour Stations, October 1999. A "C" under "subsample factor" indicates subsampling of highly numerous organisms at the identification stage (see text).

Station	28	29-1	29-2	30-1	30-2	31	32	34	35	36	37
Species											
ANTHOZOA											
Cerianthus borealis	200	40	10	0	200	60	0	0	320	80	40
Edwardsia elegans	20	0	0	0	0	0	0	0	0	0	0
NEMERTEA											
Amphiporus sp 1	0	0	0	0	0	0	0	0	0	0	0
Amphiporus sp 2	0	0	0	0	0	0	0	0	0	0	0
Cerebratulus sp.	80	10	10	0	0	50	360	0	480	0	1360
Nemertean sp 3	0	0	0	0	0	0	0	0	0	0	0
Nemertean unid	0	0	0	0	0	0	80	0	0	0	0
Protodrilidae sp. 1	0	0	0	0	0	0	40	0	0	0	0
Saccoglossus ?	0	0	0	0	0	0	0	0	0	0	40
Tanaidacea	0	0	0	0	0	0	0	0	0	0	0
Harpacticoidea	0	0	0	0	0	0	0	0	0	0	40
Ostracods	0	0	0	0	0	0	0	0	5560	0	0
Phoronis architechta	220	0	0	0	0	600	120	0	0	80	2280

Table A4. Dominant species for subdivisions of Sydney Harbour from P. Lane and Associates (1988 & 1989).

Inner Sydney Harbour

April 1987
Number of Stations=3

Species	Abundance	%
Sabella sp.	43	84.3
Pectinaria gouldii	3	5.9
Mytilus edulis	2	3.9
Nereis virens	1	2.0
Placopecten magellanicus	1	2.0
Nephtys sp.	1	2.0

August 1987
Number of Stations=3

Species	Abundance	%
Myxicola infundibulum	62	45.9
Buccinum sp	27	20.0
Pectinaria gouldii	22	16.3
Nephtys sp.	5	3.7
Littorina sp.	5	3.7
Cerastoderma pinnulatum	3	2.2
Mytilus edulis	3	2.2
Yoldia limulata	3	2.2
Hoploscolopos robustus	2	1.5
Ninoe nigripes	1	0.7
Micrura leidyi	1	0.7
Edwardsia elegans	1	0.7

August & November,1988
Number of Stations=3

Species	Abundance	%
Sabella sp.	43	84.3
Pectinaria gouldii	3	5.9
Mytilus edulis	2	3.9
Nereis virens	1	2.0
Placopecten magellanicus	1	2.0
Nephtys sp.	1	2.0

Northeast and Central Sydney Harbour

April 1987
Number of Stations=10

Species	Abundance	%
Myxicola infundibulum	122	61.0
Buccinum sp	23	11.5
Pectinaria gouldii	17	8.5
Astarte sp.	14	7.0
Littorina sp.	6	3.0
Mytilus edulis	5	2.5
Placopecten magellanicus	5	2.5
Capitella capitata	3	1.5
Nephtys sp.	2	1.0
Polydora sp.	2	1.0
Nematostella vertensis	1	0.5

August 1987
Number of Stations=6

Species	Abundance	%
Myxicola infundibulum	26	31.7
Buccinum sp	16	19.5
Pectinaria gouldii	15	18.3
Mytilus edulis	6	7.3
Nephtys sp.	3	3.7
Yoldia limulata	3	3.7
Cerastoderma pinnulatum	3	3.7
Cerianthus borealis	2	2.4
Nematostella vertensis	2	2.4
Edwardsia elegans	2	2.4
Lineus arenicola	2	2.4
Astarte sp.	1	1.2
Nereis virens	1	1.2

August and November 1988
Number of Stations=11

Species	Abundance	%
Myxicola infundibulum	15	17.6
Scolecolepides viridis	10	11.8
Pectinaria gouldii	7	8.2
Ceriantharian sp.	7	8.2
Nephtys sp.	6	7.1
Capitella capitata	4	4.7
Sabella sp.	4	4.7
Nereis diversicolor	4	4.7
Scoloplos acutus	3	3.5
Placopecten magellanicus	3	3.5
Buccinum sp	3	3.5
Pholoe minuta	2	2.4
Nematode	2	2.4
Lineus arenicola	2	2.4
Haploscolopos robustus	2	2.4
Naineris quadricuspida	2	2.4
Tharyx sp.	1	1.2
Aricidea sp.	1	1.2
Astarte sp.	1	1.2
Malacobdella grossa	1	1.2
Littorina sp.	1	1.2
Mytilus edulis	1	1.2
Prionospio streenstrupi	1	1.2
Nereis virens	1	1.2

Note: Scolecolepides viridis = Marenzellaria viridis
Hoploscoloplos = Scoloplos