MACROBENTHIC SUCCESSION AND CHANGES IN SEDIMENT BIOGEOCHEMISTRY FOLLOWING MARINE FISH FARMING

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Doctor of Philosophy
by

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I'd like a worm named after me,
one with six eyes and a hairy knee.
I'd like a worm named after me,
one with antennae and a big, big bellie.
I'd like a worm named after me,
make sure it's not cute, cos I'll puke.
I'd like a worm named after me,
make sure it's a HE and not a SHE!

M.Heasman, October 96

SUMMARY

Following cessation of fish production at a fish farm site in Loch Creran, Scotland, a study of the recovery of the benthic environment was undertaken. Sediment samples for macrofauna and physicochemical parameters (Redox potential; organic carbon and nitrogen; oxygen and nutrient fluxes; sulphide and pH depth profiles; particle size) were collected every 5 weeks from 3 stations at various distances from a fallowed fish farm site for 14 months. The data collected were analysed by a combination of uni- and multi-variate statistical methods. Macrobenthic communities in the 2 stations furthest from the fish cage site showed signs of recovery with time in terms of species diversity, indicator species, number of species and abundance, being moderately to slightly disturbed at the end of this study. At the station nearest to the fish cage site recovery of the macrobenthic community was also evident, although this station was still highly impacted 15 months after fish production ceased, with opportunistic species dominant. Changes in the chemical parameters were most apparent during the first 2 months. Fourteen months after fallowing, highly reduced conditions were still persistent in subsurface sediments at all stations. Bulk sediment organic carbon, redox potential and the UK Infaunal Trophic Index, although indicators of a spatial gradient, were not found to be significant indicators of recovery. Oxygen uptake appeared to be the main factor conditioning early stages of recovery, although combinations of different environmental parameters were found to be related to different stages of recovery. The seasonal timing of fallowing and the initial condition of the sediment appeared to be important in the evolution of the recovery. The exclusion of nematodes as a bulk taxon from the multivariate analyses made no difference to the conclusions.

CONTENTS

1. INTRODUCTION

The expansion of coastal marine aquaculture in northern Europe has been predominantly through the intensive net cage production of salmonids (Gowen & Rosenthal, 1993). In some countries the increase in production over the last decade has been dramatic. In Scotland, Atlantic salmon production was 12,700 tonnes in 1987, but was predicted to reach 100,100 tonnes in 1997 (SOAEFD, 1996). This expansion has led to growing concerns about environmental impacts on the marine environment.

Intensive cultivation generates large amounts of organic and inorganic waste (uneaten food, faecal and excretory material) all of which are continually produced and released from point sources into the environment although changing in amount through the growth cycle (2 years). The pelagic environment appears rather unaffected at most sites due to the rapid dilution of waste products (Gowen & Ezzi, 1992; Holmer & Kristensen, 1992) whereas the sedimentation of particulate waste products may lead to an elevated level of organic matter in the sediment underneath the net cages. Gowen and Bradbury (1987) estimated that the deposition of organic waste beneath a fish farm could be as high as 10 kg m^{-2} per year directly beneath the cages and 3 kg m^{-2} per year in the immediate vicinity of the farm.

Although generalisations on the degree of impact of fish farm waste on the sediment are difficult due to the differences in operating procedures, stocking density, feeding regimes, bottom topography, currents around the

culture facility and depth (Black *et al.*, 1996), the deposition of organic waste results in physical, chemical and biological changes in the substrate.

Site characteristics

The initial development of fish farming in Scotland took place in protected sea-lochs. While these natural structures provide suitable locations for cage farming in terms of the proximity of deep water to the shore and shelter, they have a number of distinct physical features which can compound the ecological effects of the waste released from cage farms.

Sea-lochs were glacially formed and exhibit very characteristic deep U-shaped valleys surrounded by hills. Due to their restricted exchange, sea-loch hydrography may be driven by wind and density rather than by tides, and currents are frequently weak. Indeed, maximum current speeds as little as 16 cm s^{-1} were found in a number of Scottish fish farms (Gowen *et al.*, 1988). Sea-lochs typically have deep basins separated from the sea by one or more shallow sills. In these basins the water below the sill depth may be retained for varying periods by a density gradient (Overnell & Young, 1995). Furthermore, the high input of organic matter from primary production and from terrestrial origin together with the depositional characteristics of sea-lochs, make them naturally organically enriched areas compared to other coastal zones.

Organic carbon and nitrogen compounds (carbohydrates, lipids, proteins) form the bulk of the waste food and faeces. Both waste food and faeces are more dense than sea water (Gowen & Bradbury, 1987) and unless dispersed

by strong tidal flows, will sink to the sediment in the immediate vicinity of the farm and decay. Gowen and Bradbury (1987) suggested that the area of seabed over which the fish farm waste will be dispersed will depend on the surface area of the farm, settling velocity of uneaten food and faeces, current speeds and depth of water beneath the farm. In general loading will be high beneath fish farms and the scale of effect will, in most cases, be restricted to the immediate vicinity of the farm. Some studies have shown that the effects of fish farm waste are negligible beyond a distance of about 30 to 40 m (Holmer & Kristensen, 1992; Hall *et al.*, 1990) and even 15 m from the fish cages (Brown *et al.*, 1987). Weston (1990), however, observed that while the alterations of sediment chemistry, as a result of organic enrichment, were evident only to a distance of 45 m from the farm, benthic community effects were apparent to a distance of at least 150 m.

Impacts of organic enrichment on sediment chemistry

The majority of coastal marine sediments have a thin oxic layer overlying an anoxic layer in which reducing processes predominate. The thickness of the oxygenated layer can be measured as the depth of the "redox-potential-discontinuity" (RPD), a layer where oxidising processes become displaced by reducing processes (Fenchel & Riedl, 1970). The depth of the RPD is determined by a balance between the consumption of oxygen during the aerobic decomposition of organic matter by micro-organisms and its supply from overlying water. The relationship between the RPD and other chemical properties is summarised in Fig. 1.

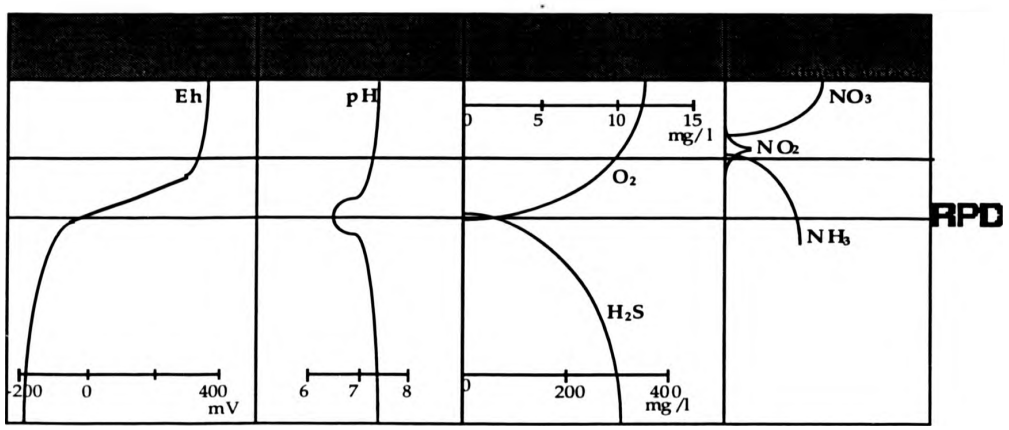


Fig. 1. Vertical distribution of some compounds and ions in sediments related to profiles of redox potential (adapted from Rhoads, 1974).

The reducing capacity of the sediment depends on the degree of enrichment and can be assessed by measuring the redox potential in the sediment (Pearson & Stanley, 1979). Sandulli and Nicola (1991) used the redox potential of the sediment to assess the effects of untreated domestic sewage and found that in the proximity of the outfall the sediment became highly reducing with redox levels as low as -220 mV at 1 cm depth. Redox potentials as low as -186 mV at 4 cm depth have been measured in the sediment beneath fish cages (Brown *et al.*, 1987) indicating that fish farm waste is produced in sufficient quantity to cause the sediment to become highly reducing.

Food components, together with the by-products of metabolism, are potential waste products. Thus fish farm waste will include organic carbon and nitrogen (carbohydrate, lipid and protein), ammonium, urea, bicarbonate, phosphate, vitamins, therapeutants and pigments (Gowen & Bradbury, 1987). Increases in the sedimentary content of organic and inorganic carbon, nitrogen and phosphorus from waste food and faeces can

therefore be expected. When attempting to construct a carbon budget for a marine fish farm, Hall *et al.* (1990) determined that 23 to 69% of the total carbon input to the farm was lost and accumulated in the sediment beneath the cages, leading to an organic enriched sediment with organic carbon 10 to 15 times compared with the sediment 20 m outside the farm. Kaspar *et al.* (1988) found that the sediment under the net cages contained 3 times more organic nitrogen than the sediment 10 m away from the cages. Holby and Hall (1991) have shown that 47-54% of the total phosphorus input to the environment from a fish farm accumulated in the sediment and that, on a seasonal basis, the benthic flux transferred only 4-8% of the sedimented phosphorus back to the overlying water. Furthermore, phosphorus shows an almost constant distribution with depth in farm sediment and decreases rapidly in the underlying sediment layer approaching the concentrations observed outside the farm (Holby & Hall, 1991) thus being considered a good indicator of the thickness of the sediment layer originating from the farm.

The input of organic-rich material from fish farms stimulates microbial activity in the underlying and surrounding sediments (Holmer, 1991) and, therefore, the oxygen demand for microbial processes and for reoxidation of reduced products increases. In highly organically enriched sediments such as those found under active fish farms, the oxygen demand often exceeds the diffusive flux into the sediment, which becomes anoxic. As a result, the balance between oxidation and reduction processes changes and the latter become the dominant pathway for the turnover of organic matter (Gowen & Rosenthal, 1993). Of these processes, sulphate reduction is likely to be the

most important, at least initially, with methanogenesis also playing an important role in the decomposition of particulate waste (Westrich & Berner, 1984; Hall *et al.*, 1990; Holby & Hall, 1991; Holmer & Kristensen, 1992). This phenomenon is observed at the farm as a migration upwards of the RPD and by a depletion of oxygen in the bottom water (Brown *et al.*, 1987; Holmer & Kristensen, 1992) or by the presence of white mats of sulphide oxidising bacteria, *Beggiatoa* spp., covering the seafloor (Weston, 1990; Hall *et al.*, 1990; Brown *et al.*, 1987). *Beggiatoa* spp. are filamentous bacteria which oxidise hydrogen sulphide in the environment to elemental sulphur, and are therefore dependent on both abundant supplies of hydrogen sulphide and oxygen (Holmer, 1991). They are thus restricted to areas on the seabed where sulphide produced within anoxic sediments diffuses into overlying oxygenated water.

Anaerobic processes result in the production of reduced compounds (ammonium, hydrogen sulphide and methane) which, if produced in sufficient quantities, can be released from the sediment (Brown *et al.*, 1987; Hall *et al.*, 1990). Average rates of ammonium released from sediments under fish farm cages were found to be up to 27 times higher than background values (Hargrave *et al.*, 1993). Samuelsen *et al.* (1988) showed that the composition of gas leaving the sediment surface was 70-90% methane, 10-30% carbon dioxide and 1-2% hydrogen sulphide. Hydrogen sulphide is toxic to fish in small concentrations and out-gassing of this from the sediments beneath fish farms may have a detrimental effect on fish health (Kiemer *et al.*, 1995). However, Samuelsen *et al.* (1988) found that most of the hydrogen sulphide is oxidised by the time the bubbles have

reached a height of 10 m above the seabed. Furthermore, hydrogen sulphide has never been detected within fish cages. It has been suggested, however, that although the causes remain unproven, the ecological change induced by fish farms may cause a deterioration in fish health (Black *et al.*, 1996; Gowen, 1991).

Impacts of organic enrichment on the benthic community

The main impact of organic loading is a stimulation of benthic sediment metabolism, e.g. microbial activity, oxygen uptake and nutrient release. The penetration of oxygen into the sediment decreases and the sediment becomes increasingly reduced towards complete anoxia. Benthic community structure changes towards dominance by pollutant-tolerant species and may even become azoic (Holmer, 1991).

Macrobenthos

Classical models of the impact of organic enrichment on macrobenthic communities (Pearson & Rosenberg, 1978) predict a number of stages between an unpolluted and a grossly polluted situation. As levels of organic enrichment increase faunal abundance and diversity may initially rise. As levels of organic enrichment increase further, first diversity and then abundance decline (Fig. 2).

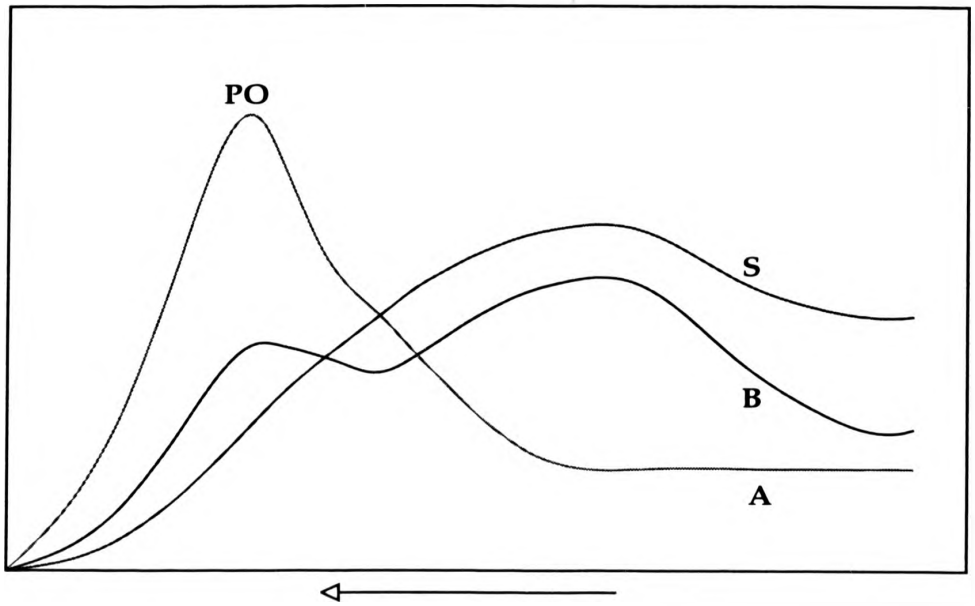


Fig. 2. Schematic illustration (SAB-curve) of the changes in faunal species number (S), abundance (A) and biomass (B) along a gradient of organic loading of the sediment. PO illustrates the peak of opportunist species (after Pearson & Rosenberg, 1978).

Studies of impacts on macrobenthic communities in fish farm sediments are less common and results are highly variable, probably due to the different methodologies used and to different hydrographic properties of the sites studied. In some sediments a clear correlation is found between changes in fauna and organic input (Brown *et al.*, 1987; Weston, 1990), whereas other studies are more inconsistent (Ye *et al.*, 1991). The general indicator is that the most pronounced effects are seen at locations with low water exchange and high fish production, whereas in areas with high water currents and no accumulation, the sediment communities may remain unaltered (Holmer, 1991). The overall trend is towards a depleted fauna directly beneath the net cages and in the immediate vicinity. With

increasing distance from the cages the most pollutant-tolerant species, such as *Capitella capitata* and *Malacocerus fuliginosus*, appear, often in very high numbers, developing a peak in total faunal biomass. Further away a more diverse community is found. The number of species increases and less pollutant-tolerant species are observed. It may be possible to measure a zone of biostimulation, where total abundance is higher than under undisturbed conditions. This is due to an increase in biological activity due to a higher organic pool, but without the introduction of critical oxygen levels and reduced conditions in the sediment.

Brown *et al.* (1987) identified four zones of effect of fish farm waste. Directly beneath the cage there was an azoic zone. From the edge of the cage to a distance of less than 8 m was a highly "enriched" zone characterised by low species diversity and dominance of opportunistic polychaetes. A slightly enriched "transitional zone" occurred between 8 and 25 m and a zone which was considered to exhibit normal conditions at distances greater than 25 m. Other studies find more complicated connections between sedimentation and benthic community structure. Ye *et al.*(1991) found an input of organic waste products as far as 60 m from the cages, whereas the benthic community was undisturbed 30 m away. Norwegian studies (Aure *et al.*, 1988; cited in Braaten, 1991) found large differences between each farm and concluded that it was necessary to examine each farm separately in relation to topographic and hydrographic factors. Danish studies (Christensen & Horsted, 1991; cited in Braaten, 1991) found that at 2 fish farms located in shallow water (5-10 m), it was impossible to find any connection between the benthic community structure and the dispersion of

waste products. One of the farms was situated at a location with relatively high water currents compared to other investigations (Gowen *et al.*, 1988), but at the other farm, water currents were of a similar order of magnitude. Weston (1990) found no azoic zone and no "peak of opportunists" as described in the Pearson and Rosenberg (1978) model (Fig. 2) but current velocity in the area was very high when compared to Scottish studies.

In addition to organic input, hydrographic and topographic conditions, the type of sediment must also be considered when studying macrofaunal communities under fish farms. Olsgard (1984; cited in Holmer, 1991) concludes that the particle size distribution in the transitional zone sediment seems to have more influence on the community structure than the input of waste products from the fish farm. Brown *et al.* (1987) found a correlation between mean particle size and the distribution of some polychaetes, when data from the transitional zone and "normal" sediment were studied.

Little consideration has been given by the authors to the effect of organic enrichment on macrobenthic epifauna. Migration away from, or into a polluted area may take place rapidly depending on the tolerance of individuals and so the distribution of epifaunal species in enriched areas does not follow the same pattern as infauna (Pearson & Rosenberg, 1978).

Meiobenthos

In recent years, the meiofauna of marine sediments has received an increasing interest for its potential in biomonitoring studies. In particular,

high sensitivity, rapid turnover rate, quick response, life cycles entirely spent in sediment and relative population stability, represent the main characteristics that make meiofauna a valid means of assessing the impact of environmental stress. Nevertheless, no studies on the impact of fish farm waste on meiobenthos have been published, probably due to the taxonomic difficulties related to species identification of many meiobenthic organisms. Recent studies, however, suggest that this taxonomic limitation may be reasonably overcome since the identification at level of genus and even class or phylum may provide sufficient information on pollution responses (Warwick, 1988; Herman & Heip, 1988; Warwick *et al.*, 1990).

Of the major taxa present (Nematoda, Copepoda, Oligochaeta, Polychaeta, Ostracoda, Kinorhyncha, Priapulida), the nematodes usually predominate and, together with the copepods, comprise the vast majority of the meiofaunal animals (Warwick, 1981). It is not surprising, then, that when studying the impact of organic enrichment on meiobenthos these two taxa are, generally, the only ones considered.

The meiofauna have different mechanisms of dispersal from those of macrofauna and therefore might exhibit a different response to organic enrichment. However, in at least some situations, the meiofauna exhibit a similar response (Moore *et al.*, 1987). In general, within the meiofauna as a whole there is, initially, a decrease in species diversity and an increase in abundance with increasing organic enrichment. At high levels of organic enrichment, however, there is a decrease in both the abundance and diversity of species and an increase in species dominance. In particular, a

differential response within each major component of the meiofauna is found. The nematode assemblage decreases in abundance with increasing organic enrichment, being absent at high levels, but shows very little structural change. The harpacticoid copepod component, however, shows significant structural changes with the increasing pollution gradient. Many non-interstitial (epi- and endo-benthic) harpacticoid species are very tolerant and may even reach very high abundance in organically enriched areas (Sandulli & Giudici, 1990). Such forms, being larger and provided with more robust pereiopods than mesobenthic species, are capable of more rapid and free movement permitting periodic retreat from heavily contaminated zones. By contrast, the typically interstitial (mesobenthic) forms with smaller body size, often maintaining obligatory associations with the sediment grains, suffer heavily in eutrophic situations (Marcotte & Coull, 1974; Gee *et al.*, 1985; Vidakovic, 1983; Sandulli & Giudici, 1989; Sandulli & Nicola, 1991).

Fallowing and recovery

Fallowing in marine fish culture involves the removal of all fish and nets from sea cage sites for different periods of time (Table I). When using this technique for disease control, production is usually interrupted for only a few months (Bron *et al.*, 1993; SOAEFD, 1996). Fallowing can also be used to reduce the build up of sediments beneath the cages and thus minimise any potential risk of 'self-pollution' (Beveridge, 1987; Lumb, 1989). This is achieved either by repositioning the cages or by alternately farming two separate sites (Dixon, 1986), usually for 12 to 24 months (1 growing cycle), and is more commonly known as 'site rotation'. The frequency of which a

site is rotated varies considerably depending on company policy and farming pressure.

Table I. Number of sea cage sites employing a fallow period in 1993-1995 from the total number of sites engaged in salmon production in Scotland. (From SOAEFD, 1996)

Year	Fallowing period (weeks)					Total number of sites
	<4	4-8	8-26	26-51	≥52	
1993	7	47	74	13	86	362
1994	13	48	64	12	103	358
1995	14	60	73	6	91	354
1996	12	71	70	13	56	334

Although the spatial effect of marine fish farms on the sediment chemistry and benthos has been well reported, only accidental accounts of temporal changes over fallowing periods have been published. Lumb (1989) found that no significant benthic macrofaunal recolonization apparent 1 year after the fish cages were removed, although Ritz *et al.* (1989) observed a 7 week period for recovery from moderately disturbed to undisturbed sediment conditions. Recovery studies with other sources of organic enrichment that show the same spatial effect as fish farm waste such as domestic sludge waste (Eleftheriou *et al.*, 1982; Moore & Rodger, 1991), pulp mill waste (Christie & Green, 1982; Rosenberg, 1972, 1973, 1976) and oil (Cabioch *et al.*, 1982; Gray, 1982) show biological parameters (diversity, abundance and number of species) to be similar to background after 3 to 12 or more years depending on the degree of contamination and on hydrographic parameters.

Study aims

The outputs from fish farms cause localised pollution effects which have detrimental effects on the benthic biota. Based on studies on pulp mill waste, Pearson & Rosenberg (1978) suggested that structural faunal changes are similar in both temporal and spatial gradients. However, the effects of permanent changes on the physical and biological properties of the sediment and the amount of time required for recovery to take place are yet to be quantified. The general aim of this study was to investigate the effect and time scale of the cessation of the input of fish farm waste on the sediment chemical processes and macrobenthic succession. Uni- and multivariate analyses were used to attempt to understand sediment-animal relationships and thus which individual or group of chemical parameters were the main restrictions to recovery.

Sensitive/tolerant species have been widely used as pollution indicators. Macrobenthic species respond quickly to pollution gradients, and some species of polychaetes are recognised as general indicators of highly enriched systems. As organic enrichment diminishes the effect of other variables will become more significant and indicator species will have only local significance. An aim of this work was to determine which species are indicative of decreasing organic enrichment at the site studied.

Although nematodes are the main constituent of meiobenthic samples and used as pollution indicators, they are often excluded from macrobenthic analysis, especially when present in a disproportionately elevated number.

Therefore this study also assessed the consequences of including or excluding this phylum from analyses.

2. MATERIAL AND METHODS

2.1. Sediment sampling

Site selection

Three sampling stations were selected from the vicinity of a fish farm, located in Loch Creran, Scotland, that had been fallowed since July 1994. This loch is a semi-enclosed sea-loch with a constricted opening into the Lynn of Lorn, at the north end of the Firth of Lorn. The loch has two main basins separated by shallow sills (Fig. 3.1). The larger outer basin, in which the sampling site was located, is 9 km long and 49 m maximum depth, and the shallower inner basin is 3 km long and 27 m maximum depth (Anon, 1990). The loch is sheltered from wave action and has a freshwater runoff of $286.3 \times 10^6 m^3.year^{-1}$ (Edwards & Sharples, 1985), mainly from the river Creran which enters at the head of the Loch's upper basin. The fish farm was composed of 10 cages moored together. Each cage was a square structure (25x25 m) from which a net was hung to a depth of 11 m. Although the site had been previously fallowed (from March 1992 to March 1994), it had been used for fish farming for several years. The site resumed production in May 1996.

Stations were selected to be characteristic of a sediment with high organic enrichment under the influence of the fish farm, a medium enriched sediment still under the influence of the fish farm and a sediment where the organic enrichment was characteristic of the site under study but with no influence from the fish farm. In order to select these sampling stations, preliminary

transects were set in July 1994 while the fish cages were still in place. The degree of organic enrichment was assessed by measuring redox potential profiles, based on a technique developed by Pearson & Stanley (1979). Observation *in situ* of the sediment by divers was also taken into consideration. The stations selected follow a gradient of impact from the former cage location with station A at 30 m south east from one of the cage groups, station B at the south east edge of the same cage group and station C at the south west edge of the cage group, 25 m from station B (Fig. 3.2). The stations selected were at 19±1.5 m water depth.

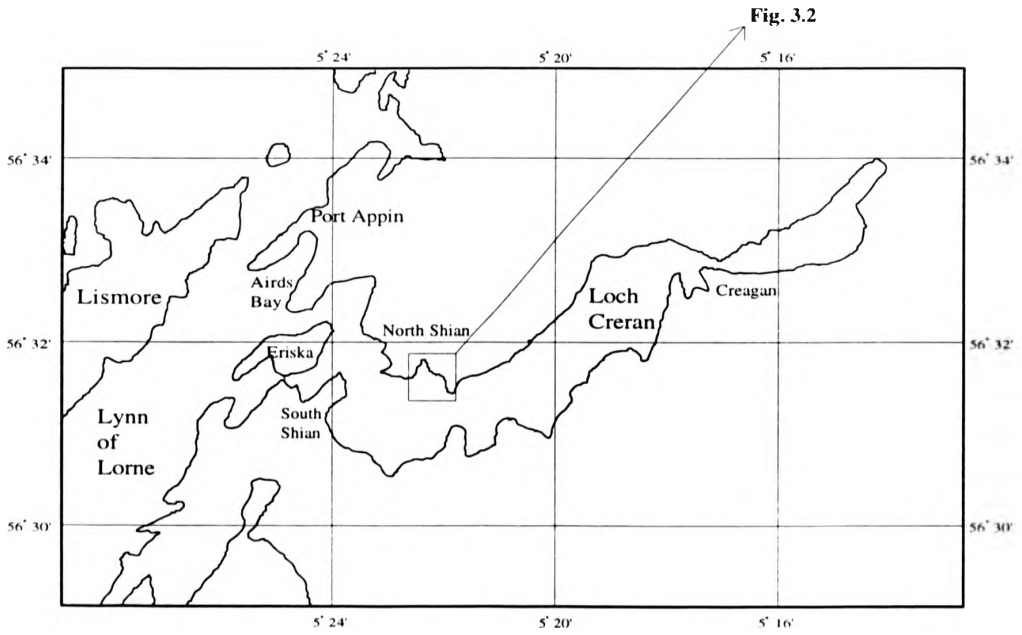


Fig. 3.1. Diagram showing Loch Creran and the study bay.

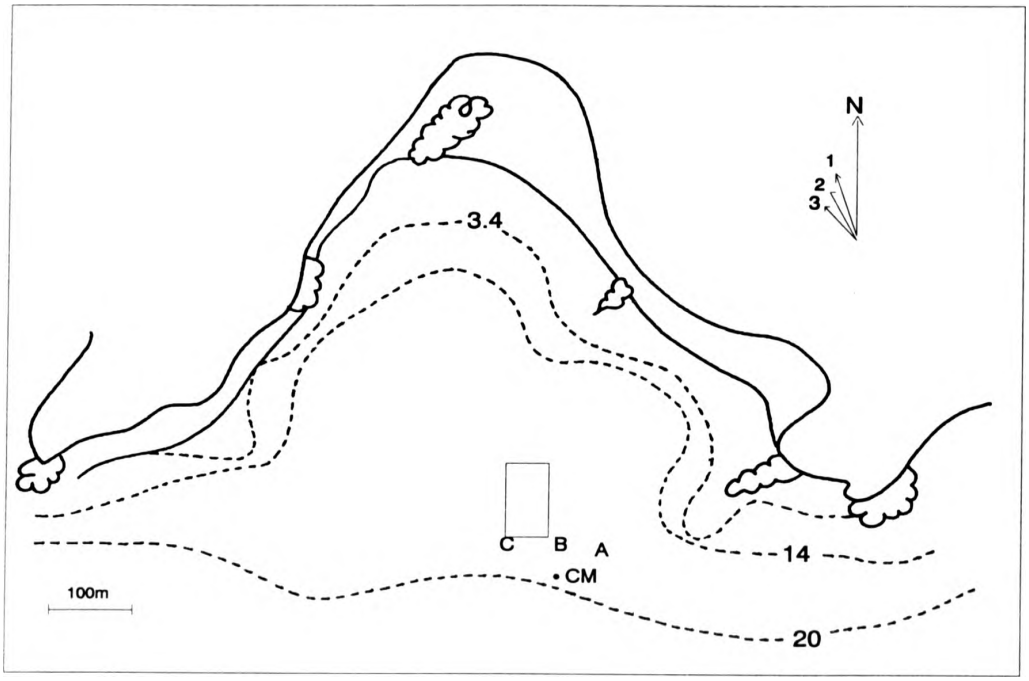


Fig. 3.2. Sampling site with stations A, B and C positions relative to the former fish cage. CM - Current meter mooring; 1, 2, 3- Direction of current as measured by the current meters deployed, respectively, at 2.5, 9.5 and 16.5 m water depth.

Sediment collection

It was planned to collect samples over 24 months, at 5 week intervals for the first year of the study, when the major changes in sediment biogeochemistry were expected to occur, and at 12 week intervals on the second year in order to encompass seasonal effects. However, the transect line was trawled 16 months into the study and thus no samples were available from October 1995.

Divers collected sediment samples using perspex core tubes (57 mm i.d. x 230 mm height). Care was taken so that the sediment sampled was not disturbed

by the preceding sample events, but still taken from a 4 m^2 area around the station marker. In most cases the cores penetrated the sediment to a depth of about 9 cm, the remaining core volume being filled with overlying water, capped with a rubber bung before extraction from the sediment, capped from underneath and transported undisturbed to the surface. Due to the depth of the stations limiting diving time to a maximum of 46 minutes per dive, the cores were collected in two dives, normally with an interval of two days (Table II).

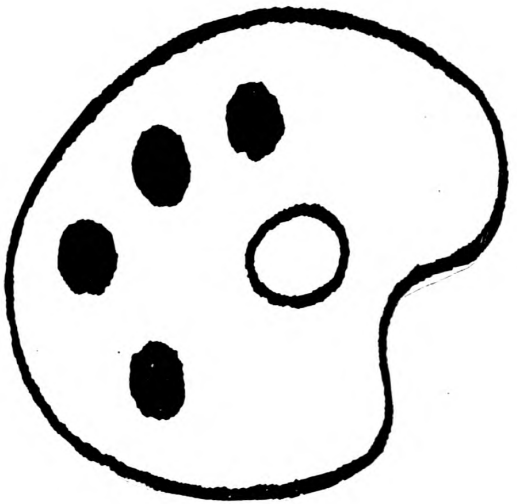
Table II. Dates of sampling

Date	Day	Samples	Notes
30-6-94	0	-	Production stopped
2-8-94	33	I	
4-8-94	35	II	
27-8-94		-	Cages dismantled
5-9-94	67	I	
8-9-94	70	II	High current
26-10-94	118	I	
28-10-94	120	II	
6-12-94	159	I	Scallop dredge; low visibility (0.5 m)
8-12-94	161	II	Low visibility (0.5 m)
24-1-95	208	I	
26-1-95	210	II	
27-2-95	242	I	
6-3-95	249	II	
10-4-95	284	I	
12-4-95	286	II	
26-5-95	330	II	
29-5-95	333	I	
3-7-95	368	I , II	
21-8-95	417	I , II	
11-10-95	468	I	
13-10-95	470	II	
Dec 95			transect removed

I - Samples for oxygen, hydrogen sulphide and nutrient fluxes; pore water nutrients; carbon and nitrogen; sulphide and pH
II - Samples for macrobenthos, redox potential and particle size

The cores with the samples for faunal and redox analysis were processed as soon as possible (either on the boat or the beach) and all remaining cores were

ORIGINAL IN COLOUR



transported by sea (uncapped) to the laboratory in aquaria supplied with a constant flow of seawater. In the laboratory the cores were maintained in the dark, uncapped, in two incubation tanks filled with sea water taken from the study site. The water was kept aerated (ca. 100% oxygen saturation) and at a temperature of 11±1°C. The overlying water in each core was constantly mixed using submersible magnetic stirring heads (Rank Bros., Cambridge) supported by vented core collars (Fig. 4).

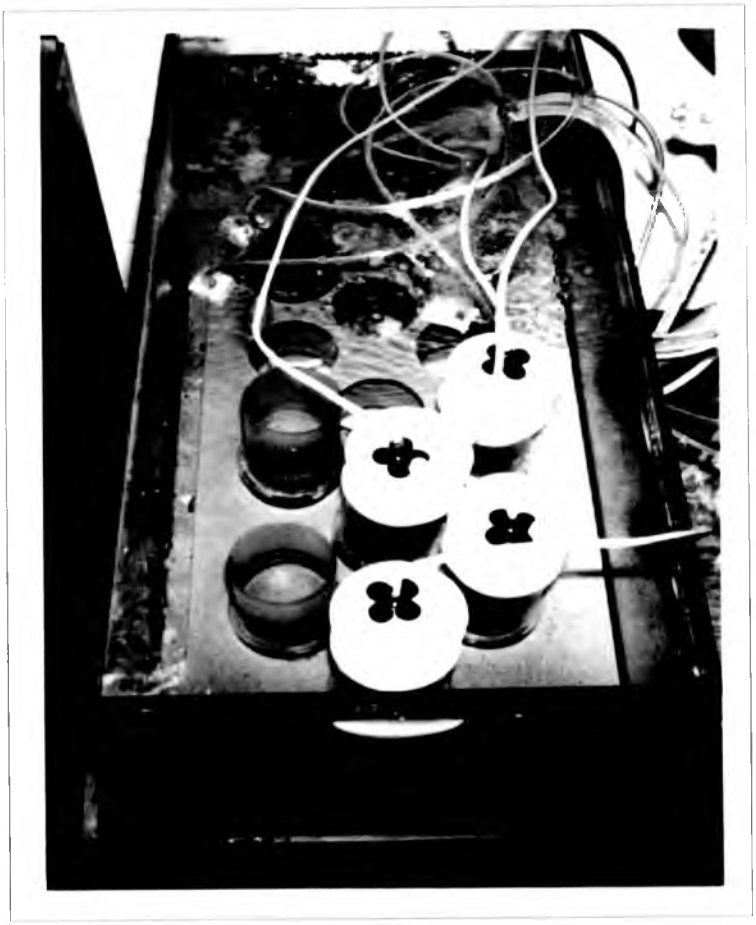


Fig. 4. Incubation system with sediment cores vented by submersible magnetic stirring heads.

2.2. Physical parameters

Hydrography

Three recording current meters (SD 2000, Sensordata Ltd., Bergen) were deployed on a U-shaped mooring (Fig. 5) at the sampling site (see Fig. 3.2 for approximate location) at different water depths (2.5, 9.5 and 16.5 m) on the 21st of December 1994 and were recovered on the 9th of January 1995. Measurements (current speed and direction and sea water temperature) were recorded every 20 minutes for an entire tidal cycle, with an averaging window of 4 min.

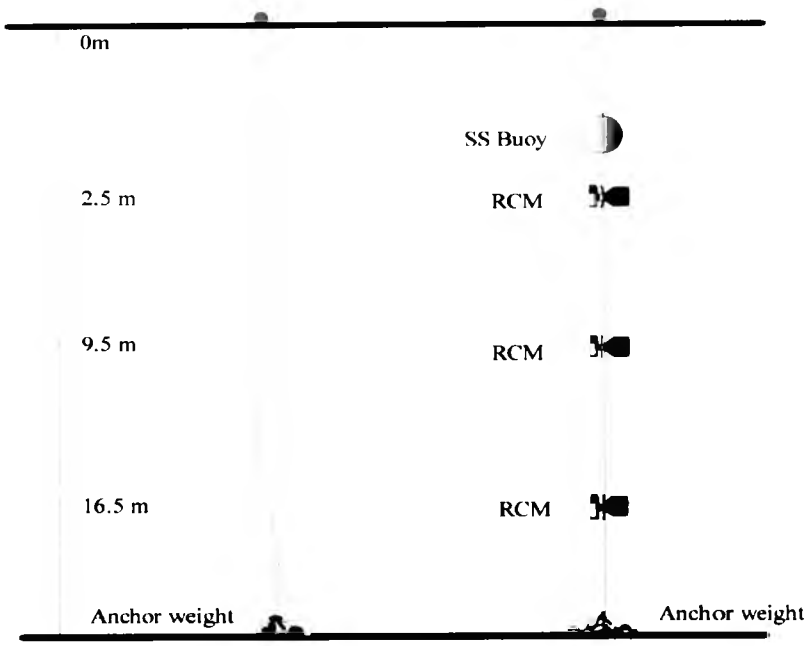


Fig. 5. Current meter mooring.

Sea water temperature

Sea water temperature was measured for each sampling trip with a digital diving depth meter (Uwatec, Switzerland) in the water overlying the sediment.

Particle size analysis

A Malvern Mastersizer/E (Malvern Instruments Ltd.) with a 300 mm lens was used to determine the particle size of wet sediment (1 - 2 g, sieved through a 500 μm mesh) taken at 3 cm intervals from all stations to a depth of 9 cm. Computed results (NEC PC 486SX running Mastersizer/E version 1.2a) were used for further analyses (See Appendix II for measures used).

2.3. Chemical parameters

Redox potential

Two sediment samples were collected per station for redox potential measurement. This parameter reflects the degree of reduction in the sediment as measured across a platinum electrode (type no. CMPtR106/300 mm, Russell pH Ltd., Auchtermuchty, Scotland) with reference to a standard (Zobell's solution) and serves as a guide to the chemical condition of the sediment and the degree of organic loading to which it has been subjected (Pearson & Stanley, 1979). Measurements were made each 0.5 cm from the surface to a depth of 7 cm and in the overlying water at 1 cm from the sediment. The readings were left to stabilise for at least 60 seconds (Pearson & Stanley, 1979).

Oxygen and nutrient flux

An initial 30 cm^3 water sample was taken for nutrient analysis from the overlying water in cores that were kept in the incubation tanks. The cores were subsequently sealed with a submersible stirrer head (Parkes & Buckingham, 1986) and two 10 cm^3 samples for oxygen analysis were taken immediately with glass syringes, fixed by adding manganese chloride and alkaline iodide and stored at less than 10°C prior to analysis. After 3 hours incubation, two further samples of 10 cm^3 were collected and fixed for oxygen analysis. Approximately 20 cm^3 of air was then introduced by hypodermic syringe into the water column to prevent hypoxia. The cores were left sealed for a further 15 hours after which time a final 30 cm^3 sample was taken for nutrient analysis. This sampling was carried out in duplicate.

The oxygen concentration in seawater was determined by a modified Winkler method (Grasshoff, 1983). After addition of manganese (II) chloride and alkaline iodine to the sample, a white precipitate of manganous hydroxide is generated which absorbs any oxygen to form a brown manganic oxide. After acidification manganese ions react with iodide to liberate iodine, in an amount equivalent to that of the original oxygen. The iodine is determined by titration with thiosulphate, with reference to a iodate standard (KI, 1.66 mM).

Samples were collected in 10 cm^3 glass syringes, taking care to avoid the introduction of air bubbles. Manganese(II) chloride (0.1 cm^3, 1.8 M) and alkaline iodide [0.1 cm^3, made of a solution of potassium iodide (3.6 M) and

potassium hydroxide (5.3 M)] were immediately introduced into the glass syringe by means of a small 1 cm^3 syringe with stainless steel needles. The needle tip was inserted almost to the bottom of the syringe and slowly withdrawn while the reagents were added. After each reagent addition the solution was thoroughly mixed. The samples were stored at constant temperature (4°C) in the dark for no more than 12 hours. Before titration, sulphuric acid (0.2 cm^3, 50% w/v) was introduced into the glass syringe and the contents mixed before being transferred into a conical flask. The titration with sodium thiosulphate (0.20 M) was then carried out. The reagents are described by Grasshoff (1983).

The water samples collected for nutrient analysis were filtered through a Whatman GF/F filter into a polypropylene, acid washed vial and frozen immediately before being analysed for ammonia and nitrate on a Technicon automated analyser (Grasshoff, 1976).

Automated ammonium analysis

Ammonium in sea water reacts with alkaline phenol and reactive chlorine in the presence of sodium nitroprusside as a catalyst, to produce a blue coloured phenolic product which can be detected spectrophotometrically (630 nm). The precipitation of magnesium and calcium hydroxide is suppressed by the addition of a complexing reagent.

Reagents

A) *Complexing buffer*. Trisodium citrate (120 g) and sodium hydroxide (2 g) were dissolved and made up to 1 litre with deionised water.

B) *Phenol reagent*. Phenol (35 g) and sodium nitroprusside (0.4 g) were dissolved and made up to 1 litre with deionised water.

C) *Hypochlorite reagent*. Sodium hydroxide (9.34 g) and dichloroisocyanurate (2 g) were dissolved and made up to 1 litre with deionised water.

Automated nitrate analysis

The automated determination of nitrate in seawater is based on the quantitative reduction of the nitrate to nitrite by means of a heterogeneous reaction on a copper-cadmium reductor. The nitrite then reacts with sulphanilamide under acidic conditions to form a diazo compound which when coupled with *n*-1-naphtyl-ethylene diamine dihydrochloride forms an intensely red coloured azo dye that can be measured spectrophotometrically (550 nm).

Reagents

A) *Buffer*. Ammonium chloride (18 g) was dissolved and made up to 1 l with deionised water

B) *Sulphanilamide*. Sulphanilamide (5 g) was dissolved in a mixture of concentrated hydrochloric acid (50 cm^3) and of deionised water (300 cm^3) and then made up to 500 cm^3 with deionised water. 30 cm^3 of this stock solution was diluted to 180 cm^3 with deionised water for use.

C) *n-1-naphtylethylenediamine* (0.5 g) was dissolved and made up to 500 cm^3 with deionised water. 30 cm^3 of this stock solution were diluted to 180 cm^3 with deionised water for use.

D*) Copper-cadmium reducter column.* Approximately 20 cm of a 1 mm diameter cadmium wire was threaded inside a piece of Teflon tubing. Copper sulphate solution (2% w/v) was sucked up into the coil and allowed to coat the wire for a few seconds before it was expelled. The column was them rinsed in deionised water and filled with ammonium chloride solution before being put in place taking care to avoid air contact.

Hydrogen sulphide flux

An initial 50 cm^3 sample was taken from the overlying water of sediment samples kept in the incubation tanks. The cores were then sealed with submersible stirrer heads and left to incubate for 6 hours after which a final 50 cm^3 sample was taken. Both samples were immediately fixed with zinc acetate (1 cm^3), which precipitates the sulphide as zinc sulphide. Hydrogen sulphide was determined by the methylene blue method (Grasshoff, 1983). Hydrogen sulphide and dimethyl-*p*-phenylene diamine dihydrochloride (0.5 cm^3) react in acid medium with ferric chloride (0.5 cm^3) as catalyst to form a thiazine dye, methylene blue, which can be detected spectrophotometrically (660 nm) after at least 1 hour. The sampling was carried out on duplicate.

Pore water ammonium

Pore water samples were collected from the core sediment and analysed for ammonia. Each core sample (one per station) was sliced into 1 cm sections under a stream of oxygen free nitrogen to a depth of 8 cm. Each section was placed in a polypropylene centrifuge tube and centrifuged at 2000 rpm for 10 minutes to separate the pore water. Pore water samples were then filtered through Whatman GF/F filters in a nitrogen atmosphere and stored frozen for subsequent analysis. The samples were analysed within one month of collection on a Technicon automated analyser (Grasshoff, 1976) as above.

Sulphide and pH profiles

The sulphide profile (fully dissociated sulphide S^{2-}) in relation to depth was obtained with a ion-specific sulphide needle electrode (Microscale measurements, Haren). Measurements were taken each half centimetre from the surface to a depth of 7 cm. The probe was activated for 10 seconds in Ammonium polysulphide solution (20.0%) prior to measurements. A calibration equation was calculated according to the manual supplied with the probe.

After calibration, pH measurements were taken with a probe (type no. SSMWL/4 mm, Russell pH Ltd., Auchtermuchty, Scotland) using the same core as for the sulphide profile and at the same depths.

Carbon and nitrogen

a) percentages in the sediment, feed and faeces

Each sediment core was sliced into four slices (0-1 cm; 1-3 cm; 3-6 cm; 6-9 cm). A fraction of each slice was freeze dried and then homogenised in a mortar to reduce subsampling errors. Samples from the feed used at the fish farm prior to fallowing and samples from salmon faeces collected from experimental indoor tanks were also analysed after freeze drying and homogenisation. All carbon and nitrogen analyses were performed on a Leco CHN-900 analyser. Instrument responses were calibrated for each two sample set (n=48) using 5 to 6 standards (acetanilide) and 6 empty tin (4 x 3.2 mm) or silver capsule blanks (4 x 3.5 mm, Elemental Microanalysis) to obtain a straight-line calibration. Sample weights were determined on a Perkin-Elmer AD-2Z autobalance.

Total carbon (TC) and total nitrogen (TN) were first measured in untreated samples by standard CHN-analysis. Organic carbon (OC) was measured using the vapour acidification method (Hedges & Stern, 1984) where inorganic carbon was removed from pre-weighed samples in a desiccator by exposing them for 48 hours to hydrochloric acid vapour.

Duplicate samples were prepared by weighing into silver capsules and transferred, unclosed, to a polystyrene plate drilled to hold 60 capsules in numbered wells. The loaded plate was then enclosed in a glass desiccator along with a small beaker containing concentrated hydrochloric acid (HCl).

The samples were exposed to HCl vapour for 48 hours at room temperature, then removed and heated in an oven for 1 hour at 50°C to drive off residual HCl. The silver capsules were then closed and transferred to the CHN-analyser.

b) annual inputs

The organic carbon input from the fish farm into the sediment was determined based on the weight of food fed for the periods from March 1992 to Feb 1993 and from March 1993 to June 1994 assuming a 49% carbon content of the diet fed (measured as for the sediment), a 9% water content in the food, a wastage of 10% (Findlay & Watling, 1994), that 15% of the consumed food is excreted through faeces based on the value of 85% digestibility (N. Bradbury, pers. com.) and a carbon content in faeces of 30% (measured as for the sediment).

The total amount of organic carbon in the sediment that originated from the fish farm (C_f) was calculated as follows:

F_c (kg) = F x 0.91 x 0.9

F_w (kg) = F x 0.91 x 0.1

C_w (kg) = F_w x 0.49

Fae (kg) = F_c x (1- A)

C_f (kg) = Fae x 0.3

C_t (kg) = C_w + C_f

where F is the amount of food fed in kg (wet weight); F_c is the amount of food consumed (kg dry weight); F_w is the amount of waste food (kg dry weight); Fae is the amount of faeces (kg dry weight); A is the percentage of food that is assimilated (0.85); C_w is the amount of carbon wasted and C_f is the amount of carbon in the faeces.

c) carbon deposition model

A model adapted from Cromey *et al.* (1996) was used to predict the dispersion of organic carbon originating from the fish farm in the 2 years preceeding the cessation of fish production. This model calculates the steady rate for carbon deposition assuming that the feeding rate is constant over time whilst the steady state is being reached. The results give an indication of carbon deposition in terms of g carbon m^{-2} yr^{-1}. The same data and assumptions as for calculating the total annual input of carbon were made when using this model.

2.4. Macrobenthos analysis

Collection and preservation

Three sediment core samples were collected per station and each was sectioned within one hour into three 3 cm slices. These sections were fixed in 40% formalin buffered with borax (pH=9.1-9.3) and stained with rose bengal until further analysis. Prior to identification the samples were carefully washed through a 0.5 mm sieve, all the retained benthos was hand sorted with the aid

of a binocular microscope (Wild M5, Heerbrugg, Switzerland) into major taxonomic groups and preserved in 70% ethyl alcohol.

Identification, abundance and biomass

The benthos collected was identified as far as possible to the following level:

Species - most polychaeta; Mysidae

Genus - some polychaeta

Family - all other polychaeta

Order - Tanaidacea, Amphipoda

Subclass - Prosobranchia

Class - Copepoda, Echinoidea, Ophiuroidea

Phylum - Nematoda, Kinorhyncha, Sipuncula

Due to the small size of Bivalvia specimens these were divided in three groups based on their shape: Group I- shell oval or triangular with smooth surface; group II - shell elongate; group III shell oval with radiating ridges. Day (1967), Fauchald (1977), Fauvel (1969a, 1969b) and Hayward & Ryland (1995) were the main taxonomic keys used for identification to the family level but other keys were also used for identification to the genera and species level (Appendix I). Due to the different levels at which the organisms were identified, 'taxa' will be used instead of 'species' when referring to the macrobenthos analysed.

When needed, chaetae were mounted on a slide in a 50:50 mixture of glycerol and ethanol (70%) and studied under a compound microscope (Gillett & Sibert

Ltd, London). An ethanolic solution of methyl green, a non-permanent stain, was used to reveal additional features.

All individuals of a taxon in a given depth stratum in a given core were grouped for abundance and biomass measurement. In the case of annelids, only individuals with an anterior end, whole or fragmented, were counted for abundance. Biomass of each taxon was measured as the wet weight, after blotting with absorbent paper, of the total number of individuals belonging to that taxon. Animals were removed from tubes prior to biomass determination, but mollusc biomass includes the weight of calcified structures.

The definition of community used in the study is the one used by Pearson and Rosenberg (1978), given by Mills (1971) as "an assemblage of organisms occurring in a particular environment, presumably interacting with each other and with the environment and separable from other communities by means of ecological survey".

2.5. Statistical analyses

Uni-variate analysis

A number of uni-variate measures of community structure were used to assess between-station variability at each sampling date.

Total number of taxa (S): The total number of taxa recorded from the three samples taken at each station at each date.

Mean abundance (A): The mean number of individuals recorded from the three samples at each station at each date.

Mean biomass (B): The mean wet weight biomass recorded from the three samples at each station at each date.

Abundance ratio (A/S): Mean number of organisms per taxon in each replicate at each station at each date (Pearson *et al.*, 1982).

Size ratio (B/S): Mean weight of an individual in the sample, recorded from the three samples at each station at each date (Pearson *et al.*, 1982).

Shannon-Wiener diversity index (H') (Krebs, 1972):

$$H' = -\sum_{i=1}^{S}(p_i \log_2 p_i) \quad \text{where} \quad p_i = \frac{\text{mean abundance of the } i^{th} \text{ taxon}}{\text{mean total abundance}}$$

S = total number of taxa per sample

Pielou evenness index (J') (Pielou, 1966):

$J' = H'/\log_2 S$ where S = total number of taxa per sample

Infaunal Trophic Index (ITI UK) (Wrc plc, 1992):

$$ITI\ UK = 100-[33.33\ ((0n_1+1n_2+2n_3+3n_4)/(n_1+n_2+n_3+n_4))]$$

where n_{1-4} = number of individuals in groups 1-4

Groups 1 to 4 defined on basis of food size and type and the location of food resource (see Appendix I).

Taxa selection criteria: all taxa with known feeding modes (Appendix I).

The abundance-biomass comparison (ABC) method (Warwick, 1986; Warwick *et al.*, 1987) was not used, following Weston's (1990) suggestion that this technique may incorrectly characterise the disturbance status of a site.

Multi-variate analyses

Transformations:

To satisfy statistical assumptions for significance-testing procedures such as normality and homogeneity of the variance, all environmental data excluding particle size and temperature variables, were log_{10}-transformed and faunal abundance data square-root transformed (MAFF, 1993).

Environmental variables:

Significant differences in the individual environmental parameters between stations and dates were calculated at the 95% level through two-way crossed analysis of variance (anova) with time and site as the two variables using the Microsoft Excel computing programme.

Due to different scales each environmental variable was normalised after transformation, by subtracting means across stations and dividing by standard deviation (Clarke & Warwick, 1994). The data were subjected to hierarchical, agglomerative classification employing group-average linking (Lance & Williams, 1967) with Euclidean distance as the distance measure. Classification analyses were performed using the CLUSTER program in the PRIMER (Plymouth Routines in Multivariate Ecological Research) package.

Faunal analyses:

The CLUSTER program in PRIMER was used to compute a similarity matrix based on the Bray-Curtis similarity coefficient (Bray & Curtis, 1957) and the similarity matrix was subjected to hierarchical, agglomerative classification employing group-average sorting (Lance & Williams, 1967) to classify the stations based on faunal groupings. To test for statistically significant differences between the benthic communities at the different stations and sampling dates, a two-way crossed ANOSIM test (Clarke & Green, 1988) from PRIMER was used. This test is based on a non-metric permutation procedure,

applied to the above (rank) similarity matrix. Non-metric Multidimensional Scaling analysis (MDS ORDINATION; Shepard, 1962; Kruskal, 1964) were done using PRIMER on the similarity matrices obtained using the Bray-Curtis similarity coefficient. Goodness-of-fit in the MDS ordination plots was measured as stress with Kruskal's stress formula I (Kruskal & Wish, 1978). Following the division into station groups from the classification and ordination results, the species having the greatest contribution to this division were determined using the similarity percentages program SIMPER (Clarke, 1993) available in the PRIMER package, using non-transformed abundance data.

Linking of environmental variables and fauna:

In order to demonstrate the most important environmental variables related to faunal patterns, two different methods were employed; superimposition of the environmental variables on the biotic MDS ordination (Field *et al.*, 1982) and rank correlations between Principal Components Analysis (PCA) and MDS ordinations with the program BIOENV (Clarke & Ainsworth, 1993) in the PRIMER package. The untransformed values of each environmental variable were represented as circles of varying diameter and superimposed on the biotic MDS ordination of the corresponding samples. BIOENV was the second method used for extracting important explanatory variables. This harmonic analysis uses a weighted Spearman's rank correlation between the resulting ranked similarity matrices which underlie the MDS ordinations of fauna and covariance-based PCA ordinations of the environmental variables. Use of a

covariance-based PCA implies that a normalisation of environmental data is not necessary prior to this analysis. The variable or combinations of variables which give the highest correlation coefficient is assumed to be the most important explanatory variable(s). Normalised environmental variables selected by the BIOENV program were further subjected to Principal Component Analysis (PCA) performed on a correlation matrix using PRIMER to visualise the correlation with the biotic MDS ordination.

3. RESULTS

3.1. Physical parameters

Sediment analysis

The sediment surface description of the stations selected, at the start of this study, as observed by divers, is given in Table III.

Table III. Description for the different stations.

Station	Location[1]	Depth (m)	Sediment description
A	33 m S.E. from cage edge	19±1.5	Light brown, coarse shelly sediment
B	3 m S.E. from cage edge	19±1.5	Fine brown/black sandy mud (with plant debris)
C	Southwest cage edge	19±1.5	Flocculant layer at the surface. Fine, soft black sandy mud with grey/white light mats of *Beggiatoa* spp. (with plant debris)

[1] See Fig. 3.2

Small size (1 to 5 mm dia.) plant debris from terrestrial and marine origin was retained after sieving in quite high proportions at the first 6 cm of stations B and C when compared to station A, where almost no plant debris was retained in the sieves. The proportion of fragmented calcified structures retained when sieving stations B and C was negligible relative to station A.

Particle size analysis indicated that the sediment from the three stations was similar, being composed mainly of poorly sorted very fine sand and coarse silt (Appendix II). Figs. 6, 7 and 8 show the change in time, at

different depth horizons, in sorting coefficient, particle size diameter and clay fraction from the sediment of the three stations. No trend over time was found for any of the parameters considered at any of the stations.

Light mats of *Beggiatoa* spp., a sulphide oxidising bacterium that lives in the intermediate zone between the sulphide containing and oxygenated environment (Holmer, 1991), were scattered at the sediment surface of station C at the first two sampling dates of the study. These mats were again observed at stations B and C in August and October 1995.

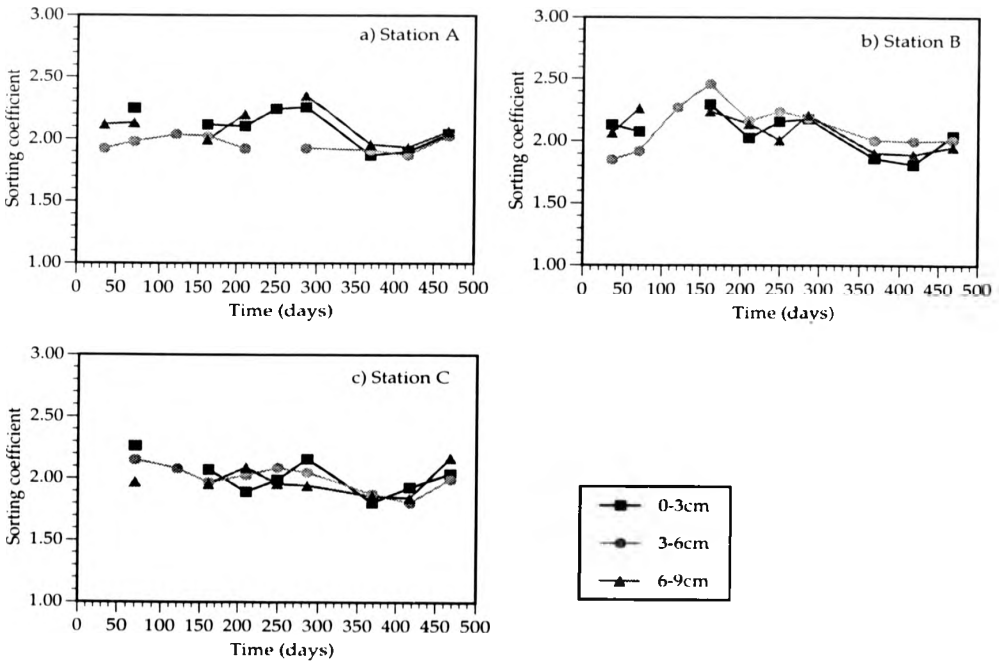


Fig. 6. Temporal changes in sediment sorting coefficient (σI), at different depth horizons. Day 0: 30-6-94

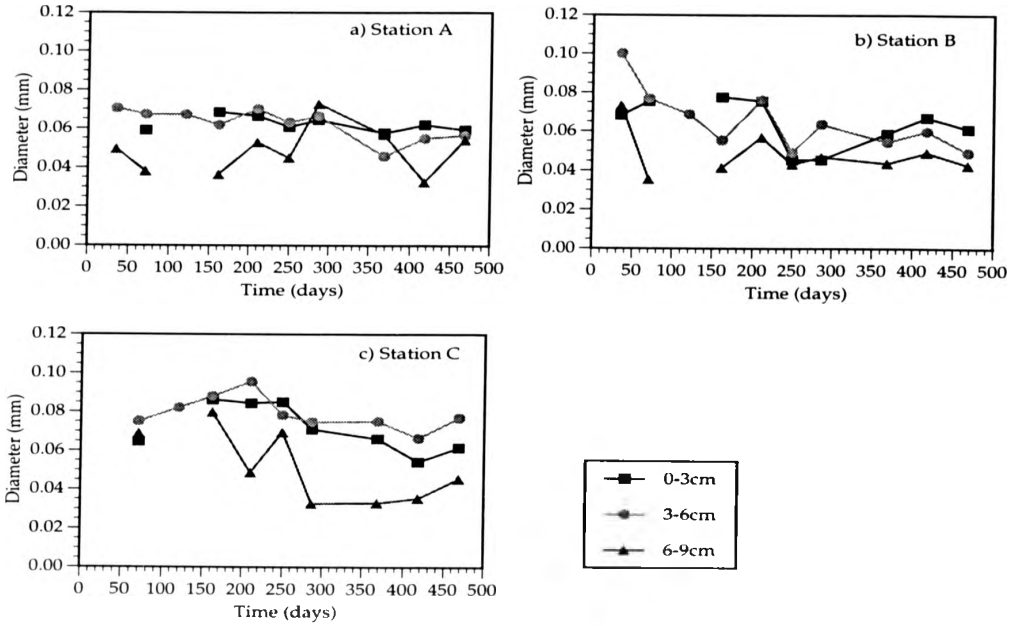


Fig. 7. Temporal changes in sediment median particle diameter (Md), at different depth horizons. Day 0: 30-6-94

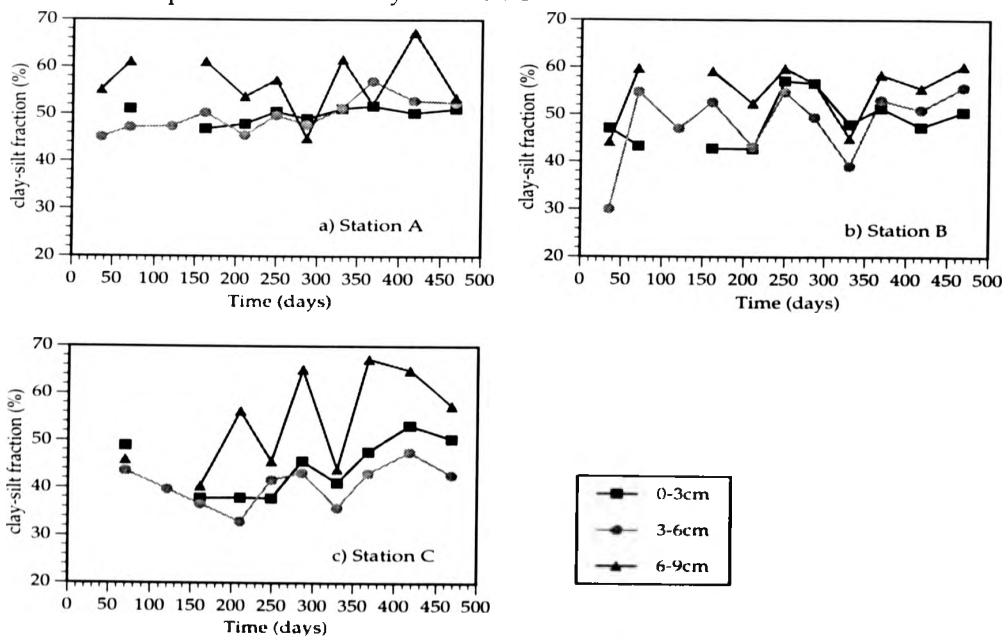


Fig. 8. Temporal changes in sediment clay fraction (%), at different depth horizons. Day 0: 30-6-94

Hydrography

Mean current speeds were greater at the surface of the water column than close to the sediment (Table IV). The observed currents were similar to those at several other sea-loch fish farm sites with mean bottom current speeds of 3.8 $cm.s^{-1}$ (Black *et al.*, 1996). The residual current direction was north westerly at all seawater depths considered, perhaps indicating an eddy in the bay studied (Fig. 3.2).

Table IV. Characteristics of water currents at the sampling site. Measurements taken from 21st of December 1994 to 9th of January 1995.

Depth(m) from the sea bed	Max. current ($cm.s^{-1}$)	Mean current ($cm.s^{-1}$)	Residual speed ($cm.s^{-1}$)	Residual direction (degrees, true)
2.5	37	3.8	1.6	314
9.5	39	5.4	3.1	303
16.5	39	6.4	3.8	301

The measurement period included neap and spring tides.

Sea water temperature

The maximum near bottom sea water temperature reported in the sampling area was 14°C in August 1995. Minimum values of 6°C were recorded at the end of February and mid March 1995 (Fig. 9).

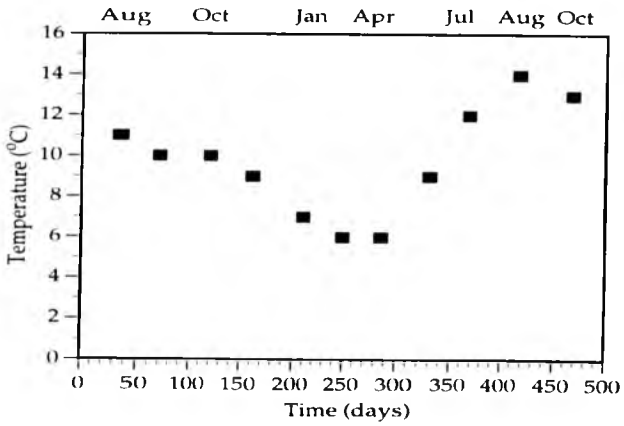


Fig. 9. Temporal changes in bottom water temperature (°C).
Day 0: 30-6-94

Fig. 10 shows seawater temperature changes over time for the period between 21st December 1994 to 9th January 1995 at three different sea water depths. At the top of the water column (2.5 m water depth), there was an average 2°C difference between night and day temperatures while at the other two depths (9.5 m and 16.5 m water depth) the daily changes in temperature were of the order of 0.2°C (Fig. 10). Temperatures near the sea bed were consistently warmer by 2 to 0.3°C than the temperature at the water surface and by 0.2 to 0.05°C than the middle of the water column (Fig. 10). These differences in temperature between bottom and surface sea water were reversed during summer when surface water was warmer than bottom water.

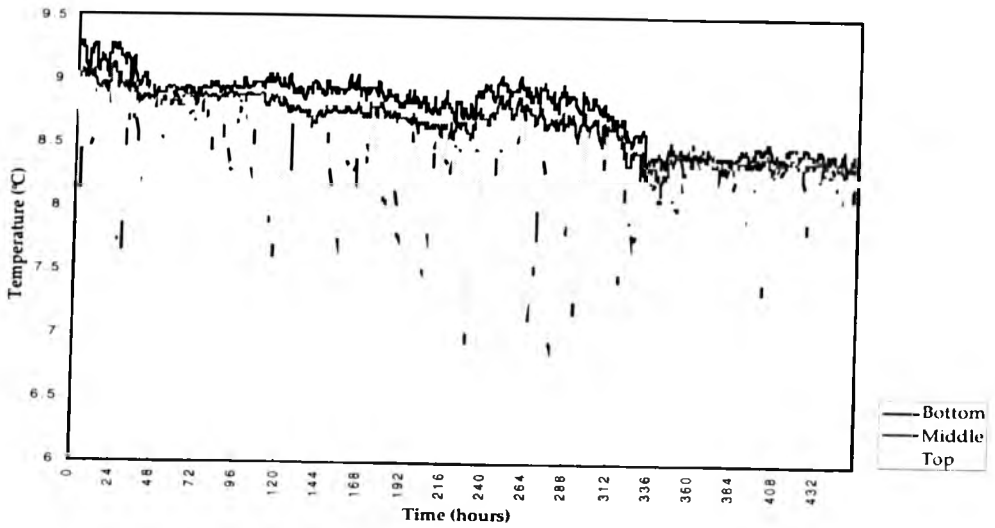


Fig. 10. Sea water temperature variation over time (from 21/12/1994 to 9/1/1995) at three water depths at the fish farm site.
Bottom: 16.5 m water depth; Middle: 9.5 m water depth; Top: 2.5 m water depth

3.2. Chemical Parameters

Redox potential

The reducing capacity of the sediment depends on the degree of carbon input, and can be assessed by measuring the redox potential. Fig. 11 shows the changes over time in redox potential values at different depth horizons, at stations A, B and C. Although the mean redox potential values at all horizons of station A were consistently higher than at stations B and C, no significant[1] differences were found between stations at any of the depths analysed. There is an indication of seasonality at all stations, from a depth of 0.5 cm, with levels improving (becoming more positive) during the winter months. Redox potential levels returned to initial values by April 95, remaining at this level at stations B and C until the end of the study.

[1]Two-way crossed ANOVA at 95% level of significance

Due to the unreliability of the calibration of the redox potential probe on the July 1995 sampling date, no values are presented for that date.

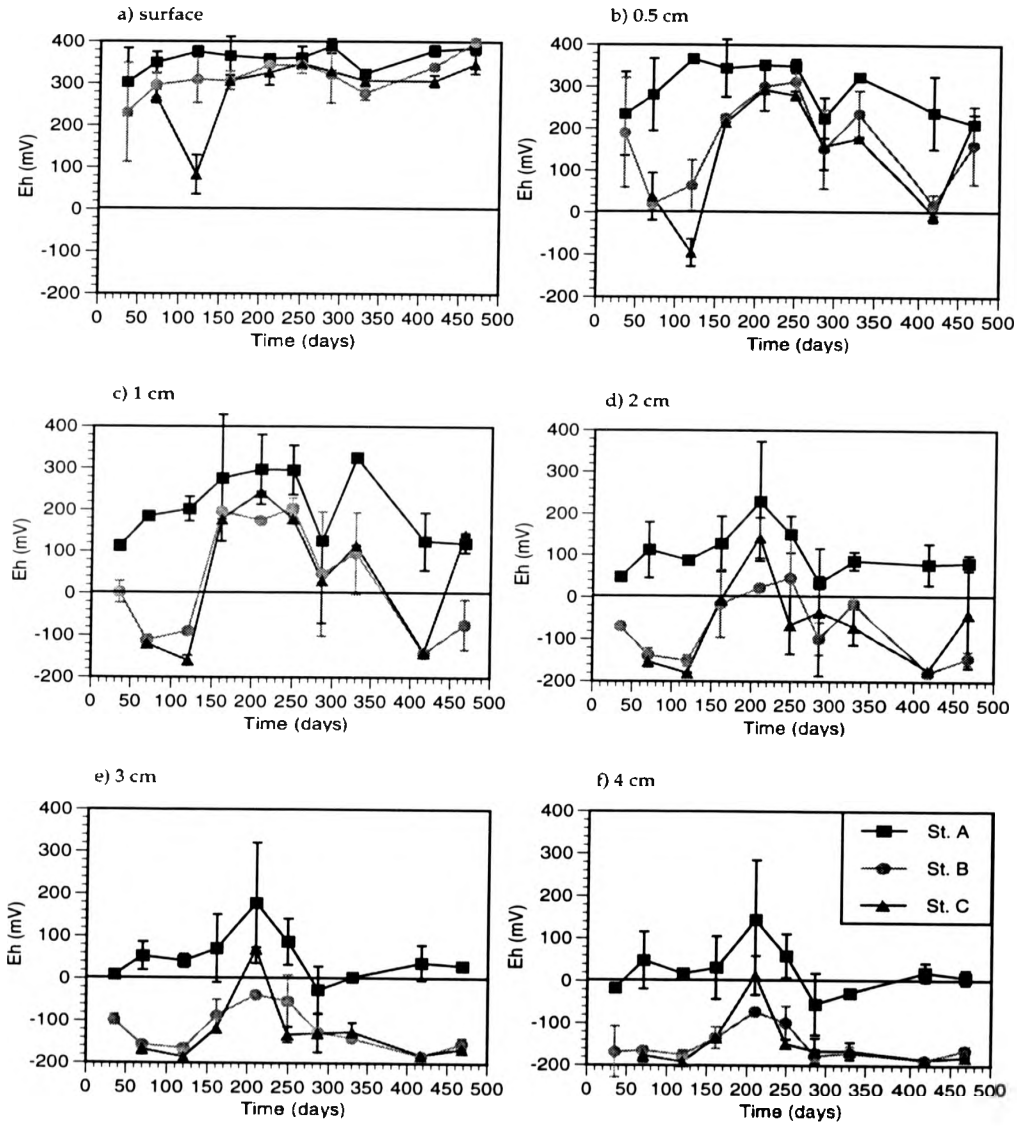


Fig. 11. Temporal changes in redox potential values (mV) at different sediment depth horizons. Results are expressed as the mean $\pm\sigma_{n-1}$.
Day 0: 30-6-94

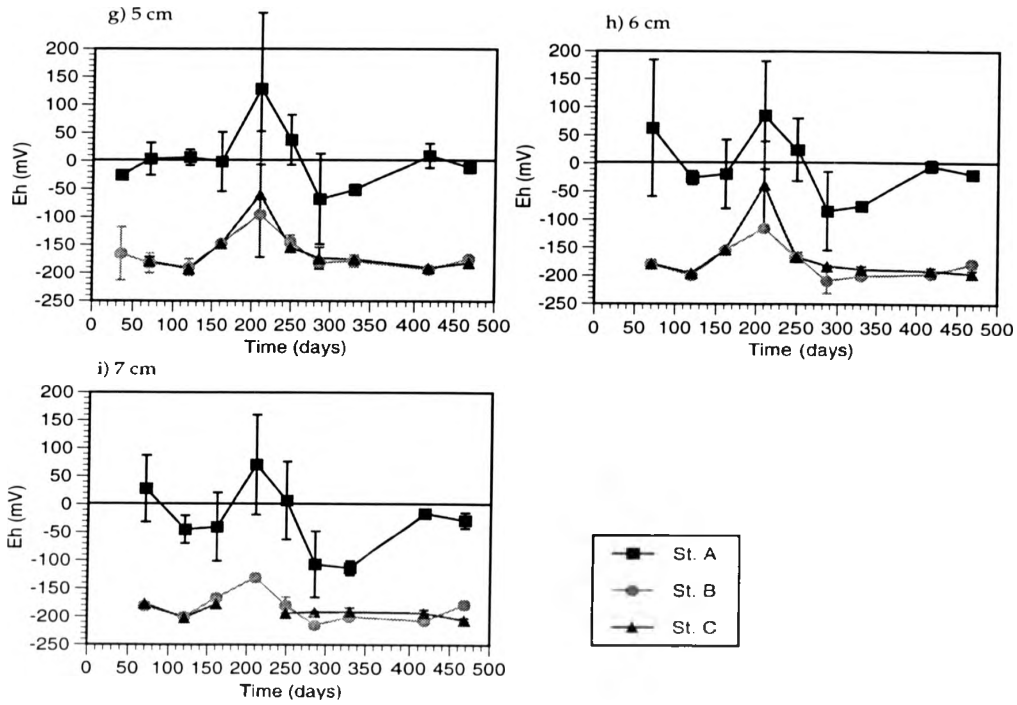


Fig. 11 (cont.). Temporal changes in redox potential values (mV) at different sediment depth horizons. Results are expressed as the mean $\pm\sigma_{n-1}$.
Day 0: 30-6-94

The redox potential discontinuity (RPD) is the level where oxidising processes become displaced by reducing processes (Fenchel & Riedl, 1970). This RPD layer, taken as that part of the sediment where the redox potential changes from positive to negative values (Eh=0mV), migrates up and down the sediment column apparently in response to fluctuations in organic input (Pearson & Stanley, 1979). The depth of the RPD in the sediment appears to follow a seasonal pattern, deepening in the sediment over the winter months (Fig. 12). For any sampling event, the RPD at stations B and C was found nearer to the surface than at station A, fluctuating between 0.3 and 3 cm of sediment depth. At station A the RPD layer was found below 3

cm sediment depth only rising above that level in the samples taken in April 1995. At station A in March 1995, the RPD layer was below 7 cm depth.

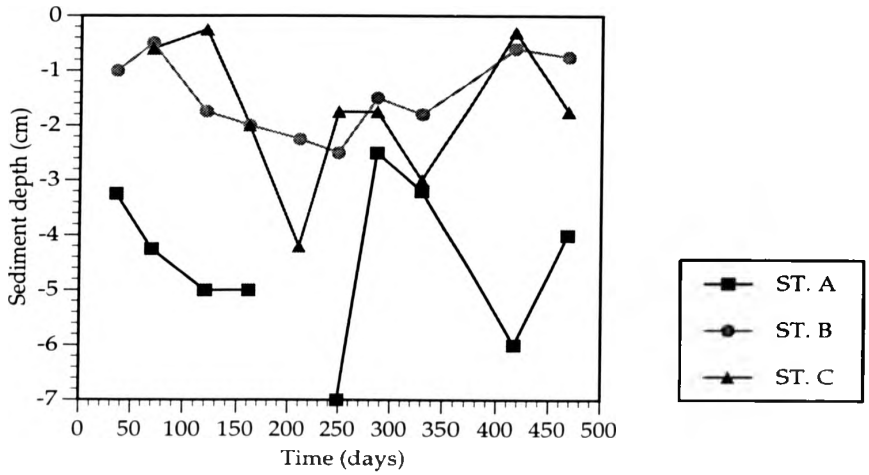


Fig. 12. Temporal changes in the sediment depth of the redox potential discontinuity (RPD). No measurements were made below 7 cm depth.
Day 0: 30-6-94

Oxygen and Nutrient flux

At the beginning of the sampling period all three stations presented elevated oxygen uptake rates (75 to 80 $mmol.d^{-1}m^{-2}$ at stations A and B and 100 $mmol.d^{-1}m^{-2}$ at station C) that decreased over time (Fig. 13a.). From October 1994, oxygen consumption for all three stations remained at the same level (between 30 and 50 $mmol.d^{-1}m^{-2}$) with the exception of station B in January which had a higher oxygen uptake rate than at the other two stations. No significant differences[1] in the temporal pattern of oxygen uptake were found between stations.

[1]Two-way crossed ANOVA at 95% level of significance

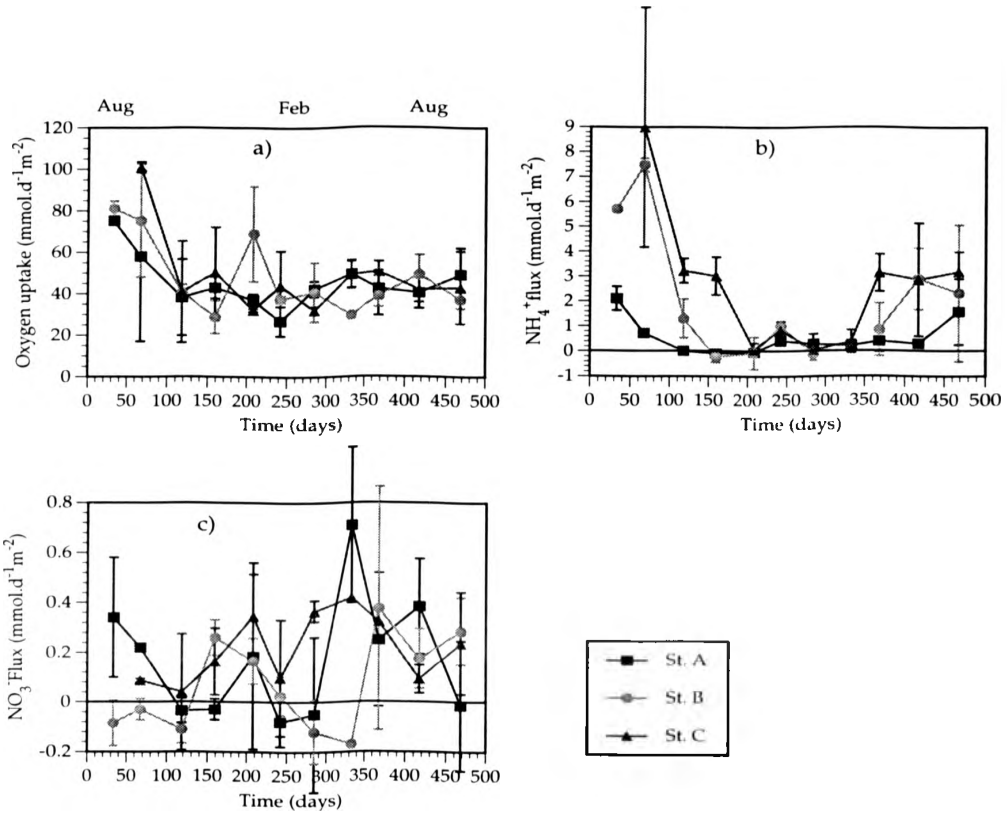


Fig. 13. Temporal changes of sediment flux rates. Results are expressed as the mean $\pm\sigma_{n-1}$.
a) Oxygen uptake (mmol.d^{-1} m^{-2}); b) Ammonium flux (mmol.d^{-1} m^{-2}); c) Nitrate flux (mmol.d^{-1} m^{-2}). Day 0: 30-6-94

Although at the beginning of the study ammonium flux rates were significantly lower at station A than at the other two stations, no significant differences[1] were found over time between any of the stations. A seasonal pattern is shown with ammonium production decreasing with time at all three stations over the winter months, increasing again from July 1995 (Fig. 13b).

No obvious trend over time was shown in nitrate fluxes at any of the stations. (Fig. 13c). No significant differences[1] were found between stations over time.

Hydrogen sulphide flux

Despite the strong smell of hydrogen sulphide when slicing cores from stations B and C at all sampling dates, hydrogen sulphide flux was negligible for stations A and B (Fig. 14) with only a small concentration leaking from the sediment at station C in October 1994. No smell of hydrogen sulphide was detected from the overlying water in any of the samples from the three stations. This analysis was discontinued from April 1995 as no flux had been detected since October 1994.

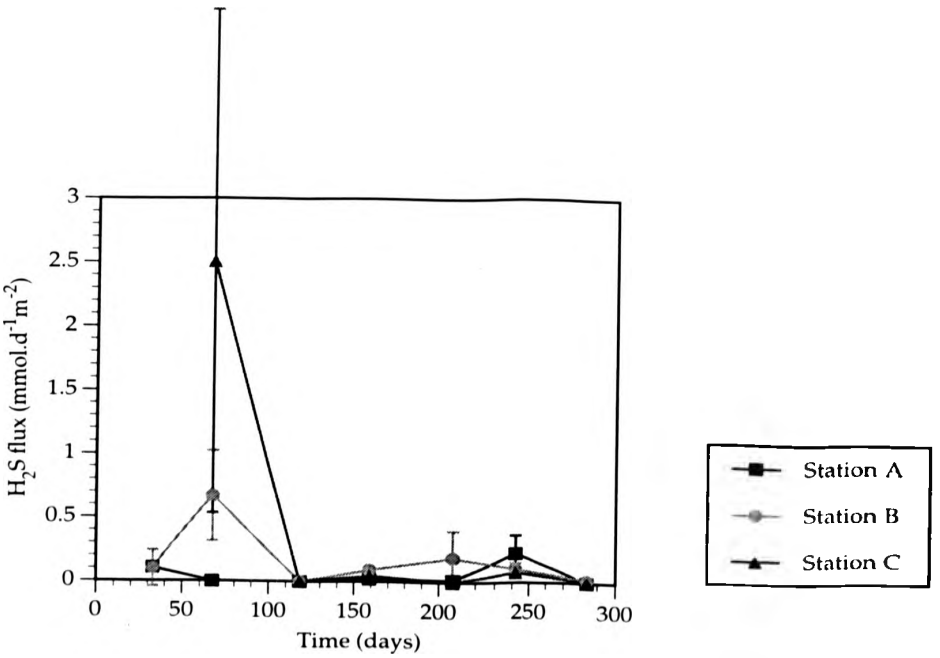


Fig. 14. Temporal changes in hydrogen sulphide flux ($mmol.d^{-1}\ m^{-2}$). Results are expressed as the mean $\pm\sigma_{n-1}$. Day 0: 30-6-94

Pore water ammonium

Elevated ammonium concentrations were detected at station C at sediment depths of 3 to 7 cm with respect to the same depths at stations A and B (Fig. 15). The ammonium concentration increased with increasing depth of sediment, this difference being more accentuated in station C.

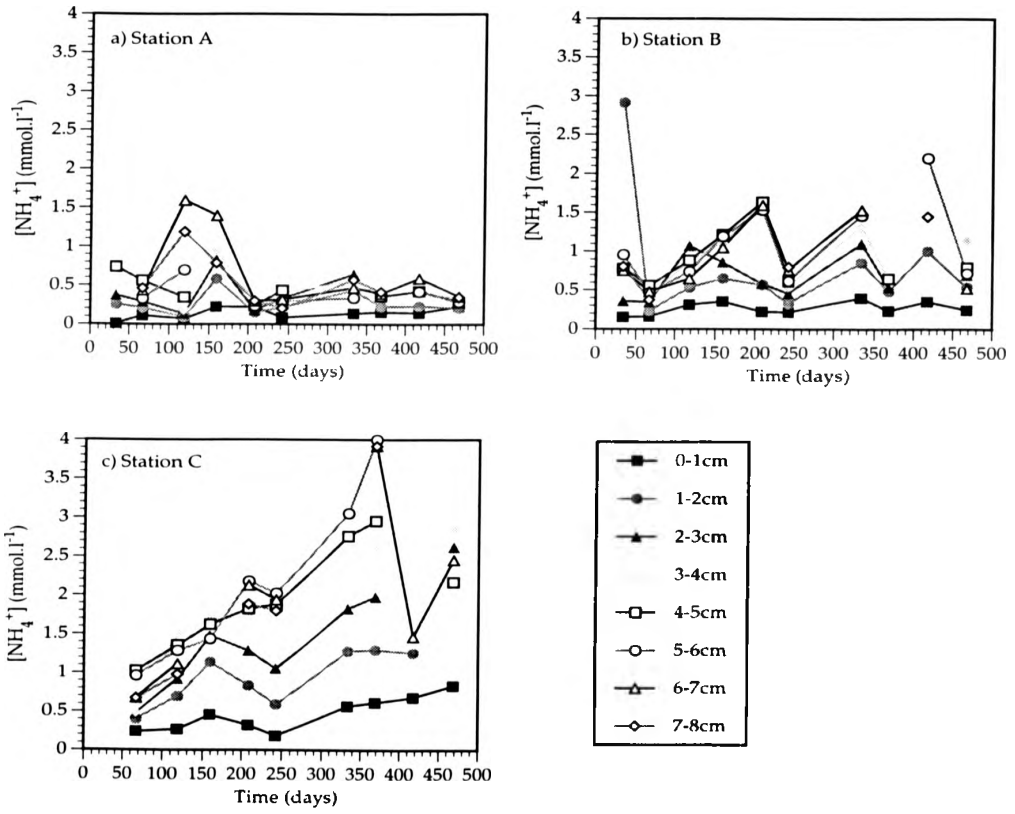


Fig. 15. Temporal changes in pore water ammonium concentration.
Day 0: 30-6-94

Ammonium pore water concentrations tend to increase with temperature (Boyton & Kemp, 1985). A seasonal pattern was found at station C, down to a sediment depth of 3 cm, with ammonium pore water concentrations

decreasing over the winter months. This seasonality, however, was not found at stations A and B.

Sulphide and pH profiles

pH values in the sediment are related to redox potential (Krauskopf, 1979). Positive correlations (r=0.8 to 0.9) were found between pH and redox potential with depth at each station, but there was no correlation with time. At station A pH values were relatively constant over time and with depth, to a sediment depth of 4 cm, decreasing below this depth to 4.5 (Fig. 16).

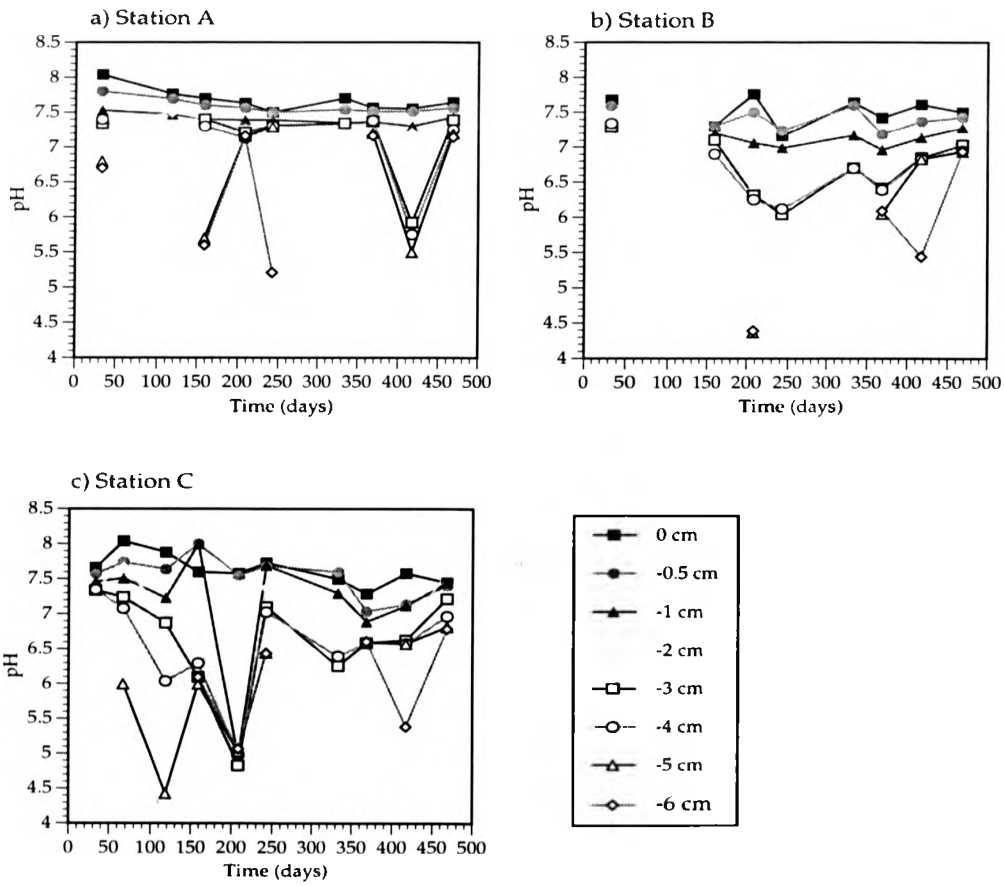


Fig. 16. Temporal changes in pH at different depth horizons. Day 0: 30-6-94

Lower pH values were detected at stations B and C relative to station A, from the surface of the sediment to a depth of 6 cm. Stations B and C showed a small and steady decrease in pH with depth, with the exception of the sample taken on January at station C, where a sharp pH decrease was measured at 1 cm depth remaining relatively constant thereafter. pH values at stations B and C decreased over time until January 1995 especially at depths below 1 cm.

Holmer and Kristensen (1992) found that, after the cessation of intensive farming, sulphate reduction rates decreased considerably but could still be detected for several months. In general sulphide concentration increases with sediment depth (Fig. 17). No sulphide was detected in sediments until a depth of 1 cm at any station and at station A for any depth analysed (Fig. 17a). Sulphide concentrations at station B and C decreased with time at all depths, until December 1994 when no sulphide was detected at station B, and station C reached its minimum values. After December 1994 the sulphide concentration in the sediment started increasing again, with maximum values being reached in October 1995 at station B and August 1995 at station C.

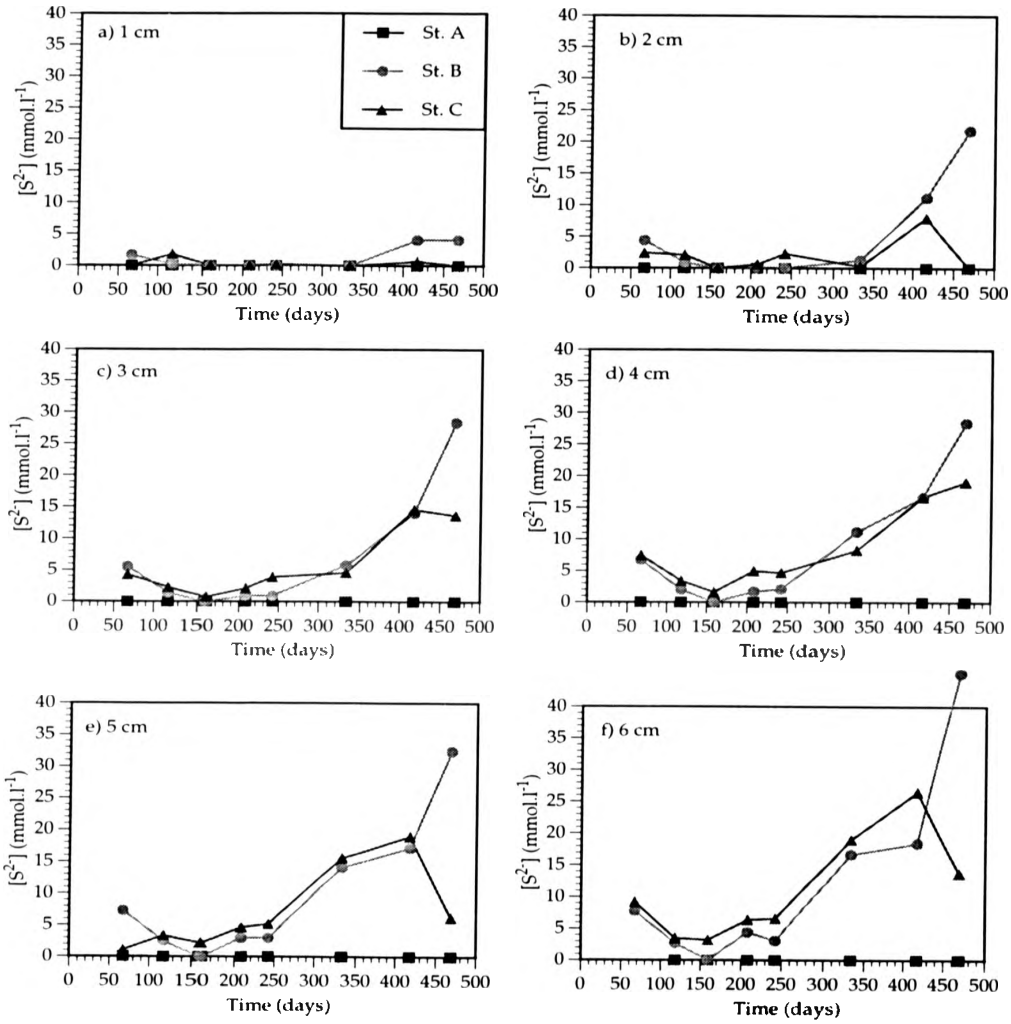


Fig. 17. Temporal changes in sulphide concentration (mmol.l^{-1}) at different depth horizons. Day 0: 30-6-94

Carbon and nitrogen analysis

a) percentages in the sediment, feed and faeces

Figure 18 shows the pattern of change with time of organic carbon percentage in the sediment from stations A, B and C. Station A levels of

organic carbon remained relatively low and stable over time, with values between 1 and 1.5 % (dw) of organic carbon in the sediment. The only exceptions are the values from December 1994 that increased to a maximum 2.7 % of organic carbon. This increase was not manifested at the other stations and may have been due to scallop dredging activities south east of the transect. The percentage of organic carbon at station A did not change significantly for the depths considered. At the beginning of the study station B showed a decrease in the percentage of organic carbon in surface sediments (0-3 cm) from a maximum value of 4 % in August 1994 to 3% in September 1994 (Fig. 18). From September 1994 organic carbon at stations B and C remained relatively stable over time but, for all depths excepting the 6 to 9 cm layer, their values were significant higher ($p<0.05$)[1] than those found at station A.

The spatial and temporal variation of total nitrogen content in the sediment followed the same pattern as for organic carbon (Fig. 19).

The sediment organic carbon to nitrogen ratio (OC:N) remained relatively constant and comparable in time (Fig. 20) for stations B and C with mean values of 10. Station A showed higher OC:N ratios, with a maximum of 32 in May 95.

The salmon feed sampled contained 49.4 (±0.6)% carbon and 7.47 (±0.11)% nitrogen. The faeces contained 30.1 (±0.3)% carbon and 3.48 (±0.05)%

[1]Two-way crossed ANOVA at 95% level of significance

nitrogen. Carbon to nitrogen ratios for food and faeces were 6.6 and 8.6 respectively.

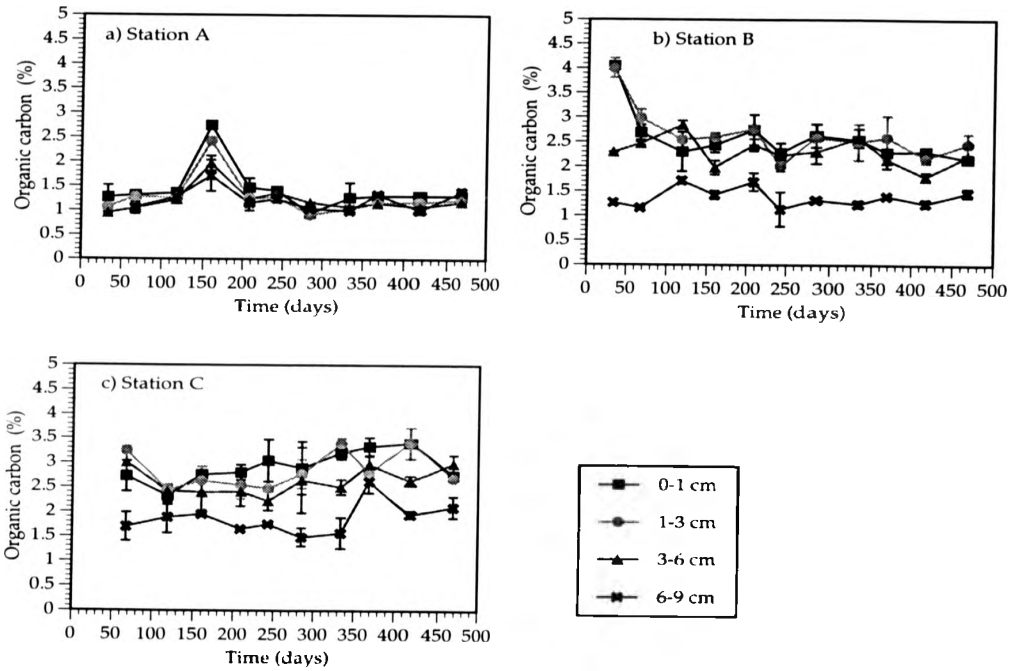


Fig. 18. Temporal changes in organic carbon percentage in the sediment, at different depth horizons. Results are expressed as the mean $\pm\sigma_{n-1}$.
Day 0: 30-6-94

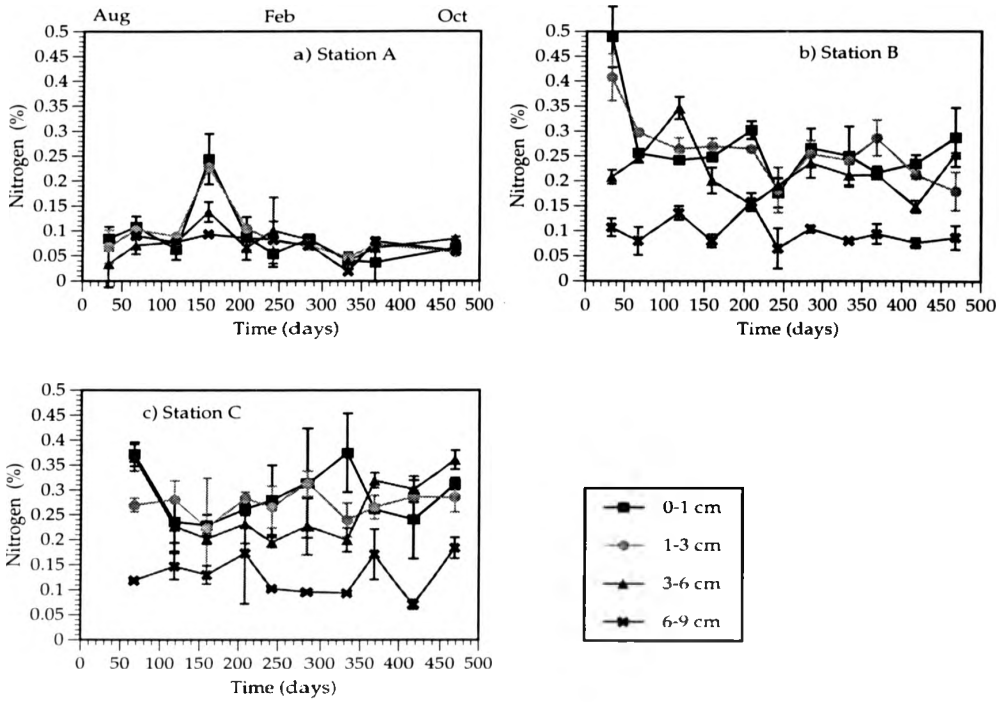


Fig. 19. Temporal changes in nitrogen percentage in the sediment, at different depth horizons. Results are expressed as the mean $\pm\sigma_{n-1}$. Day 0: 30-6-94

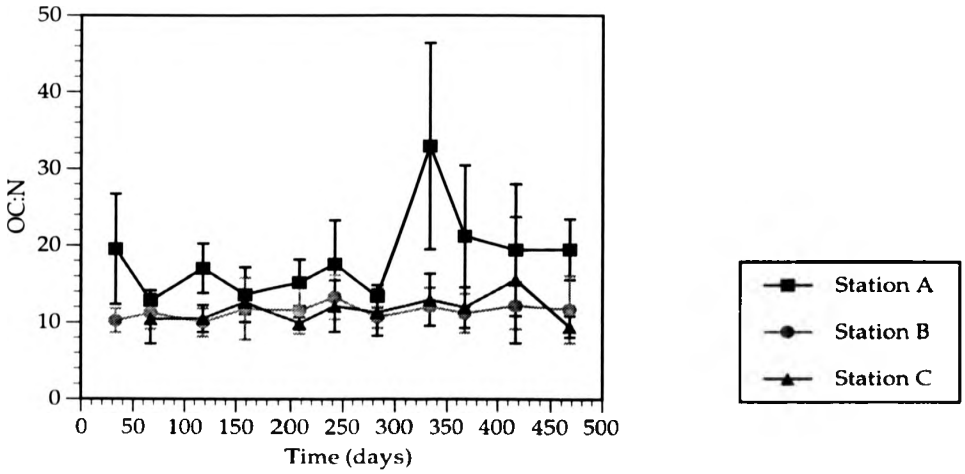


Fig. 20. Temporal changes in mean organic carbon:nitrogen ratio in the sediment. Results are expressed as the mean $\pm\sigma_{n-1}$. Day 0: 30-6-94

b) annual inputs

The organic carbon input from the fish farm into the environment was calculated as 35 tonnes for the period between March 1992 and Feb 1993 and 133.8 tonnes between March 1993 and June 1994, when fallowing started.

c) carbon deposition model

This work was carried out by Mr. C. Cromey and Mr. D. Pender (Appendix III) and the results suggest that although stations A, B and C are representative of an increasing organic enrichment gradient, the area with the highest carbon loading was not covered by the sampling at these stations.

3.3. Summary of results from the environmental parameters

Table V shows a summary of the results from the environmental parameters analysis.

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3.3. Summary of results from the environmental parameters

Table V shows a summary of the results from the environmental parameters analysis.

Table. V. Loch Creran site, environmental parameters at each station.

Station	A					B					C			
[1]Distance to fish cage (m)	33	33	33	33	33	3	3	3	3	3	edge	edge	edge	edge
Date of sampling	Aug-94	Sep-94	Mar-95	Aug-95	Oct-95	Aug-94	Sep-94	Mar-95	Aug-95	Oct-95	Sep-94	Mar-95	Aug-95	Oct-95
Months of fallowing	1	2	8	13	14	1	2	8	13	14	2	8	13	14
Clay fraction (%)	50.2	53.1	52.5	56.8	52.3	40.4	52.6	57.2	51.2	55.5	46.2	41.7	55.2	50.2
Particle diameter (mm)	0.060	0.055	0.056	0.050	0.057	0.081	0.063	0.046	0.059	0.051	0.070	0.078	0.052	0.061
Sorting coefficient	2.021	2.120	2.243	1.902	2.043	2.014	2.085	2.134	1.900	1.999	2.128	2.012	1.860	2.067
Temperature (°C)	11	10	6	14	13	11	10	6	14	13	10	6	14	13
Eh(2cm) mV	48.5	112.5	150.5	78.5	82	-68.5	-138	46.5	-179	-145	-153	-65.5	-174	-40
Eh(4cm) mV	-17	48.5	59.5	21	9	-168	-165	-98.5	-188	-164	-177	-148	-187	-180
Depth of RPD (cm)	-3.25	-4.25	-7	-6	-4	-1	-0.5	-2.5	-0.6	-0.75	-0.6	-1.75	-0.3	-1.75
Organic carbon (%)	1.10	1.18	1.32	1.14	1.27	2.90	2.33	1.92	1.89	2.08	2.67	2.37	2.93	2.63
OC/N	19.6	12.8	17.6	19.4	19.5	10.2	11.3	13.3	12.2	11.7	10.5	12.1	15.5	9.5
Sulfide ($\mu mol.l^{-1}$)		0	0	0	0		5.6	0.9	14.1	28.4	4.3	3.9	14.6	13.7
O_2 flux ($mmol.m^{-2}d^{-1}$)	75.14	58.03	26.785	40.54	49.25	81.09	75.28	37.42	49.27	37.19	100.9	43.98	42.14	42.94
NO_3 flux ($mmol.m^{-2}d^{-1}$)	0.34	0.22	-0.08	0.25	-0.02	-0.09	-0.03	0.03	0.38	0.29	-0.09	0.11	1.09	-0.35
NH_4^+ flux ($mmol.m^{-2}d^{-1}$)	2.12	0.73	0.43	0.3	1.59	5.73	7.48	1.01	2.9	2.34	8.99	0.85	2.87	3.2

[1] See Fig. 3.2

3.4. Macrobenthos

3.4.1. Abundance, species numbers and biomass

Mean abundance and biomass values for each taxon at each station and sampling date are shown in appendix IV and V respectively. Abundance values for each taxon at all sampled cores, are given in Appendix VI. Biomass values for each taxon at all sampled cores are given in Appendix VII.

The high abundance percentage of nematodes (90 to 99% of all taxa), their allocation to a high single taxon level due to the difficulty in separating

them into species, and the fact that nematodes typically fall into meiofaunal size classes (Weston, 1990) justify the need to assess the difference in the results when including and excluding them from the uni-variate and multi-variate analyses.

Nematodes

The mean number of nematodes per individual station ranged from 327,648 (station A, August 1995) to 2,559,065 ind.m^{-2} (station C, September 1994).

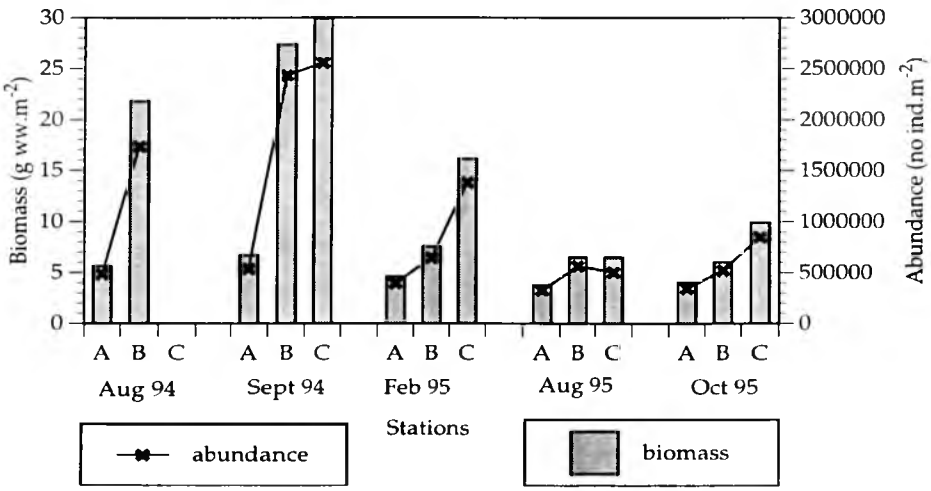


Fig. 21. Mean abundance (ind.m^{-2}) and biomass (g ww.m^{-2}) of nematodes at sampling stations from August 1994 (1 month of fallowing) to October 1995.

Biomass and abundance values decreased at all sampling dates with increasing distance from the former fish farm site. While nematode density at stations B and C declined with time, approaching nematode numbers at Station A (Fig. 21), the percentage of nematodes in the total abundance remained high and comparable in time for the 3 stations (Fig. 22). The

nematode abundance and biomass at station A remained relatively stable over time and although the nematodes were still the dominant group in terms of abundance, their biomass at 5 to 18 % contributed little to the total macrobenthic biomass. In contrast, nematodes represented a significant proportion of the total biomass at stations B and C (13-82 % at station B; 59-94 % at station C), where the communities were dominated by very small animals.

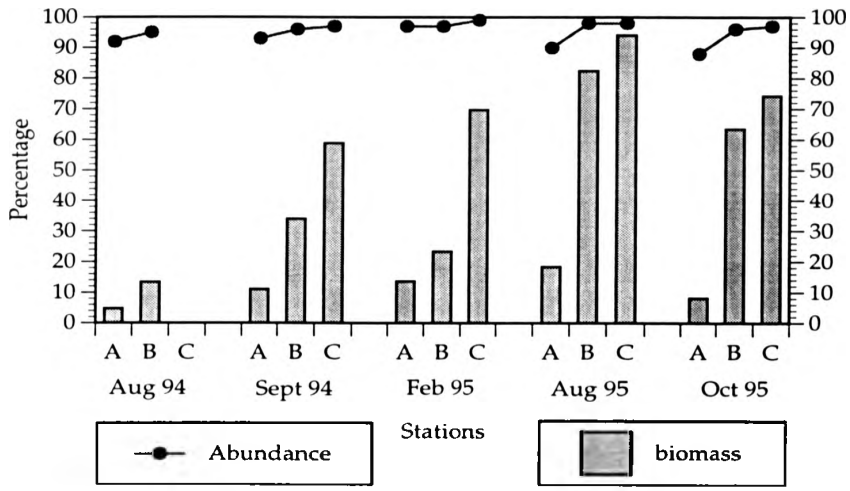


Fig. 22. Percentage abundance and biomass of nematodes at sampling stations from August 1994 (1 month of fallowing) to October 1995.

All taxa excluding nematodes

A total of 71 taxa were identified. The number of taxa per individual station ranged from 10 (station C, September 1994) to 37 (station A, October 1995). Mean abundance varied from 10962 (station C, August 1995) to 94871 ind m^{-2} (station B, September 1994). Mean biomass decreased with time for all stations until August 1995, station C showing a depleted biomass when

compared to the other two stations (Fig. 23). Between August 1995 and October 1995 biomass increased at all stations. Changes over time in macrobenthos abundance at station A (Fig. 23a) showed a seasonal pattern, with values in August and October 1995 higher than at the other two stations. With the exception of the samples from October 1995 abundance at station B was higher than at station C (Fig. 23b,c). The number of taxa increased with distance from the fish farm at all dates and in time at stations A and C (Fig. 23). At station B the total number of taxa increased with time until August 1995, decreasing to October 1995.

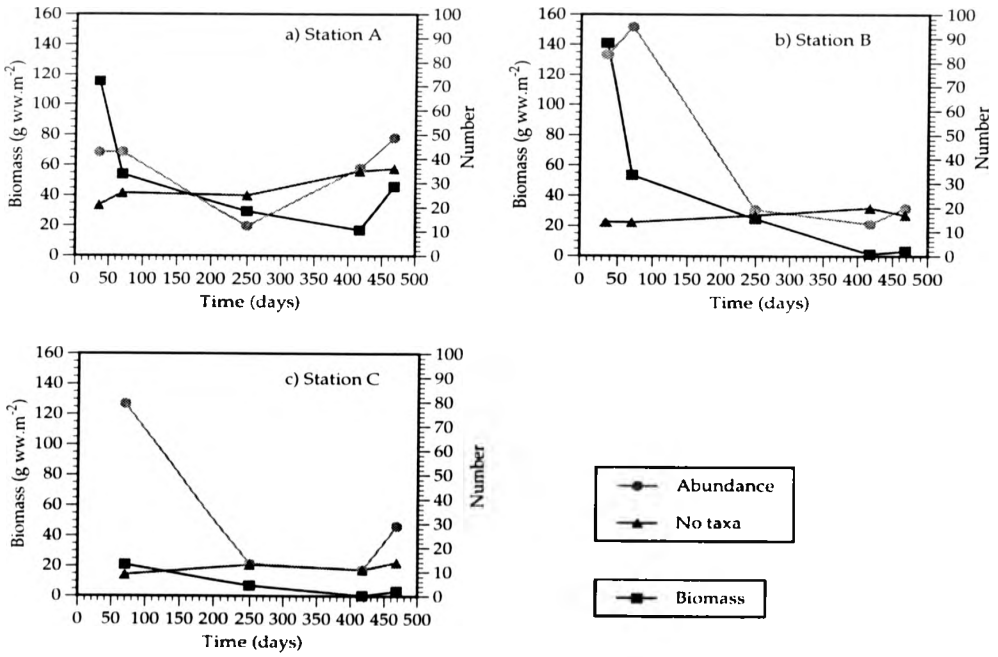


Fig. 23. Temporal changes in mean abundance (indx10^{-3}.m^{-2}), mean biomass (g ww.m^{-2}) and total number of taxa. Data excluding nematodes.

The changes observed in population statistics can best be summarised by integrating them into the ratios A/S, the abundance ratio, representing the mean number of organisms per taxon in each sample, and B/S, the size ratio, being the mean weight of an individual organism in the sample (Pearson *et al.*, 1982). The changing values of these ratios in time, at the three stations, are shown in figure 24.

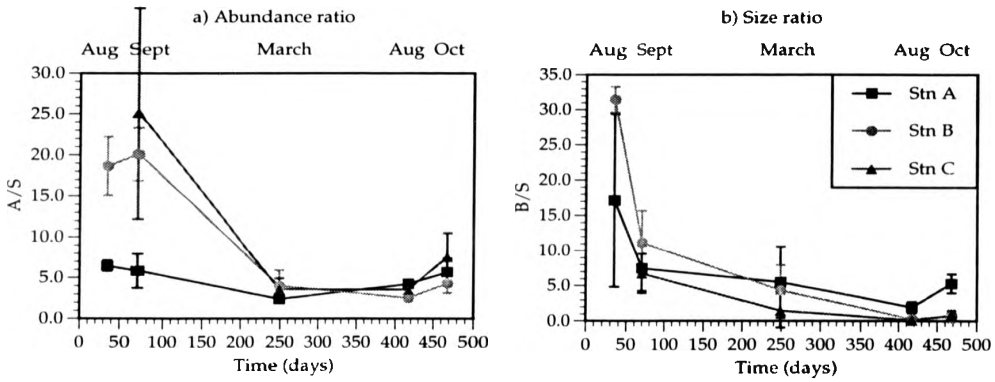


Fig. 24. Temporal changes over time in a) abundance ratio and b) size ratio. Results are expressed as the mean $\pm\sigma_{n-1}$. Day 0: 30-6-94

The average number of individuals per taxon declined steeply over the first 5 months of the study (Fig. 24a) at stations B and C, indicating a switch in the communities from a system dominated by a lower number of opportunistic species to a relatively diverse system. The abundance ratio for station A indicates a more stable community with a seasonal trend in diversity. The average weight of organisms per taxon decreased with time at all stations until August 1995 with the sharpest decrease at the first month of the study (Fig. 24b). This decrease in the size ratio indicates that although the abundance of opportunistic species with small biomass is

decreasing, the short duration of the present study, enhanced by the seasonal effect, did not allow for individuals in the less abundant taxa to grow to their maximum size and thus contribute to a higher biomass. Although the abundance ratio is similar at the three stations from March 1995 (Fig. 24a), the number of taxa that comprise more than 90% of total abundance shows that station C was dominated by few species over the whole period of this study (Fig. 25). Station B values did reach station A values in August 1995, but declined at the last sampling date. Temporal changes of the number of taxa that comprise more than 90% of total abundance at station A indicate a seasonal pattern with maximum values in March 1995 (Fig. 25).

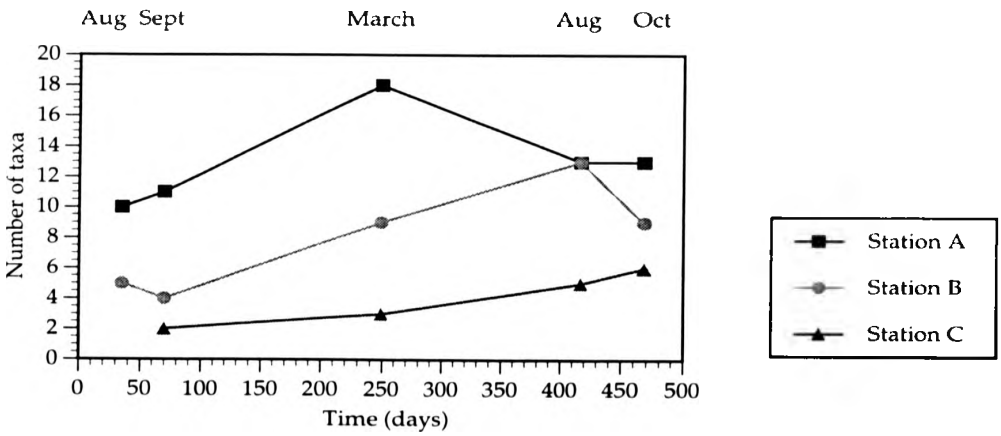


Fig. 25. Temporal changes in the number of taxa that comprise 90% of total abundance (excluding nematoda). Day 0: 30-6-94

Community structure

Excluding nematodes, polychaetes numerically dominated in all dates at stations A and B and in all but the last sampling date at station C, when crustaceans, mainly copepods, were the dominant phylum (Fig.26).

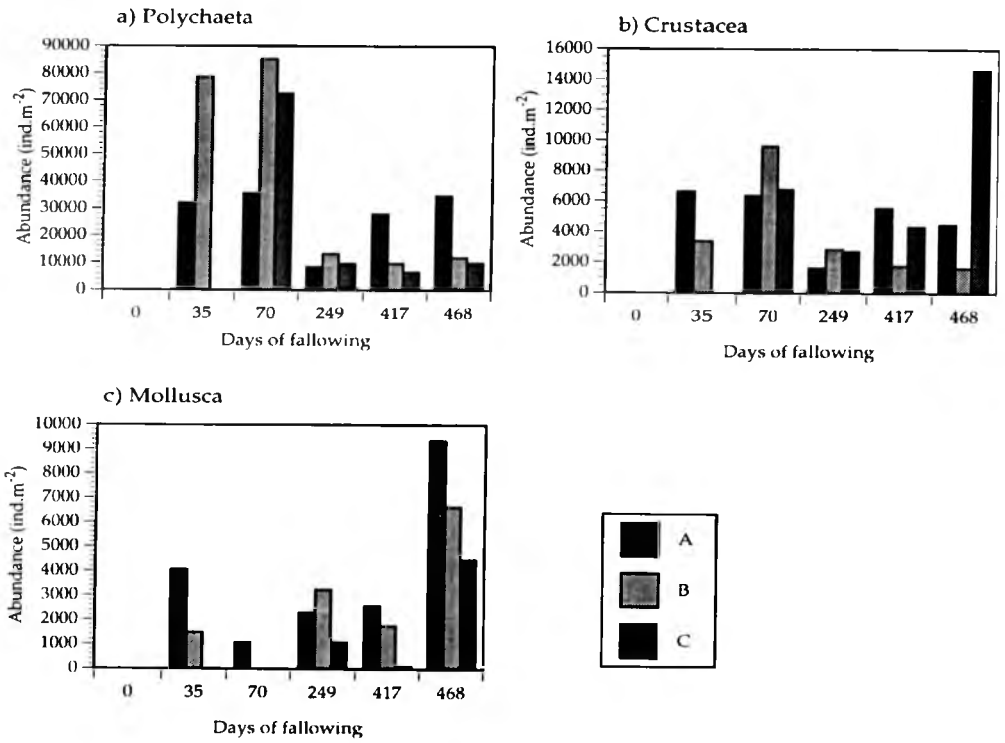


Fig. 26. Temporal changes in abundance (no ind.m^{-2}) of macrobenthic phyla at the 3 stations.

At station A polychaete and crustacean abundance showed a seasonal influence, with depleted numbers in March relative to the summer samples. At stations B and C polychaete numbers decreased sharply between September 1994 and March 1995 remaining at around 10,000 ind.

m^{-2} to the end of the study. The molluscs consisted mainly of bivalves and showed a general decrease in total numbers with increasing proximity to the fish cage site. The total number of molluscs followed an erratic pattern over time. In addition to the phyla referred to above, Sypunculids, Kinoryncha and Echinodermata were occasionally observed.

The use of a single or group of indicator species to characterise the degree of organic enrichment in the sediment has been used by many authors (Pearson & Rosenberg, 1978; Rosenberg, 1976). *Capitella capitata* in particular has been recognised as the initial dominant colonist following elimination of macrofauna by organic enrichment (Pearson & Rosenberg, 1978 -Table Ib). *Malacocerus fuliginosus, Ophryotrocha* sp. and nematoda in general are other characteristic taxa from highly enriched sediments. *Mediomastus fragilis, Prionospio fallax, Spio decorata, Scalibregma inflatum* and Cirratulidae were considered as dominant species to be found in moderately enriched sediments from Scottish lochs (T.Nickell, pers. com.). Figure 27 shows the change in density over time of the six most abundant annelids at the three stations. Table VI shows the top three taxa ranked by abundance, excluding nematodes, for all stations at all dates.

Temporal changes

Station A: Excluding nematodes, *Ophryotrocha hartmanni* remained numerically dominant at the first 2 sampling dates, being absent from any other sampling events (Appendix IV). *Mediomastus fragilis* was the annelid with the second highest density in August and September 1994,

dominating at the last 3 sampling dates. Their number, however, was depleted in March 1995 when compared with the samples from the other dates. *Prionospio fallax* was present in high numbers at all sampling dates, being the second most abundant polychaete in October 1995. *Pholoe synophthalmica* numbers decreased from August 1994 to March 1995, showed a maximum in August 1995 and decreased slightly in October 1995. *Scalibregma inflatum* was always present in station A with maximum number in August 1995, when all the individuals were small juveniles. This species showed the higher biomass over the study period.

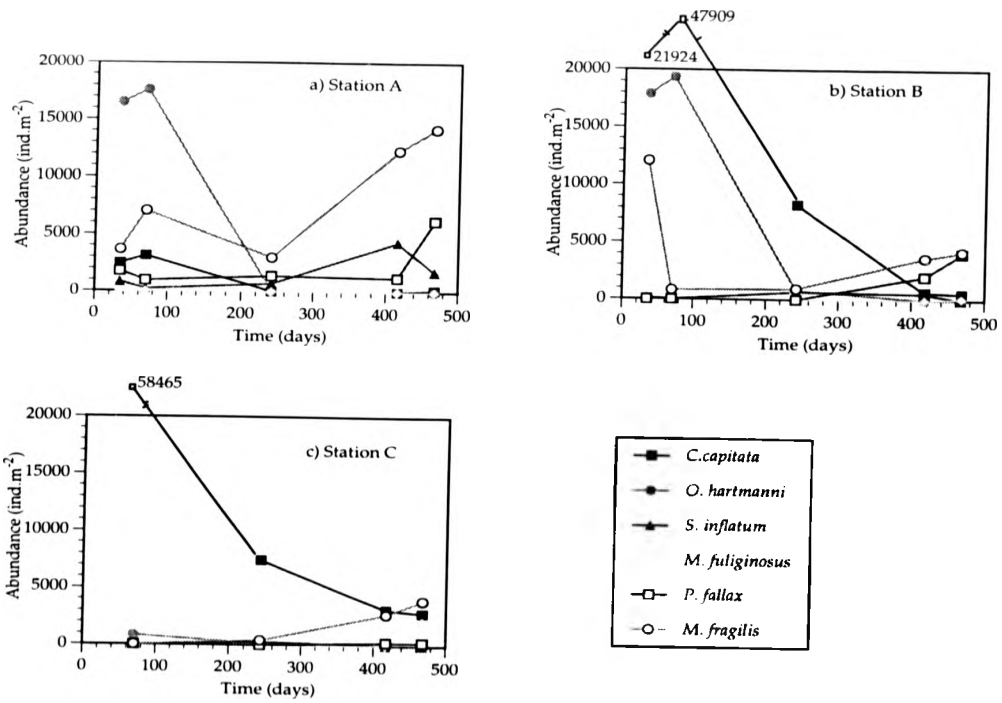


Fig. 27. Temporal changes in the mean abundance (ind.m^{-2}) of the six most frequent polychaete species. Day 0: 30-6-94

Table VI. Top three taxa ranked by abundance, excluding nematoda, showing percent and cumulative percent abundance, for all stations at all dates.

Station	Date	Species/taxa	Percent	Cumul. percent
A	4-8-94	*Ophryotrocha hartmanni*	38.6	38.6
		bivalvia I	9.5	48.1
		Mediomastus fragilis	8.5	**56.6**
	8-9-94	*Ophryotrocha hartmanni*	41.0	41.0
		Mediomastus fragilis	16.4	57.4
		Capitella capitata	7.3	**64.7**
	6-3-95	*Mediomastus fragilis*	24.2	24.2
		bivalvia I	18.7	42.9
		Prionospio fallax	11.0	**53.9**
	21-8-95	*Mediomastus fragilis*	33.9	33.9
		Scalibregma inflatum	11.9	45.8
		Pholoe synophthalmica	7.5	**53.3**
	11-10-95	*Mediomastus fragilis*	29.1	29.1
		bivalvia I	17.8	46.9
		Prionospio fallax	12.8	**59.7**
B	4-8-94	*Capitella capitata*	26.3	26.3
		Ophryotrocha hartmanni	21.4	47.7
		Malacocerus fuliginosus	16.4	**64.1**
	8-9-94	*Capitella capitata*	50.5	50.5
		Ophryotrocha hartmanni	20.4	70.9
		Malacocerus fuliginosus	16.5	**87.4**
	6-3-95	*Capitella capitata*	42.7	42.7
		bivalvia I	13.3	56.0
		copepod IV	9.8	**65.8**
	21-8-95	*Mediomastus fragilis*	27.6	27.6
		Prionospio fallax	15.3	42.9
		bivalvia I	8.2	**51.1**
	11-10-95	bivalvia I	27.2	27.2
		Mediomastus fragilis	21.1	48.3
		Prionospio fallax	20.4	**68.7**
C	4-8-94	not sampled		
	8-9-94	*Capitella capitata*	73.7	73.7
		Malacocerus fuliginosus	16.6	90.3
		copepod IV	4.8	**95.1**
	6-3-95	*Capitella capitata*	55.6	55.6
		copepod IV	17.2	72.8
		bivalvia I	7.1	**79.9**
	21-8-95	*Capitella capitata*	28.4	28.4
		Mediomastus fragilis	24.7	53.1
		copepod IV	23.5	**76.6**
	11-10-95	copepod I	23.8	23.8
		copepod IV	22.9	46.7
		bivalvia I	15.4	**62.1**

In August and September 1994 *Capitella capitata* was the third most abundant polychaete. This opportunistic species was absent from station A in March and August 1995 samples and only a small number were present in October 1995. *Malacocerus fuliginosus* was never present in station A samples.

Station B: *Capitella capitata* was dominant from August 1994 to March 1995 while *M. fragilis* predominated in August 1995 and Bivalvia in October 1995. *Capitella capitata* density increased from August to September 1994, decreasing after then to a minimum of 541 ind.m^{-2} in October 1995. *Mediomastus fragilis* was the polychaete with the highest mean abundance in October 1995. This species showed an opposite pattern in abundance to that found for *C. capitata*, decreasing from August to September 1994 and increasing from then on. From being the third most abundant species in August and September 1994, *M. fuliginosus* was absent from station B in March and August 1995 but returned in very small numbers in October 1995 (Appendix IV). *Prionospio fallax* was first found in station B in August 1995, one year after sampling started, and doubled in number in October 1995 being the second most abundant species and the polychaete that most contributed to total biomass on this date. *Ophryotrocha hartmanni*, as for *M. fragilis*, decreased in number from August to September 1994, although remaining the second most abundant species in both dates. Only a small number was found on March 1995 and no individuals of this species were found in August or October 1995. *Pholoe synophthalmica* was only present, and in small numbers, in August 1994 and August and October 1995.

Scalibregma inflatum showed a maximum density of 677 ind.m^{-2} on March 1995, being absent from station B on September 1994 and October 1995.

Station C: From September 1994 to August 1995, *C. capitata* was found to have the highest abundance of all the taxa present although decreasing with time. On the last sampling date, October 1995, copepods and bivalves were found in the sediment in higher densities than any polychaete species. *Mediomastus fragilis* was found in smaller numbers than at the other two stations but showed a steady increase over time, being the annelid with the highest density 15 months after fallowing, closely followed by *C. capitata* and *M. fuliginosus*. *Malacocerus fuliginosus* was the second most abundant polychaete species in September 1994, being absent from station C in March and August 1995. *Prionospio fallax* was only present in station C in August and October 1995 and at a very low density (271 ind.m^{-2}). *Ophryotrocha hartmanni*, however, was absent from all sampling dates excepting March 1995 when a small number of individuals was observed. *Scalibregma inflatum* was also found at a very low density and only in the winter sampling event (March 1995). Regarding mean biomass, *C. capitata*, *S. inflatum*, amphipods and bivalves were the successive dominants over time. At the last sampling date (October 1995),*C. capitata* and *M. fuliginosus* were the annelids with the highest biomass.

3.4.2. Diversity and evenness indices

The Shannon-Wiener diversity index is based on the observed distribution of individuals among taxa and provides a measure related to dominance in

the population. When excluding nematodes from the data, there was a clear trend of increasing diversity with distance from the fish farm site ($p<0.05$)[1] and generally increasing in time for all stations (Fig. 28a). Station A proved highly diverse with all Shannon-Wiener values greater than 3.00. At station B, although diversity values from August 1995 were significantly higher than values one year before, the values in October 1995 were not found to be significantly different[1] from those in August 1994. At station C, although increasing over time, diversity index values over the sampling period indicate a low diversity community, characteristic of highly impacted sediments.

Pielou's evenness index approaches a maximum value of 1 the more evenly the individuals are divided among species, independent of the number of species in the sample. Evenness index values for all stations at all dates, excluding nematode data, are given in figure 29a. Pielou's index shows that at the beginning of this study evenness increased with distance from the fish farm site, and generally increased with time. However, no significant differences[1] were found in the overall trend between stations A and B. At station A evenness values in August and October 1995 were lower than March values and at the same level as values at the beginning of the study. No significant differences[1] were found in time for station A. At station B Pielou's index followed the same temporal pattern as Shannon's diversity index with a decrease in September 1994 and October 1995. A significant increase was found in evenness values from August to September 1994 at Stations B and C ($p<0.05$)[1].

[1]Two-way crossed ANOVA at 95% level of significance

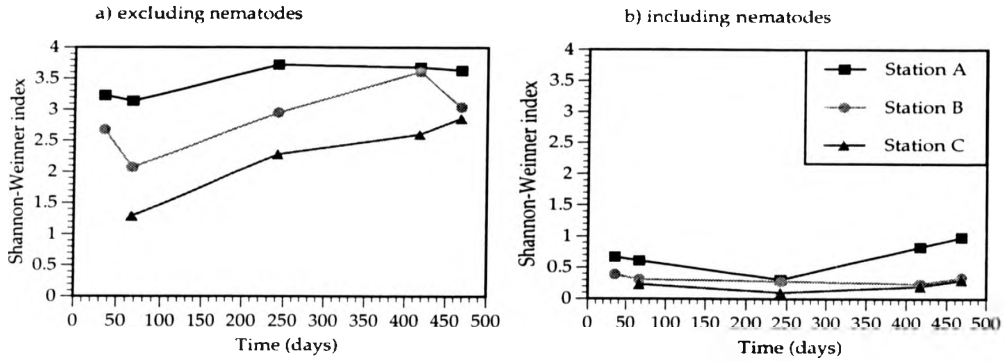


Fig. 28. Temporal changes in Shannon-Wienner diversity index. Day 0: 30-6-94

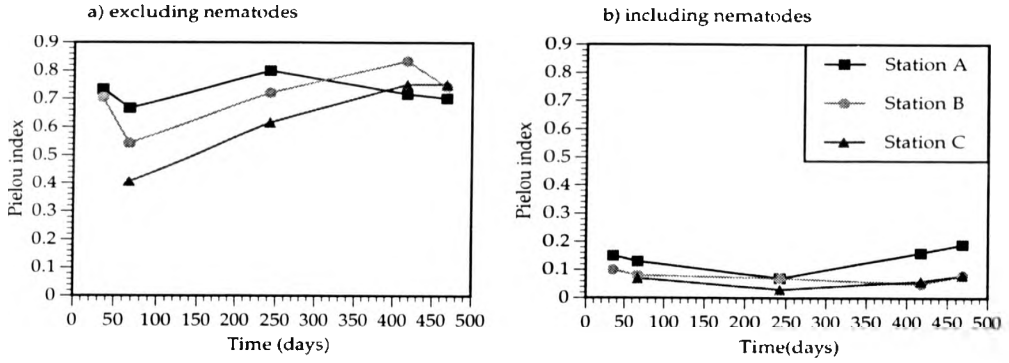


Fig. 29. Temporal changes in Pielou evenness index. Day 0: 30-6-94

When including the nematode data in the uni-variate calculations, both diversity (Fig. 28b) and evenness (Fig. 29b) indices decreased sharply showing values characteristic of highly impacted sediments at all stations. This is due to the classification of the nematodes as a single taxon and to their high abundance.

3.4.3. Infaunal Trophic Index

The UK Infaunal Trophic Index (UK ITI) (Wrc plc, 1992), a derivative of the Infaunal Trophic Index developed for US Pacific waters, has been used as a

marine biotic index for environmental quality assessment. This index scores each benthic community according to the trophic status of its members and, as such it is strictly a trophic index. The assessment of pollution status can, however, be inferred from the knowledge that increasing organic enrichment favours animals from specific trophic groups (Yonge, 1928), resulting in lower index values. Based on this index, the area sampled can be classified as either 'degraded' (ITI<30), 'changed' (30-60) or 'normal' (ITI>60). A list of the total taxa found over the sampling period and their allocation into one of the four trophic groups defined by the ITI is shown in Appendix I. According to the ITI values, all stations can be classified as degraded at the beginning of the study (Fig. 30).

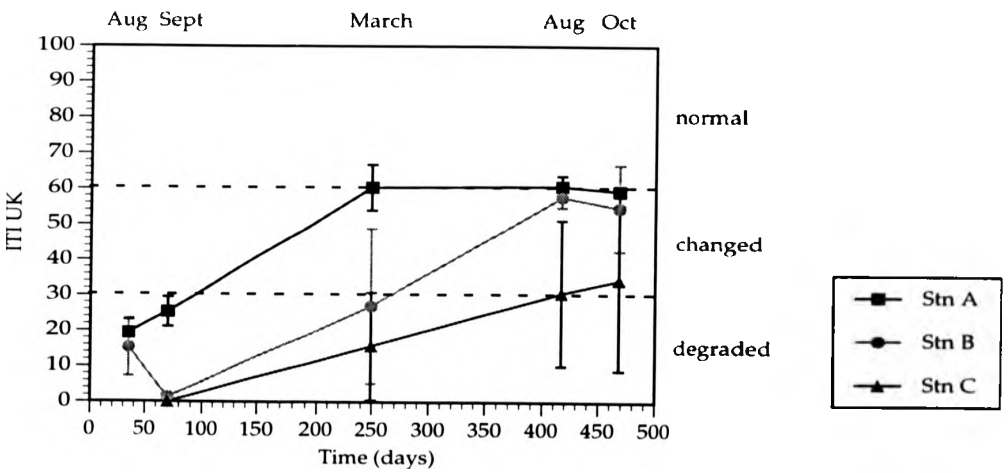


Fig. 30. Temporal change in Infaunal Trophic Index UK values. See Appendix I for taxa considered. Results are expressed as the mean $\pm\sigma_{n-1}$. Day 0: 30-6-94

In general, all stations showed an increase in ITI values with time, station A reaching the boundary between 'changed' and 'normal' communities by March 1995. Although stations B and C never reached ITI values characteristic of unaffected sediments, station B showed higher values than station C. Patchiness at the stations was considerable, especially at station C where ITI values in replicate cores varied, for example, between 5 and 50 in October 1995.

3.5. Summary of the results from biological parameters

Table VII. shows a summary of the results from the biological parameters analysis.

Table VII. Loch Creran site, uni-variate biological parameters at each station.

Station	A					B					C			
[1]Distance to fish cage (m)	33	33	33	33	33	3	3	3	3	3	edge	edge	edge	edge
Date of sampling	Aug-94	Sep-94	Mar-95	Aug-95	Oct-95	Aug-94	Sep-94	Mar-95	Aug-95	Oct-95	Sep-94	Mar-95	Aug-95	Oct-95
Months of fallowing	1	2	8	13	14	1	2	8	13	14	2	8	13	14
Nematodes (no.ind/0.1m²)	4534	5037	3717	3070	3228	16218	22795	6058	5286	4894	23965	12932	4707	7944
C.capitata (no.ind/0.1m²)	24.4	31.1	0.0	0.0	1.2	219.2	479.1	82.4	6.7	5.3	462.9	74.3	31.1	28.4
M.fragilis (no.ind/0.1m²)	36.5	70.2	29.6	123.0	142.1	120.4	8.1	9.3	36.5	41.8	0.0	4.1	27.0	39.2
M.fuliginosus (no.ind/0.1m²)	0.0	0.0	0.0	0.0	0.0	136.7	158.3	0.0	0.0	1.2	131.1	0.0	0.0	21.5
P.fallax (no.ind/0.1m²)	17.5	9.3	13.4	12.2	62.1	0.0	0.0	0.0	20.3	40.6	0.0	0.0	2.7	2.7
O.hartmanni (no.ind/0.1m²)	165.1	175.8	0.0	0.0	0.0	178.6	193.5	8.1	0.0	0.0	8.1	1.2	0.0	0.0
Dominant polychaete species	O.hart	O.hart	M.fra	M.fra	M.fra	C.cap	C.cap	C.cap	M.fra	M.fra	C.cap	C.cap	C.cap	M.fra
ITI	19	25	60	61	59	15	1	27	58	55	0	16	31	34
Diversity index (H')	3.23	3.14	3.72	3.68	3.63	2.68	2.07	2.95	3.61	3.04	1.29	2.28	2.6	2.86
Evenness index (J)	0.74	0.67	0.80	0.72	0.70	0.71	0.54	0.72	0.84	0.74	0.41	0.62	0.75	0.75
[2]Abundance (no.ind/0.1m²)	428	429	123	363	487	834	949	194	133	199	793	134	110	289
Number of taxa	21	26	25	35	36	14	14	17	20	17	9	13	11	14

[1] See Fig. 3.2.; [2] Excluding nematodes

3.6. Multi-variate statistics

Multidimensional scaling (MDS) was performed on the averaged data using square-root transformed species abundance data and the Bray-Curtis similarity measure to establish the relationship between macrofauna in the different stations at the different sampling dates. This was done separately considering all taxa including nematodes and all taxa excluding nematodes, with different results.

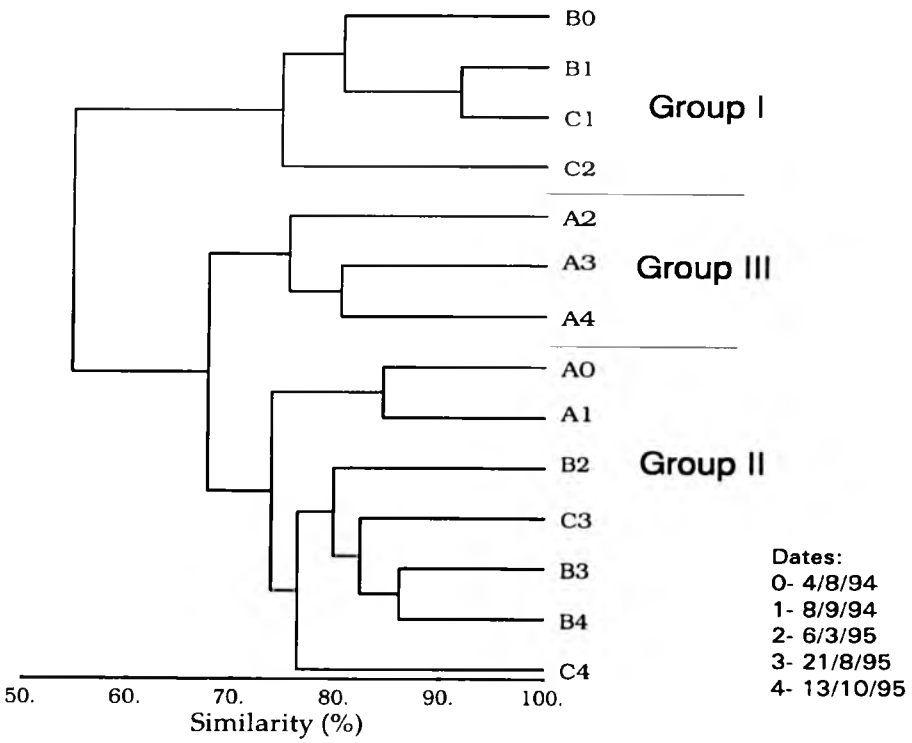
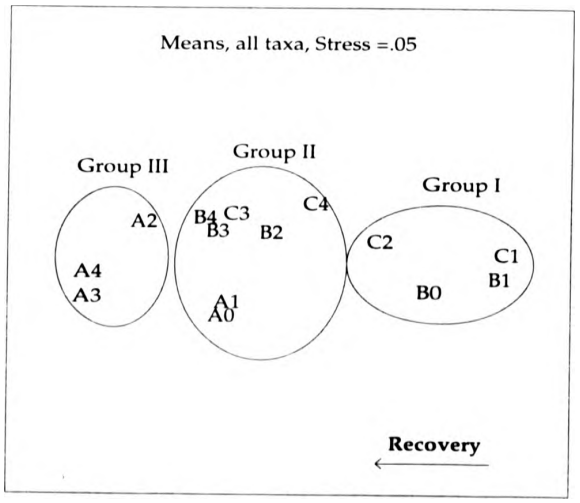


Fig. 31. Similarity diagram for the square-root transformed species-abundance mean data (including nematodes) at each station (A, B, C) and at each sampling date.

When considering all taxa, cluster analyses on the averaged data delineated 3 sample groups at 70% similarity, one for stations B and C at the beginning of this study, a second group for station A at the last three sampling dates and a third group with station A at the beginning of the study and stations B and C at the last three sampling dates (Fig. 31). Although station A is the most distant from the fish farm site, it joined Group II at the first two sampling dates, at a high level of similarity.

This ordination of sample groups is better shown under multidimensional scaling (MDS) (Fig. 32). There is a clear linear sequence of community change with time at stations B and C towards the community structure of station A (recovery). However, between August and October 1995 station C tends towards the initial community structure.



Dates:
0- 4/8/94
1- 8/9/94
2- 6/3/95
3- 21/8/95
4- 13-10-95

Fig. 32. MDS configuration of square-root transformed species-abundance mean data (including nematodes) at each station (A, B, C) and at each date (0, 1, 2, 3, 4).

The two-way crossed Analyses of Similarities test (ANOSIM) was used to assess the degree of difference in community structure between stations and dates, and its statistical significance, using square-root transformed data. Although there was a similar tendency for all stations to move towards recovery, all stations were shown to be significantly different from each other at the 5% level, when all taxa were included (Table VIIIa). Variations in the R statistic of the ANOSIM test (the magnitude of the change) show that stations A and C are the most dissimilar (R=0.843), and stations B and C the least dissimilar (R=0.519). The rate of change was different between the stations with station B changing (recovering) at a higher rate than station C. At station A recovery appears to take a different form with a strong seasonal influence (A2, Fig. 32). Significant differences (5% level) were found between all sampling pairs with the exception of August 95/October 95 (Table VIIIb). The R statistic of the ANOSIM test shows decreasing dissimilarity with time.

Table VIII. Two-way crossed ANOSIM test for differences between stations and sampling dates, using square-root transformed species abundance data including nematodes, and the Bray-Curtis similarity measure. (The samples from stations A and B in August 94 were not analysed as there were no comparative data from station C) [3 replicates at each station].

a) Tests for differences between station groups (averaged across all time groups)

Sample statistic (Global R): 0.601 Significance level of sample statistic: 0.001%					
Groups Used	Statistical Value	Possible Permutations	Permutations Used	Significant Statistics	Significance Level
(A, B)	0.676	10000	5000	2	0.1%
(A, C)	0.843	10000	5000	1	0.001%
(B, C)	0.519	10000	5000	27	0.6%

b) Tests for differences between time groups (averaged across all station groups)

Sample statistic (Global R): 0.601 Significance level of sample statistic: 0.001%					
Groups Used	Statistical Value R	Possible Permutations	Permutations Used	Significant Statistics	Significance Level
Sep94, Feb95	0.778	1000	1000	2	0.2%
Sep94, Aug95	0.864	1000	1000	1	0.1%
Sep94, Oct95	0.951	1000	1000	1	0.1%
Feb95, Aug95	0.593	1000	1000	3	0.3%
Feb95, Oct95	0.667	1000	1000	2	0.2%
Aug95, Oct95	0.259	1000	1000	64	6.4%

When superimposing the nematode mean abundance on the MDS configuration, a clear correlation was found between this phylum and the ordination of the stations (Fig. 33). A new MDS analysis was then performed on the faunal abundance data excluding nematodes to obtain a configuration more representative of the changes in time and space, in the faunal community.

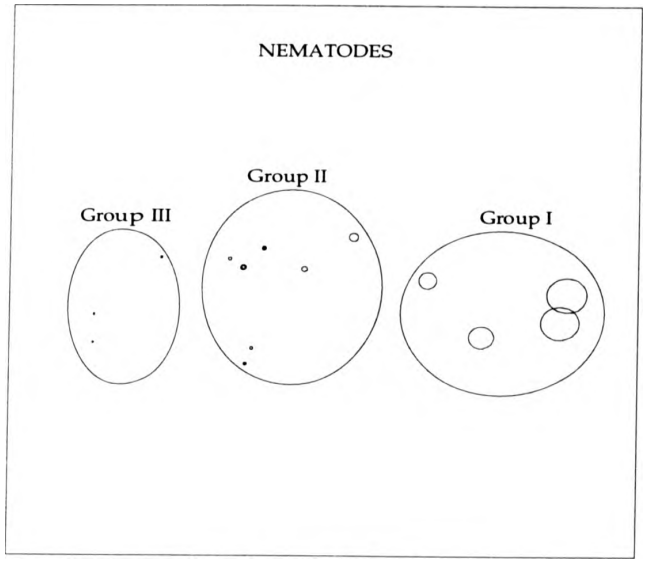


Fig. 33. As fig. 32 but station codes replaced by circles scaled in size according to mean counts of Nematoda.

When excluding nematodes from the faunal data, the stations and dates were clumped in five groups at 50% similarity (Fig. 34). The percentage of similarities between the different groups and stations within the groups, however, decreased when compared with those found for the data including nematodes (Fig. 31). Group I consists of the communities found at stations B and C in the first two sampling dates, group II consists of station C samples from August and October 1995. Group III is characterised by stations B and C samples from March 1995, group IV has the samples collected from station A at the two first sampling dates and group V, the least impacted one, consists of all the remaining samples from stations A and B.

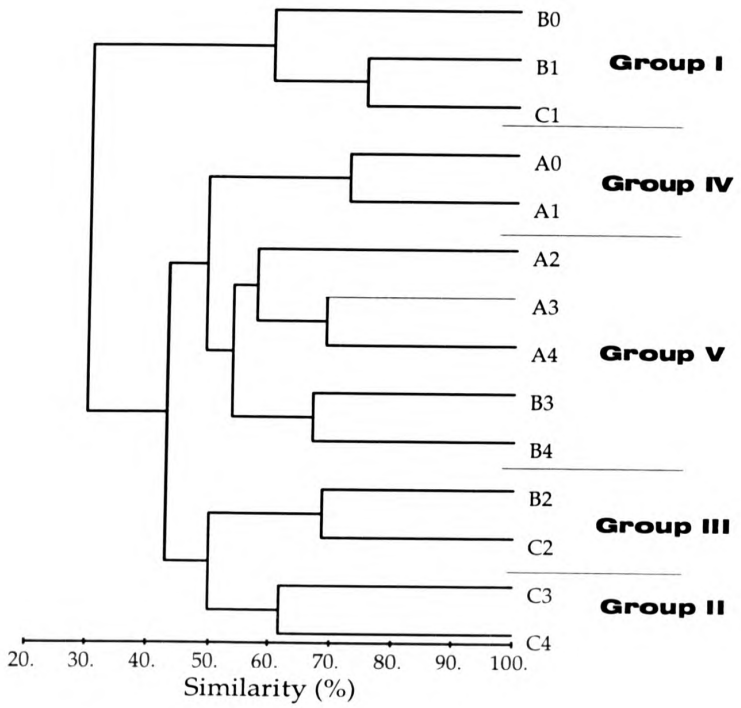


Fig. 34. Similarity diagram for the square root transformed species-abundance mean data, excluding nematodes, at each station (A, B, C) and at each sampling date (0, 1, 2, 3, 4). See Fig. 31 for key.

MDS configuration for the abundance data excluding nematodes (Fig. 35), follows a horseshoe-shaped sequence that still indicates a trend from stations B and C approaching the community structure of station A. Station A appears to show a seasonal change.

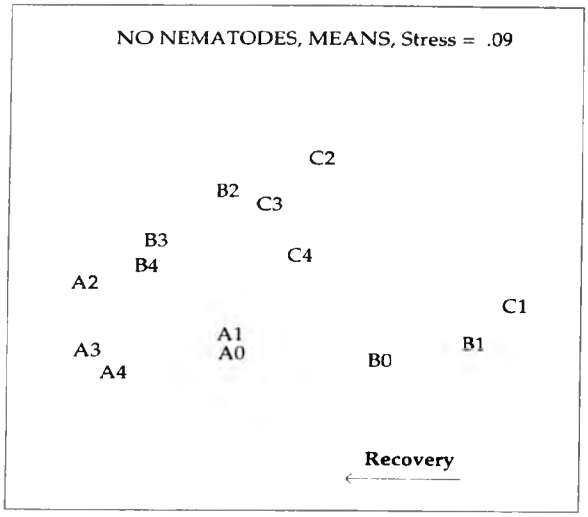


Fig. 35. MDS configuration of square-root transformed species-abundance mean data excluding nematodes, at each station (A, B, C) and at each date (0, 1, 2, 3, 4). See fig. 31 for key.

The ANOSIM test on abundance data excluding nematodes (Table IXa) gave very similar indications to those of the ANOSIM test performed on abundance data including nematodes (Table VIIIa). All stations were found to be significantly different from each other ($p<0.05$) with stations A and C being the most dissimilar and stations B and C the least dissimilar. Again, all pairs of dates were found to be significantly different with dissimilarity decreasing in time (Table IXb).

Table IX. Two-way crossed ANOSIM test for differences between stations and sampling dates, using square-root transformed species abundance data excluding nematodes, and the Bray-Curtis similarity measure. (The samples from stations A and B in August 94 were not analysed as there were no comparative data from station C) [3 replicates at each station].

a) Tests for differences between stations groups (averaged across all time groups)

Sample statistic (Global R): 0.770
Significance level of sample statistic: 0.001%

Groups Used	Statistical Value	Possible Permutations	Permutations Used	Significant Statistics	Significance Level
(A, B)	0.815	10000	5000	0	0.001%
(A, C)	0.991	10000	5000	0	0.001%
(B, C)	0.657	10000	5000	0	0.001%

b) Tests for differences between time groups (averaged across all stations groups)

Sample statistic (Global R): 0.806
Significance level of sample statistic: 0.001%

Groups Used	Statistical Value R	Possible Permutations	Permutations Used	Significant Statistics	Significance Level
Sep94, Feb95	0.938	1000	1000	1	0.001%
Sep94, Aug95	1.000	1000	1000	1	0.001%
Sep94, Oct95	1.000	1000	1000	1	0.001%
Feb95, Aug95	0.617	1000	1000	1	0.001%
Feb95, Oct95	0.728	1000	1000	1	0.001%
Aug95, Oct95	0.519	1000	1000	1	0.001%

Despite the fact that the multi-variate results are based on biological data, no mention has been made so far of the faunal characteristics. Using the SIMPER program from PRIMER the species having the greatest contribution to the division of stations in different groups as defined by the CLUSTER and MDS ordinations were determined. Tables X and XI show only the 3 taxa in SIMPER that showed highest reduction, and the 3 taxa that showed highest increase in abundance from highly enriched to medium enriched groups of stations (although there are many more than three taxa that characterise the difference between these two groups).

Table X. Most tolerant species, extracted from the SIMPER analysis as the 3 top ranked species from each analysis (including and excluding nematodes) showing highest reduction in abundance (ind.m^{-2}) from group i (most impacted) to group ii (least impacted), i.e. number individuals in group i/ number individuals in group ii.

	all taxa including nematodes[1]	all taxa excluding nematodes[2]
C. capitata	33934/45	42765/272
M. fuliginosus	10658/0	14210/28
O. hartmanni	9541/0	12675/0

[1] Group i: Station B samples from August and September 94 + station C sample from September 94; Group ii: Station A samples from March, August and October 95
[2] Group i: Station B samples from August and September 94 + station C sample from September 94; Group ii: Station A samples from March, August and October 95 + station B samples from August and October 95.

For both sets of data, including and excluding nematodes, *Capitella capitata*, *Malacocerus fuliginosus* and *Ophryotrocha hartmanni* were identified as the most tolerant species, characteristic of the conditions found at the samples from group I (Fig. 31 and 34) believed to be highly organic enriched. *Mediomastus fragilis*, *Prionospio fallax* and Bivalvia I were found to be the species

characteristic of group III from Fig. 31 and group V from Fig. 34. The consistence of the indicator species for both sets of data, shows that the use of indicator species in this study to be a good approach to the characterisation of sediment conditions.

Table XI. Most sensitive species, extracted from the SIMPER analysis as the 3 top ranked species from each analysis (including and excluding nematodes) showing highest increase in abundance (ind.m^{-2}) from group i (most impacted) to group ii (least impacted), i.e. number individuals in group i/ number individuals in group ii.

	all taxa including nematodes[1]	all taxa excluding nematodes[2]
M. fragilis	3317/9834	4297/7471
Bivalvia I	609/4421	495/3950
P. fallax	0/2931	0/2976

[1] Group i: Station B samples from August and September 94 + station C sample from September 94; Group ii: Station A samples from March, August and October 95

[2] Group i: Station B samples from August and September 94 + station C sample from September 94; Group ii: Station A samples from March, August and October 95 + station B samples from August and October 95.

3.7. Sample replication

To assess the species richness of a site for comparison with other sites, the minimum number of samples needs to be considered (Baker & Wolff, 1987). Fig. 36 shows the cumulative number of taxa per core for each station at each sampling date. At station A the increment of new species as the number of samples increases was higher than at stations B and C. The increment of new species at station B increases over time and is higher than at station C. Samples comprising three cores of the dimensions used appear to give a good

representation of the community at stations B at the first two sampling dates and at station C at all dates.

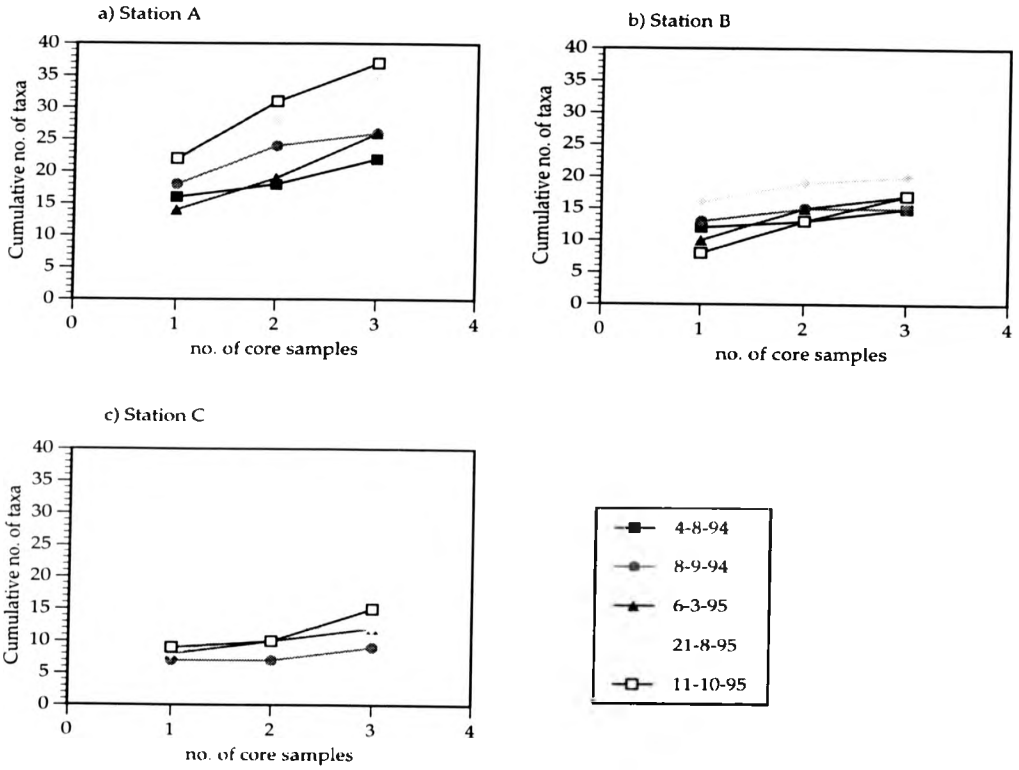


Fig. 36. Cumulative number of taxa found with increasing number of replicate cores sampled at all sampling events and at the three stations studied.

Changes over time can be better visualised by the percentage increase in species number per sample increment (Fig. 37). Again, station A showed a higher percentage increase in new species number than stations B and C, excluding cores sampled at station B in October 95. In general, allowing for a seasonal effect on diversity, the percentage increase of new species increases over time. Thus, as community diversity increases, as in the case of an

organic enrichment gradient, the optimum number of samples would need to increase to remain representative of the population.

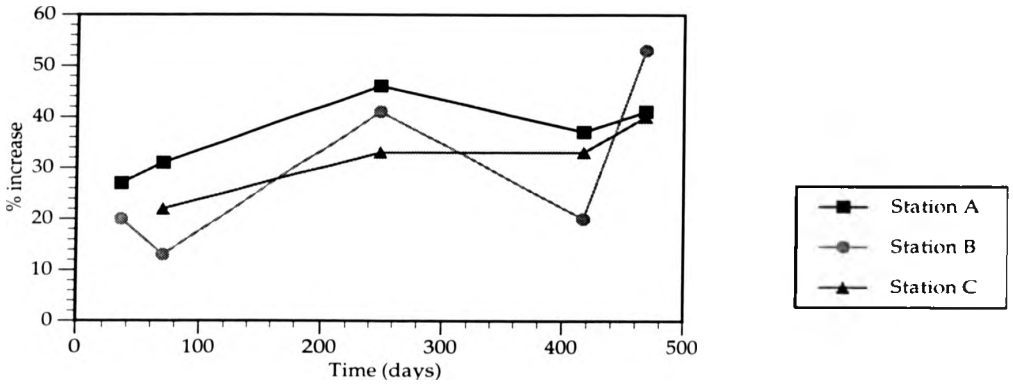


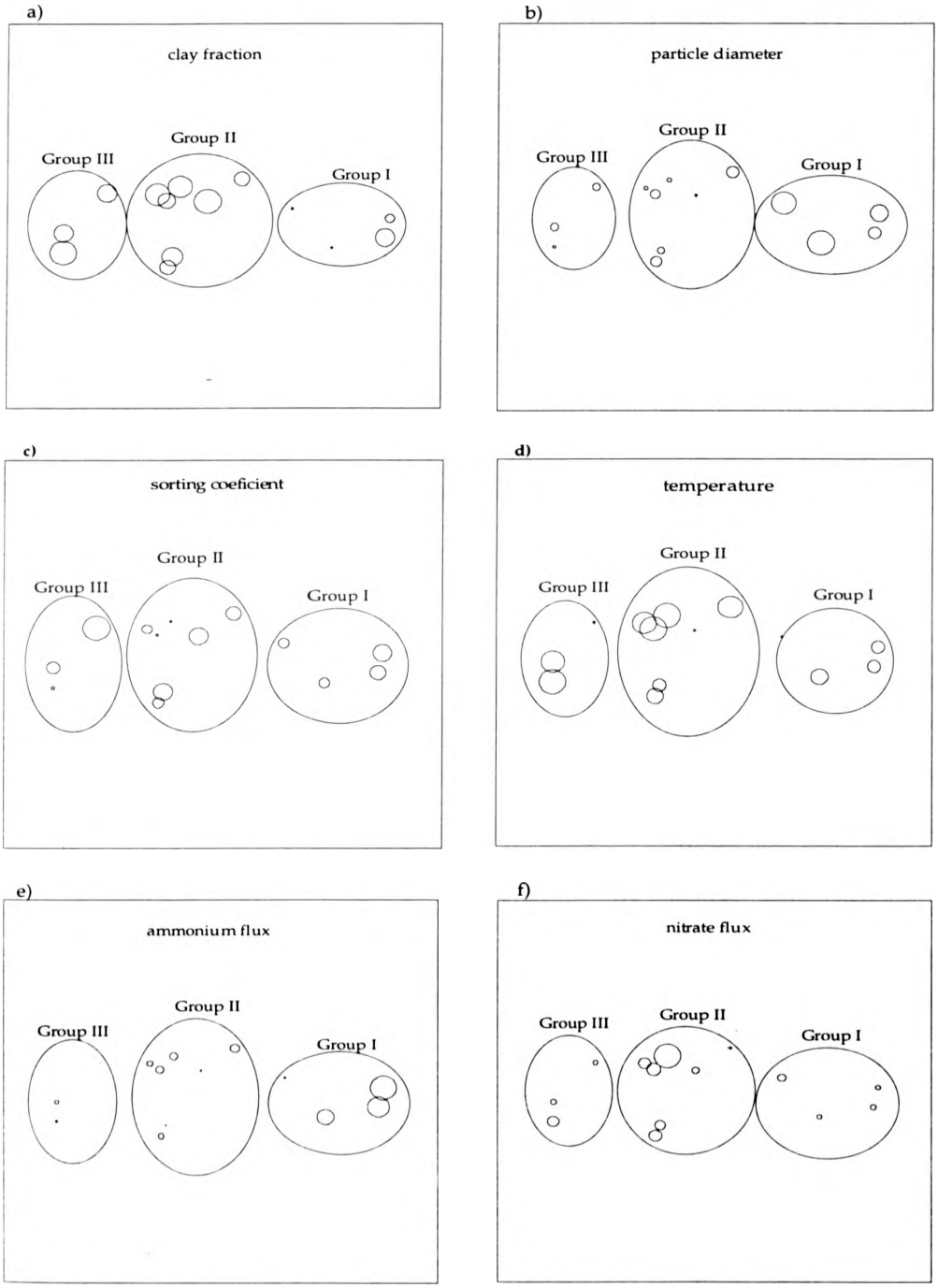
Fig. 37. Changes over time in the percentage increase on the total number of taxa captured by sampling 3 replicates instead of 1.

3.8. Linking multi-variate community structure to environmental parameters

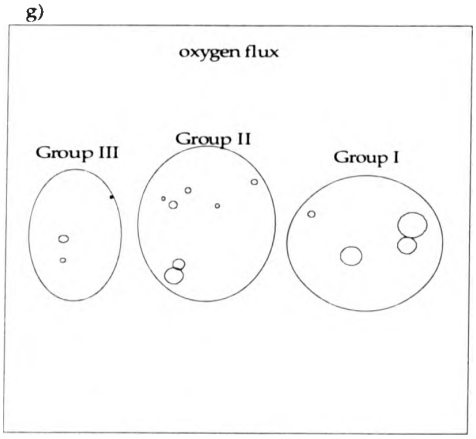
Two approaches were used:

a) superimposing the environmental variables one at a time on the faunal MDS configuration as circles whose sizes reflect the magnitude of the environmental variable at each site and date, and determining whether there is a visual correlation between the sample grouping and the variable in consideration.

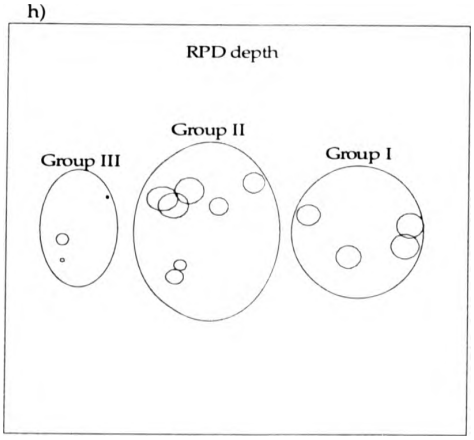
A number of environmental parameters were superimposed on the MDS configurations performed on the abundance data including (Fig. 38) and excluding (Fig. 39) nematodes, with similar results.


a)
clay fraction
Group III
Group II
Group I
b)
particle diameter
Group III
Group II
Group I
c)
sorting coeficient
Group III
Group II
Group I
d)
temperature
Group III
Group II
Group I
e)
ammonium flux
Group III
Group II
Group I
f)
nitrate flux
Group III
Group II
Group I

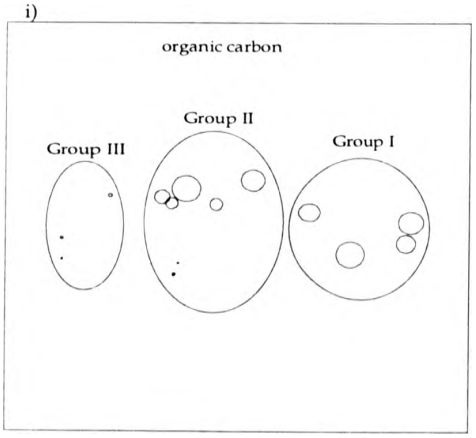
g)


oxygen flux
Group III
Group II
Group I

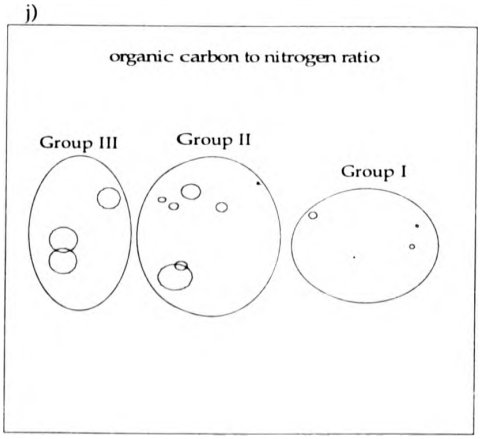
h)


RPD depth
Group III
Group II
Group I

i)


organic carbon
Group III
Group II
Group I

j)


organic carbon to nitrogen ratio
Group III
Group II
Group I

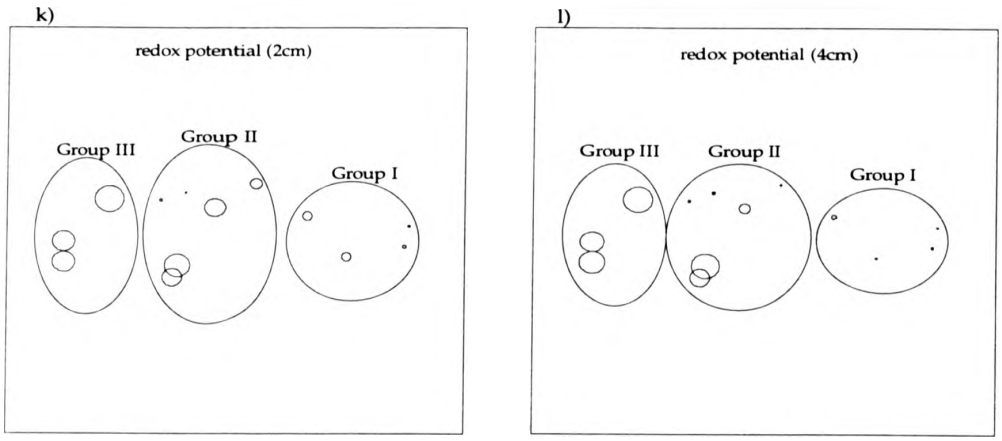
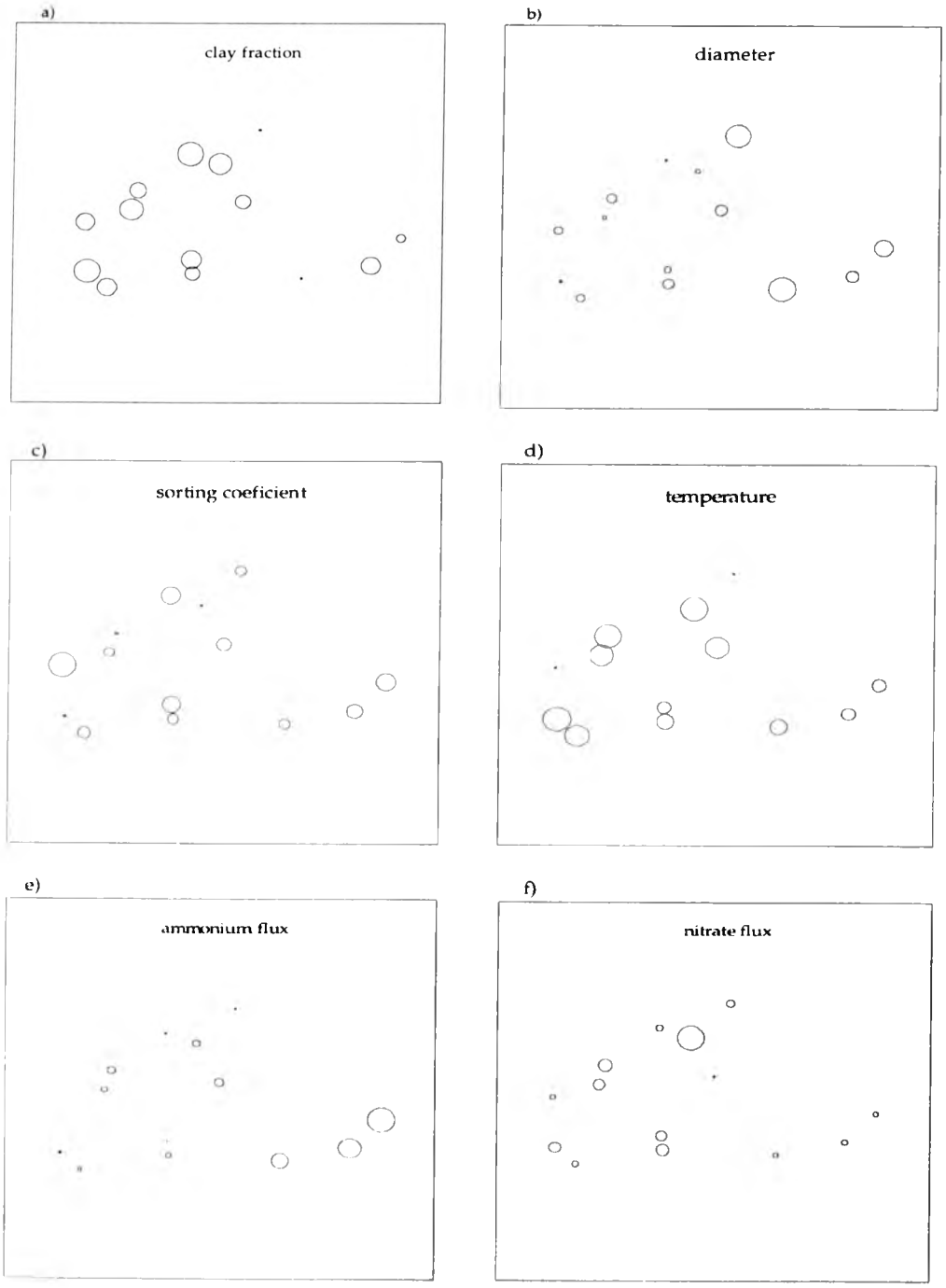
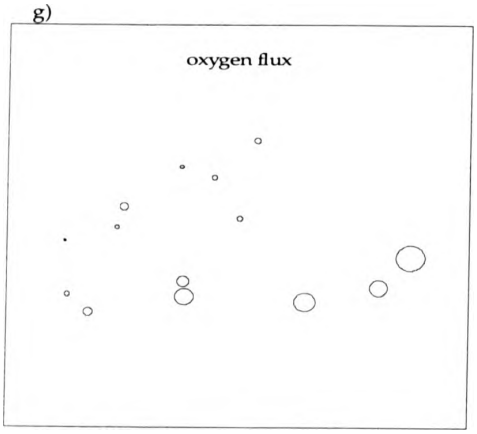


Fig. 38. As fig. 32 (data including nematodes) but station codes replaced by circles scaled in size according to the environmental parameters considered. a) sediment clay fraction; b) particle diameter; c) sediment sorting coefficient; d)seawater temperature; e)ammonium flux; f) nitrate flux; g) oxygen uptake; h) depth of RPD; i) sediment organic carbon; j)organic carbon to nitrogen ratio; k) redox potential values at 2 cm sediment depth; l) redox potential values at 4 cm depth.

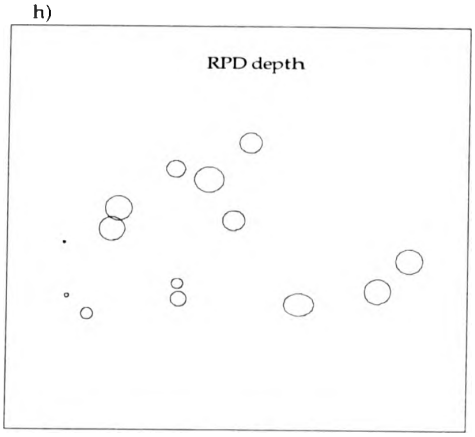
From all the physical variables considered (sediment particle size, clay fraction, sorting coefficient and seawater temperature) (Fig. 38a-d), only sediment particle diameter appeared to correlate with the MDS ordination of the faunistic data (Fig. 32). Correlation was also found on some of the pollution-related variables such as ammonium and oxygen fluxes and organic carbon to nitrogen ratio (Fig. 38e,g,j). Organic carbon and redox potential at 4 cm depth (Fig. 38i,l) separated station A from the other two stations, but do not explain the variation in time.


a)
clay fraction
b)
diameter
c)
sorting coeficient
d)
temperature
e)
ammonium flux
f)
nitrate flux

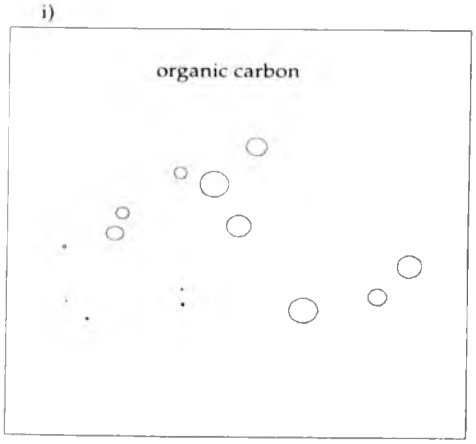
g)


oxygen flux

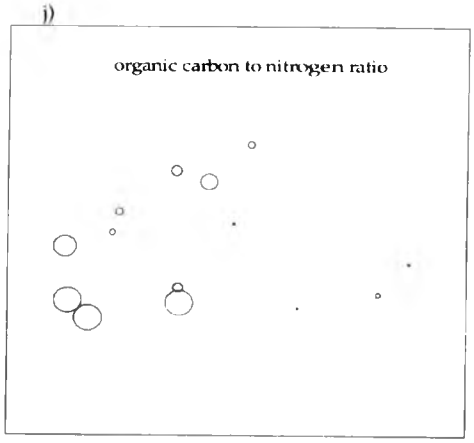
h)


RPD depth

i)


organic carbon

j)


organic carbon to nitrogen ratio

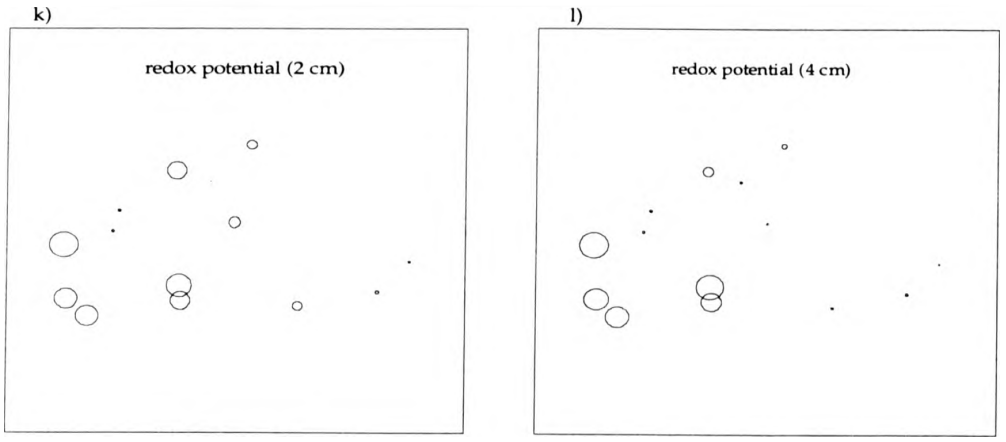


Fig. 39. As fig. 35 (data excluding nematodes) but station codes replaced by circles scaled in size according to the environmental parameters considered. a) sediment clay fraction; b) particle diameter; c) sediment sorting coefficient; d)seawater temperature; e)ammonium flux; f) nitrate flux; g) oxygen uptake; h) depth of RPD; i) sediment organic carbon; j)organic carbon to nitrogen ratio; k) redox potential values at 2 cm sediment depth; l) redox potential values at 4 cm depth.

b) performing a correlation based Principal Components Analysis (PCA) on standardised values for environmental variables in different combinations to see which combination best matches the faunistic MDS. Due to the high number of environmental variables considered and thus the high number of combinations possible, the environmental variables that "best explain" the biotic community pattern were selected by the Clarke & Ainsworth (1993) method using the BIO-ENV program from PRIMER.

Table XII displays the combinations of environmental variables which best groups the stations in a manner consistent with the faunal pattern. Ammonium flux was the single environmental variable which best grouped the stations for data both including and excluding nematodes. However, since the faunal

ordination is not essentially one-dimensional (Fig. 32 and 35), a single environmental variable is not expected to provide a very successful match.

Table XII. Combinations of the 11 environmental variables, taken k at a time, yielding the best matches of biotic and abiotic similarity matrices for each k, as measured by weighted Spearman rank correlation ρ_ω ; bold type indicates overall optimum.

a) data including nematodes

BIO-ENV; weighted Spearman rank correlation	
k	Best variable combinations (ρ_ω)
1	NH_4^+ (0.34)
2	O_2, org car (0.53)
3	diam, O_2, org car (0.58)
4	**diam, O_2, org car, OC/N (0.62)**
5	diam, O_2, NH_4^+, org car, OC/N (0.61)
6	clay, diam, O_2, NH_4^+, org car, OC/N (0.57)
7	clay, diam, O_2, NH_4^+, org car, OC/N, RPD (0.52)
8	clay, diam, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD (0.48)
9	clay, diam, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD (0.45)
10	clay, diam, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD, Eh4 (0.42)
11	clay, diam, sort, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD, Eh4 (0.37)

b) data excluding nematodes

BIO-ENV; weighted Spearman rank correlation	
k	Best variable combinations (ρ_ω)
1	NH_4^+ (0.34)
2	O_2, org car (0.57)
3	**diam, O_2, org car (0.58)**
4	diam, O_2, NH_4^+, org car (0.55)
5	diam, O_2, NH_4^+, org car, OC/N (0.55)
6	diam, O_2, NO_3^-, NH_4^+, org car, OC/N (0.51)
7	clay, diam, O_2, NO_3^-, NH_4^+, org car, OC/N (0.49)
8	clay, diam, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N (0.45)
9	clay, diam, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD (0.42)
10	clay, diam, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD, Eh4 (0.36)
11	clay, diam, sort, T°C, O_2, NO_3^-, NH_4^+, org car, OC/N, RPD, Eh4 (0.32)

clay - clay fraction in the sediment; diam - particle diameter; sort - sorting coefficient; T°C - seawater temperature; O_2 - oxygen flux; NO_3^- - nitrate flux; NH_4^+ - ammonium flux; org car - percentage of organic carbon in the sediment; OC/N - organic carbon to nitrogen ratio in the sediment; RPD - depth of the redox potential discontinuity layer; Eh4 - redox potential at 4 cm sediment depth.

The best variable combination for the data including nematodes (Table XIIa) included a physical variable, (particle diameter) and three pollution-related variables (oxygen flux, organic carbon and C:N ratio). For the data excluding

nematodes, the combination of particle diameter, oxygen flux and organic carbon variables showed the best match (Table XIIb). In neither set of data was the match very successful (0.62 and 0.58 for data including and excluding Nematoda respectively) indicating that the environmental variables measured only partially explain the distribution of the faunal data.

PCA configurations for the environmental variable combinations with the highest rank correlation for the two sets of data, are shown in Fig. 40a and 40b.

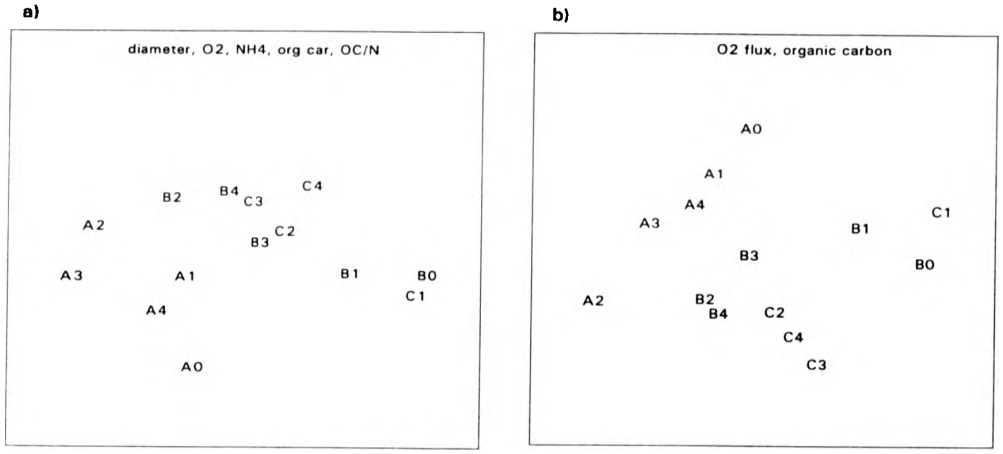


Fig. 40. Correlation based PCA for the combination of environmental parameters that 'best match' the faunistic distribution a) including nematodes and b) excluding nematodes, as found by BIO-ENV (Table XII).

The PCA ordination based on particle diameter, oxygen flux, organic carbon percentage and OC:N grouped stations B for the first two sampling dates with station C samples from September 1994 and February 1995 (B0, B1, C1, C2), formed a second group with those same stations for all other sampling dates and separated station A from stations B and C. When excluding OC:N from the PCA ordination, no stations appeared to form specific groups. When

observing the respective MDS configurations a similar pattern was shown for the faunistic ordination including nematodes (Fig. 32) but no strong correlation was found between the faunistic ordination excluding nematodes (Fig. 35) and the respective environmental ordination (Fig. 40b) as visualised by superimposing the groups defined by CLUSTER and MDS on the PCA ordination.

In neither set of data, however, was the match very successful (0.62 and 0.58 for data including and excluding Nematoda respectively) indicating that the environmental variables measured only partially explain the distribution of the faunal data. Since the stations sampled reflect different influences from the fish farm waste (due to the distance from the source) it was thought that the weight of the different environmental variables 'explaining' the community structure at the different stations could also be distinct. Table XIII shows the single and/or combinations of environmental variables which best groups the temporal variation of individual stations in a manner consistent with the faunal pattern.

Table XIII. Combinations of the 11 environmental variables yielding the best match of biotic and abiotic similarity matrices, as measured by weighted Spearman rank correlation ρ_w; correlation coefficient in brackets.
a) data including all taxa

BIO-ENV; weighted Spearman rank correlation			
	STATION A	STATION B	STATION C
Single best variable	O_2 (0.235)	NH_4^+ (0.64)	O_2 (0.94)
Best variable combination	clay, T°C, O_2, NO_3, org car, OC/N (0.34)	NO_3 , NH_4^+(0.78)	clay , O_2 (0.96)

b) data excluding nematodes

BIO-ENV; weighted Spearman rank correlation			
	STATION A	STATION B	STATION C
Single best variable	O_2 (0.58)	NH_4^+ (0.57)	O_2 (0.92)
Best variable combination	O_2, NO_3^-, RPD (0.66)	O_2, NO_3^- (0.81)	O_2 (0.92)

clay - clay fraction in the sediment; diam - particle diameter; sort - sorting coefficient; T°C - seawater temperature; O_2 - oxygen flux; NO_3^- - nitrate flux; NH_4^+ - ammonium flux; org car - percentage of organic carbon in the sediment; OC/N - organic carbon to nitrogen ratio in the sediment; RPD - depth of the redox potential discontinuity layer; Eh4 - redox potential at 4 cm sediment depth.

As expected the temporal distribution of the different stations appears to be driven by combinations of different variables. No physical variable was found to be included in the best match when excluding nematodes from the MDS ordination. The percentage of clay fraction in the sediment, and not particle diameter as found when considering all stations (Table XII), appears to be important together with oxygen uptake in the distribution of the nematode assemblage. In both sets of data the correlation coefficient decreases with distance from the fish farm site and when excluding nematodes from the data the correlation found was stronger than when including this phylum. No successful match was found for station A, especially when including nematodes.

4. DISCUSSION

Sampling strategy

In most pollution-related recovery studies, the existence of one or more reference stations is considered necessary to quantify the degree of pre-impact contamination (MAFF, 1993). This control can be achieved by baseline monitoring and/or by finding an area believed to be unaffected by the contamination source and to be representative of the total area surveyed. In Scottish sea-lochs with complex hydrographic conditions and extreme seasonal conditions, the choice of a control station is in most cases very subjective. All previous surveys at Creran A (Table XIV) have found the reference stations to show contradictory results such as higher organic carbon content, lower redox potential values and lower diversity and evenness index values than some of the stations below or near the cages. A study previous to the presence of the fish cages in Loch Creran (Gage, 1972b) showed certain stations to be dominated by opportunistic species, indicating disturbed or stressed benthic communities. Regarding the percentage of organic carbon in the sediment, heavily impacted sediments at stations B and C showed organic carbon levels comparable to those found at reference stations from previous years (SEPA, 1992, 1994) and to those observed before the introduction of fish farms in Loch Creran (2-5%, Ansel, 1974). Furthermore, the return to the pre-pollution equilibrium may never be achieved since the sediment physical, chemical and biological conditions may not return to the original conditions (Christie & Green, 1982; Olsgard & Hasle, 1993). Recovery is then reached when, after the

organic input has ceased, the benthic community is fairly stable, undergoing only small-scale quantitative and qualitative changes in time (Krebs, 1972).

Table XIV. Resumé of previous surveys on Loch Creran before the introduction of the fish farm (Gage, 1972a, 1972b) and during fish farm production (SEAS 1991; SEPA 1989, 1992, 1994). Dominant polychaete species highlighted.

Reference	Gage 1972a	Gage 1972b	SEPA 1989	SEAS 1991			SEPA 1992			SEPA 1994			
Date of sampling	Nov-67	May-68	Jun-89	Dec-91	Dec-91	Dec-91	Jun-92	Jun-92	Jun-92	Jun-94	Jun-94	Jun-94	Jun-94
Station	C-6	C-5	5	2	4	refe-rence	2	3	refe-rence	2	3	4	refe-rence
Sieve mesh (mm)	1	1	1	1	1	1	1	1	1	1	1	1	1
Depth (m)	26						17	18					
Distance (m), orientation	South	South	betwee n cages	?, South	25m, Este	?, Este	25m, West	?, South	?, Este	25m, Este	25m, South	50m, South	?, Este
Nematodes (no. /0.1m²)		6	37	11	0	53	206	68		345	437	13	14
C. capitata (no. /0.1m²)	0	2	240	0	1	0	10	1	7	556	3129	114	1
M. fragilis (no. /0.1m²)	0	0	0	119	3	16	76	227	4	249	4	2	0
M. fuligmosus (no. /0.1m²)	0	0	37	0	0	1	3	0	0	5	452	12	0
P.fallax (no. /0.1m²)	0	2	0	72	21	107	0	0	0	*201	*25	*17	*63
Ophryotrocha sp. (no. /0.1m²)	0	0	0	0	0	0	12	1	0	3	18	0	0
S.inflatum (no. /0.1m²)	0	1	1	59	4	105	10	17	1	134	0	69	25
M.palmata (no. /0.1m²)	0		0	40	360	67	6	35	40	21	0	104	92
Diversity (H')		0.23	0.86	2.97	1.95	3.09	3.19	3.31	4.02	3.8	1.52	4.36	4.23
Evenness (J')		1.72	0.27				0.61	0.58	0.7	0.67	0.34	0.76	0.72
**Abundance (no. /0.1m²)			323	545	582	690	517	1150	504	2747	4358	617	692
total no. species	29	179	9	60	50	51	37	51	54	50	23	54	58
Eh (surface) mV			-83	337	195	5				238	222	311	446
Eh (4cm) mV				34	-60	-34	73	74	83	68	130	81	93
% organic carbon				1.58	1.34	2.38	2.85	1.88	2.21				

* As *Prionospio sp.*; ** Including nematodes

Long time-scale studies are then necessary in infaunal recovery studies in sea lochs if the long term impact of fish farming is to be well understood. Rosenberg (1973, 1976) found that although the terminal stages of

macrobenthos succession were reached 5 years after the closure of a pulp mill factory, 3 more years were necessary before it was impossible to distinguish between a 'normal' and a recovery influenced succession.

Organic enrichment

Primary production has been shown to contribute 3198 tonnes of organic carbon per year to the loch while the terrestrial input has been calculated at 680 t yr^{-1} (Tyler, 1983). Although the input of carbon to the sea bed in the 2 years preceding fallowing was only calculated at 35 t in the first year of fish production (1992/93) and 134 t in the second year (1993/94), carbon loading rates of 4107 g m^{-2} yr^{-1} and 10705 g m^{-2} yr^{-1} under the fish cages for those periods (Appendix III) were 98 to 99% higher than the expected average amount of carbon originating from other sources '79 g m^{-2} yr^{-1}, Tyler, 1983). Diver observations of the sea bed and sediment redox potential measurements identified station C site as the most impacted one. Thus although the model (Appendix III) shows that station C was situated in an area receiving 87% less than the maximum predicted carbon deposition, this can be accounted for by an error in fixing the position of the station in the model grid, of only ±10 m.

Nematodes

Due to the small sieve mesh size (0.5 mm) a large number of nematodes were collected compared to the total number of the other macrobenthic groups (Fig. 21). Subsamples were found not to be representative of the total sample thus

the quantitative analysis of Nematoda was very time consuming (around 40 working days).

The decreasing abundance in nematodes with distance from the fish cage site and with increasing time of fallowing at stations B and C indicates that this phylum is favoured by organic enrichment. Other authors (Gee *et al.*, 1985; Sandulli & Giudici, 1989, 1990; Sandulli & Nicola, 1991; Wormald & Stirling, 1979) also observed an increase in nematode numbers along a gradient of increasing organic enrichment but only until a point when the environmental conditions deteriorate excessively, after which they were absent. Such a point was not observed during this study, indicating that although highly enriched, the sediment conditions were still able to sustain nematodes and other tolerant macrobenthic fauna. The increase in nematode abundance at station B from August to September 94 and at station C from August 1995 to October 1995, is consistent with the increase in number of the other opportunistic species such as *Capitella capitata* and *Malacocerus fuliginosus*, suggesting a deterioration of the sediment conditions over these periods at the respective stations. Although some environmental and other biological parameters showed a change with time at station A, nematode numbers remained relatively constant over time at this station, suggesting that this phylum only shows significant changes in abundance on a steep organic enrichment gradient.

Although similarity between the stations decreased when excluding nematodes from CLUSTER analysis, the faunistic MDS ordination and

ANOSIM analysis gave similar indications for both sets of data (including and excluding nematodes). BIOENV analysis on the total number of samples (Table XII) also gave similar indications when including or excluding nematodes. When using BIOENV analysis on the temporal changes at the individual stations (Table XIII), however, differences were found in the results for both sets of data: changes in the clay fraction of the sediment, percentage organic carbon and ammonium flux were only found to 'fit' the faunistic data including nematodes and the depth of the RPD was only found to 'fit' the data excluding nematodes. The correlation coefficient, however, increased for the data excluding nematodes, especially at station A, indicating a better 'fit' between environmental variables and faunistic data and thus reveal a higher possibility of a cause-effect relationship.

The diversity and evenness indices used indicated highly disturbed benthic communities at the 3 stations at all sampling dates when including nematodes in the analysed data (Fig. 28b and 29b). Due to the assumptions made when using these indices (see Krebs, 1972, pp. 506), the high number of nematodes found and the possibility of there being around 8 to 10 species present (M. Austen, pers. com.), it would not be appropriate to include the Nematoda assemblage as a single taxon when calculating diversity and evenness indices.

Although nematodes are the main constituent of the meiofauna (Sandulli & Giudici, 1989), they are seldom included in macrobenthos studies (Ritz *et al.*, 1989; Weston, 1990) especially when using 0.5 mm collection sieves, due to the

high density and difficulties inherent to their classification into species. However, when using 1 mm sieves for macrobenthos collection nematodes numbers are relatively low, being often included in the consequent analysis as a total taxon (Brown *et al.*, 1987; Rosenberg, 1972, 1973, 1976; SEPA 1992, 1994).

Macrobenthos recovery

Most biological uni-variate indices used illustrated gradual faunal changes over time, from a highly (stations B and C) or moderately (station A) disturbed community to a moderately disturbed one. With increasing fallowing time (and distance FROM the fish farm site), and disregarding seasonal influences, there was (1) an increase of species diversity and evenness; (2) a decrease in total abundance (stations B and C); (3) an increase in the total number of species, (4) a decrease in the total number of nematodes; (5) a decrease in the abundance of opportunistic species such as *Capitella capitata* and *Malacocerus fuliginosus*; and (6) an increase in abundance of *Mediomastus fragilis* and *Prionospio fallax*. Previous studies on the effects of fish farm waste on infauna (Weston, 1990; Brown *et al.*, 1987) showed a similar pattern with distance from the fish cages, indicating that structural faunal changes are similar in both temporal and spatial gradients, as suggested by Pearson & Rosenberg (1978) for other forms of organic enrichment.

Varying degrees of recovery were observed at the stations studied. Although stations B and C were both highly disturbed at the beginning of the study, the times between the successive stages of recovery were different for both stations with station B recovering more rapidly than station C as indicated by

the species succession and uni-variate and multi-variate results. Fourteen months after the fish farm loading was stopped, the highly disturbed benthic community from station C, although improving, was still dominated by opportunistic species characteristic of highly disturbed sediments. After 14 months of fallowing the benthic structure at station B was characteristic of a moderately disturbed community. Lumb (1989), when studying the effects of fish farm waste on a sea loch sediment, found similar results to station C, with the sediment still organically enriched and no significant macrofaunal recolonization appearing to have occurred 1 year after the fish cages were removed.

The community structure at station A in the beginning of the study indicates a moderately disturbed community. Although recovery (using total abundance, number of species, diversity and evenness as criteria) over the first 6 months was high, the increase in sea water temperature resulted in a decrease in the rate of recovery and, 15 months after fallowing, none of the biological parameters or community structure at this station (Table VII) were similar to those found at reference stations of previous surveys (Table XIV). This fact suggests that after 15 months of fallowing, the benthic community structure at station A was still influenced by the impact from the fish farm.

Partial recovery times at stations A, B and C were found to be longer than those indicated at a recovery study from 3 other sites in different sea lochs (T. Nickell, unpublished data) where, in general, highly disturbed macrobenthic

fauna from sediments affected by fish farms needed only approximately 8 months to recover to a community characteristic of moderately disturbed sediments, a further 8 months to lightly disturbed and a total of 21 to 24 months to complete recovery.

Although organic carbon and oxygen uptake decreased from August to September 1994, the other chemical variables measured and the uni- and multi-variate analysis of the community parameters showed a deterioration of sediment conditions over this period at station B. However, a similar effect was observed from August 1995 to October 1995, suggesting that it was related to a seasonal influence, as a delayed reaction to the increase in seawater temperature. The deterioration of sediment conditions over the summer months, especially in fjordic structures, is well documented (Overnell *et al.*, 1995; Stanley *et al.*, 1981; Syvitski *et al.*, 1987). As a consequence of this deterioration, and other seasonal factors such as the timing and frequency of larval recruitment (Snelgrove & Butman, 1994), the time of the year at which fish farming production is ceased may have a strong influence on the evolution of recovery in sediments. Zajac & Whitlatch (1982) found that the succession after an early spring disturbance was characterised by peak species densities and numbers, succession following an autumn disturbance was abbreviated with few species at low densities and, after a summer disturbance, intermediate trends were found.

Indicator species

The SIMPER method proved successful in isolating *Capitella capitata* and *Malacocerus fuliginosus* as tolerant species and *Mediomastus fragilis* and *Prionospio fallax* as indicator species of the start of recovery. The dominance of opportunistic polychaetes, such as *C. capitata* and *M. fuliginosus* as found at stations B and C (Appendix IV), is characteristic of highly enriched sediments (Bellan, 1970; Pearson & Rosenberg, 1978; Brown *et al.*, 1987; SEPA, 1994). *Capitella capitata*, a non-selective sub-surface feeder, is a cosmopolitan indicator of disturbance. *Malacocerus fuliginosus*, a selective deposit feeding spionid, is an indicator of highly enriched sediments in western European areas. The reoccurrence of *M. fuliginosus* at stations B and C in October 1995 indicates a slight deterioration of the sediment conditions, also shown in ammonium flux and redox potential values, in the MDS ordination and by the presence of *Beggiatoa* spp. Since no niches were vacated over this period the dynamics of *M. fuliginosus* and *C. capitata* (steady decrease over the same period) indicates, as suggested by Gray (1982), that while *M. fuliginosus* adapts by a tolerance strategy, *C. capitata* is a typical opportunist with small body size, rapid turn-over rate and planktonic larvae, which has the ability to rapidly respond to vacanct niches.

During a transitional phase indicative of recovery, the disappearance of *M. fuliginosus* and the appearance of *M. fragilis* was observed, but with *C. capitata* still as the dominant species (Table XV). *Prionospio fallax* was found, together with *M. fragilis*, to be an indicator of moderately enriched sediments as also

observed in previous surveys at this site (SEAS, 1991; SEPA 1992). Studies on the effects of domestic sludge and oil contamination also show *P. fallax* and *M. fragilis* as indicators of moderately disturbed communities (Cabioch *et al.*, 1982; Eleftheriou *et al.*, 1982). The tubicolous spionid *P. fallax* is a selective deposit feeder often found on silt-clay sediments. *Mediomastus fragilis* is a subsurface non-selective deposit feeder that, like most capitellids, is found in enriched sediments.

Table XV. Descriptive model for macrofaunal succession after cessation of organic enrichment by fish farm waste input at the site studied.

Degree of disturbance	Highly disturbed	Transitional phase	Moderately disturbed	Transitional phase (?)
Characteristic species	*C. capitata* *M. fuliginosus*	*C. capitata* *M. fragilis*	*M. fragilis* *P. fallax* *C. capitata*	*M. fragilis* *P. fallax* *S. inflatum*
Number of polychaete species	4-6	8-13	8-19	24-26
Diversity (H')	1.2-2.7	2.3-3.0	2.6-3.6	3.6-3.7
Evenness (J)	0.4-0.7	0.6-0.7	0.7-0.8	0.7-0.8
Station, date, (ITI)	B, Aug 94, (15) B, Sept 94, (1) C, Sept 94, (0)	B, Feb 95, (27) C, Feb 95, (16) C, Aug 95, (31) C, Oct 95, (34)	A, Aug 94, (19) A, Sept 94, (25) B, Aug 95, (58) B, Oct 95, (55)	A, Feb 95, (60) A, Aug 95, (61) A, Oct 95, (59)

The facultative carnivorous polychaete *Ophryotrocha hartmanni*, considered as an indicator species of enriched sediments (Pearson *et al.*, 1982), was found as the second most abundant species at the highly disturbed community of station B (August and September 1994) and as the dominant species at the moderately disturbed community of station A (August 1994). The abundance

of this species at the highly disturbed community of station C (September 1994) was not, however, as high as in the communities referred to above, indicating that this species is less tolerant than *M. fuliginosus* and *C. capitata.* Since *O. hartmanni* was not found at station A from March 1995, the absence of this species at the moderately disturbed community of station B (Aug 95, Oct 95) may be due to a lack of larval availability. *Melinna palmata*, a surface deposit feeding polychaete, was very rare and never present at station C. In previous surveys (SEAS, 1991; SEPA, 1992, 1994) *M. palmata* was found to be a species characteristic of moderate enrichment. This species, however, was also the dominant polychaete at the reference station from a June 1994 survey (SEPA, 1994) and the second or third most abundant polychaete at the reference stations from surveys in December 91 and June 1992 (SEAS, 1991; SEPA 1992). Pearson *et al.* (1982) suggested that *M. palmata* was sensitive to high organic input but still characteristic of moderately enriched sediments. The high number of juvenile *Scalibregma inflatum* at station A in August 1995, together with the reduced number at station B and absence at station C at the same sampling date, indicates that the mechanisms of settlement for this species are somehow correlated to the degree of disturbance of the sediment. *Scalibregma inflatum*, a burrowing selective deposit feeding polychaete, has been found to act as an opportunistic species in enriched sediments at Loch Ailort (Gillibrand *et al.*, 1996).

The numerical dominance of annelids over the other phyla, excepting nematodes, and the absence of echinoderms at all stations at the beginning of

the study, is an indication of organic enrichment (Pearson, 1975; Rosenberg, 1976; Weston, 1990). Crustacean numbers at station C were found to increase with time after fallowing, becoming the dominant phylum in October 1995, in contrast to other pollution-related studies where crustaceans remain a minor group in the total macrofauna found (Pearson, 1975; Rosenberg, 1972, 1973, 1976; Brown *et al.*, 1987). This divergence between studies may, however, be due to the difference in methodology, as the majority of the copepods, the main constituent of the crustaceans, are not retained in a sieve with a mesh size bigger than 0.5 mm. The erratic appearance of molluscs over time could be due to the succession in the different species and to seasonal changes (Pearson *et al.*, 1982; Pearson & Rosenberg, 1978; Brown *et al.*, 1987).

Environmental parameters

The consumption of oxygen by chemical or biological processes could not be distinguished using the data collected. The initial oxygen uptake values of 80-100 mmol.$m^{-2}d^{-1}$ were typical of enriched sediments (Holby & Hall, 1991; Hargrave *et al.*, 1993; Phillips, 1995). From October 1994, three months after fallowing, oxygen uptake rates (30-50 mmol.$m^{-2}d^{-1}$) remained relatively stable over time being, however, greater than estimates for sea-lochs not subjected to fish farming (5-25 mmol.$m^{-2}d^{-1}$) (Davies, 1975; Parkes & Buckingham, 1986; Hall *et al.*, 1990). Experiments with decomposition in sediments have considered that the organic material available to the benthos can be divided into two decomposable fractions of considerably different reactivity, and a non-metabolizable fraction (Westrich & Berner, 1984; Grant & Hargrave, 1987).

The initial high oxygen consumption was though to be due to the high levels of biologically degradable organic carbon originating from the fish farm (Stanley *et al.*, 1981).

The percentage of organic carbon in the surface sediment (0-3 cm) of stations B and C (2-4%) was within the range of background levels found at other sea-lochs (Nickell *et al.*, 1995; Ridgway & Price, 1987) and similar to values observed for Loch Creran (2-5%) before the introduction of fish farms (Ansell, 1974) and to previous years' background values when the fish farm was active (Table XIV). However, the percentage of organic carbon in the sediment (0-3 cm) decreased with distance from the fish farm site (Fig. 18), being 3 times higher at the edges of the cages (stations B and C) than 30 m away (station A), similar results being found at other fish farm sites (Brown *et al*, 1987; Hall *et al.*, 1990; Holmer & Kristensen, 1992; Ye *et al.*, 1991; Weston, 1990). The decrease of organic carbon in the surface sediment at stations B and C after fish farm production ceased, approaching the values at station A, is also an indication that the fish farm waste was the main origin of the organic carbon present in the sediment at the beginning of the study.

The presence of elevated organic carbon, when compared to station A, at all sediment depths at station C and to a depth of 6 cm at station B (Fig. 18), indicates the persistence of contamination by fish farm waste in these subsurface sediments, consistent with redox potential and pore water ammonium values found at the same depths. Moore & Rodger (1991) also

noted that although the first layers of sediment showed signs of recovery, deeper sediments would remain contaminated longer. This could affect the degree and time of response to further disturbances, with natural disturbances having a greater effect than in non depth-contaminated sediments.

Despite the ready availability of ammonium in sediments at fish farm sites it is likely that the nitrification rate (oxidation of NH_4^+ to NO_3^-) will be reduced or even wholly inhibited by the presence of sulphide (Caffrey *et al.*, 1993). Therefore a positive ammonium flux (out of the sediment) and a negative nitrate flux (utilisation by the sediment) is expected in highly enriched sediments. Initial rates of benthic ammonium efflux at stations B and C (6-9 $mmol.m^{-2}d^{-1}$) are consistent with rates observed in other marine deposits at aquaculture sites. Ammonium rates of 2-10 $mmol.m^{-2}d^{-1}$ were reported for sediments in the perimeter of fish cages (Hargrave *et al.*, 1993), sediments in marine earthen fish ponds (Blackburn *et al.*, 1988) and at a mussel culture site (Baudinet *et al.*, 1990). The low ammonium rates (1-2 $mmol.\ m^{-2}d^{-1}$) observed throughout the year at station A and during the winter months at stations B and C were similar to values observed in unenriched sediments (Hargrave *et al.*, 1993; Phillips, 1995). The increase of ammonium efflux after the winter months at stations B and C suggests that nitrification was replaced by nitrate ammonification (Phillips, 1995) due to the increased concentration of sulphide in the sediment, known to inhibit the activity of nitrifying bacteria (Miller *et al.*, 1986). Although sulphide was never detected at sediment depths above the RPD level (Fig. 17), the depth of this layer rises, approaching the sediment

surface at stations B and C, in conjunction with a rise in seawater temperature after the winter months. Nitrate flux rates, however, did not follow the expected pattern and were different from those found by other authors (Phillips, 1995).

Seasonal variations in sediment redox potential and ammonium efflux at stations B and C followed seasonal temperature changes, indicating an increased sediment metabolism during summer months of maximum temperature, but the variables were not significantly correlated as found in previous fish farm studies (Hargrave *et al.*, 1993; Holmer & Kristensen, 1992). An analogous trend in increased sediment metabolism independent of temperature changes, has been reported for coastal areas during sedimentation of spring and autumn blooms and in simulated laboratory experiments (Kelly & Nixon, 1984; Sampou & Oviatt, 1991). Thus, the lack of a significant correlation between temperature and sediment redox potential and ammonium efflux may partly be explained by the labile carbon input from primary production which lagged 2 to 3 months behind the increase in temperature.

Comparison between uni- and multi-variate analysis

When considering the succession in terms of species numbers, biomass, total and specific abundance, or community diversity, the recovery process seems to be discontinuous and heterogeneous throughout these early stages, reflecting

seasonal changes and the ability of the community to withstand further disturbances.

No consistency was found between uni- and multi-variate analysis. Although a deterioration of sedimentary conditions was indicated in the MDS ordination at station C from August 1995 to October 1995, this fact was not clearly shown by most uni-variate parameters such as diversity and evenness indices, ITI or total number of species. The increase in total and *M. fuliginosus* abundance, however, also suggest a deterioration of sediment conditions for the same period. At station B all those parameters suggested an increased disturbance of the macrobenthic community for the same period of time with no such indication in the respective MDS ordination. However, from August to September 1994 both uni- and multi-variate biological analysis showed the same results indicating a deterioration of the sediment conditions. The use of uni-variate parameters was found by other authors (Gray *et al.*, 1990; Olsgard & Gray, 1995; Warwick & Clarke, 1993) not to be as representative of the organic enrichment effects as multi-variate analysis, especially when species identities are not taken into account.

Although all uni-variate parameters measured give an indication of recovery with fallowing time, they do not agree with the recovery stage (Table XV). Furthermore, there is no single parameter that could 'accurately' quantify the recovery process. Only a combination of parameters measured over time will give an indication of the recovery stage. However, due to the overlap in all the

parameters (since definite boundaries rarely exist between the different recovery stages), the definition of these stages is very subjective. Adding the differences in methodologies, data analyses and specific background values at the different sites, comparisons between different studies are elaborate and may be misleading.

Environmental parameters responsible for benthos distribution

The most obvious question to ask is "do the effects found relate to fish farm waste?" The degree and type of disturbance observed were consistent with other studies on effects of fish farm waste on the sediment chemical (Kaspar *et al.*, 1988; Holmer & Kristensen, 1992; Phillips, 1995) and/or biological properties (Brown *et al.*, 1987; Lumb & Fowler, 1989; Ritz *et al.*, 1989; Hall *et al.*, 1990; Weston, 1990; T. Nickell, pers. com.). Although seasonal variations in 'natural' organic material input, sedimentation, temperature and larval availability will have an additional effect on the environmental and biological parameters measured, the general worsening of sediment and biological conditions with proximity to the fish farm site and the gradual improvement with fallowing time suggests that the effects found were mainly related to the cessation of input of fish farm waste.

When analysing spatial and temporal changes, organic carbon, oxygen uptake and sediment particle diameter were the environmental variables found to best correlate with benthos distribution (Tables XII and XIII). When excluding site specific properties by analysing temporal variations at the individual stations,

the correlation coefficient between oxygen uptake and macrobenthic fauna increased with proximity to the waste source, and appeared to be the main factor influencing macrobenthic changes (excluding nematodes) at station C (Table XIII). Nitrate flux was one of the environmental parameters that related to the faunistic temporal distribution at stations A and B. However, the levels and temporal variation of this variable were not believed to be representative of the existing sediment conditions. In studies of the effects of other sources of organic enrichment, toxic components present in the sediments or the overlying water, such as heavy metals or hydrocarbons, do appear to be the main influence on the macrobenthos distribution (MAFF, 1993; Moore & Rodger, 1991; Olsgard & Gray, 1995), dominating any relationship with the same environmental variables measured in this study. The decrease in correlation coefficient with distance from the fish farm site, and the fact that different groups of environmental parameters were found to correlate with the faunal distribution at the different stations, indicates that the significance of the individual environmental parameters varies with the degree of disturbance. This emphasises the importance of the macrobenthos on the evolution of the chemical processes. Nickell *et al.* (unpublished data), while studying sediment recovery after the cessation of fish farm production at other sites, also found that the temporal variations in the macrobenthos were best explained by different environmental variables at sites with different degrees of disturbance.

Although the amount of organic matter is believed to be the main factor influencing macrofaunal community structure after deposition of organic enriched waste (Feder *et al.*, 1994; Kroncke, 1996; Moore & Rodger, 1991; Pearson & Rosenberg, 1978) either through a direct (food source) and/or an indirect (increasing oxygen uptake) effect, the percentage of organic carbon in the sediment was not found to be a good indicator of the temporal changes in the macrobenthic communities, in accordance with other authors' results (Dauer & Conner, 1980; Ye *et al.*, 1991; SEAS, 1989; SEPA, 1992). This may be a result, in part, of confounding factors such as toxic or antibacterial compounds (T. Nickell, pers. com.), sedimentation, and changes in availability of oxygen due to seasonal factors. However, the most plausible explanation is that the correlation between organic carbon and community changes depends on the labile fraction of the organic matter (Westrich & Berner, 1984; Grant & Hargrave, 1987) and not on the total sediment organic carbon measured in the present and previous studies. Total organic carbon was not found to correlate with temporal variations in sediment oxygen uptake (Pamatmat & Banse, 1969; Edberg & Hofsten, 1973), the main factor appearing to influence benthic succession at stations B and C. Again, the labile fractions of organic carbon are more likely to correlate to oxygen uptake than the bulk of organic carbon as measured. Although measurements of organic carbon at station C at the last sampling dates were significantly higher than at station A (fig.18), oxygen uptakes were not significantly different (fig.13a) suggesting similar rates of

aerobic degradation and thus similar amounts of organic material available to the benthos.

Although at station A most sediment chemical variables such as ammonium flux, pore water sulphide concentration, redox potential and organic carbon showed levels characteristic of unenriched sediments, the benthic community structure indicated a moderate disturbance. These results, as for those obtained by other authors (Brown *et al.*, 1987; Weston, 1990; SEPA, 1992) where spatial effects of fish farm waste on the benthic community were still apparent even when sediment chemistry (redox potential, organic carbon, water soluble sulphide) was similar to background levels, indicates that the fauna are sensitive to enrichment at levels not detectable with the gross chemical measures used. The same effect was observed on a temporal scale in a recovery study from sludge waste where 8 months after sludge addition ceased the sediment (organic carbon and redox potential) had returned to control levels but the fauna (diversity, abundance and species numbers) had not (Eleftheriou *et al.*, 1982).

Correlation between effects on the fauna and physical and chemical variables do not necessarily show cause and effect relationships. Furthermore, one cannot be sure that an apparently explanatory variable was not a proxy for an unmeasured variable that was causal. However, the opposite, i.e. that there is no causal relationship when there is no apparent correlation, is not necessarily true, since bulk measurements of certain environmental parameters may not

be the most successful in showing any existing correlation. As Olsgard & Gray (1995) have pointed out, long-term comparative studies using experimental systems such as mesocosms are needed to determinate cause and effect relationships.

Another key question can be raised: Is it possible to distinguish between effects of physical disturbance and organic enrichment on the benthos? Gray (1982) suggested that rather than adapting to pollution by means of tolerance, many benthic species were more likely to be adapting to physical disturbance and that responses shown by species to organic enrichment were more likely to be a response to physical disturbance (sedimentation) than to tolerance of low oxygen. Olsgard and Hasle (1993) supported Gray's hypothesis, showing that the responses of species to a purely physical pollutant (mine waste) were identical to those shown to organic enrichment (Pearson & Rosenberg, 1978), in that the total number of species was severely reduced, and a few opportunistic species increased greatly in abundance, thereby increasing the total abundance and decreasing diversity. At fish farm sites it is very difficult to separately quantify the effects of sedimentation and organic loading, since the pollution gradient will be composed of a mixture of both components. However, the slow recovery after cessation of elevated sedimentation and the strong relationship, as indicated by BIOENV, encountered between sediment oxygen uptake and macrobenthos distribution at station C suggest that this parameter, and thus sediment metabolism, and not the physical effect of sedimentation, was the main restriction on the macrobenthic recovery.

ITI

The changes over time (and with distance from the fish farm site) of the UK Infaunal Tropic Index (Fig. 30) can be interpreted as an improvement in the environmental conditions. When superimposing ITI values as symbols on the biotic MDS ordination (Fig. 41) a correlation can be visualised with the symbol size increasing along one of the axes.

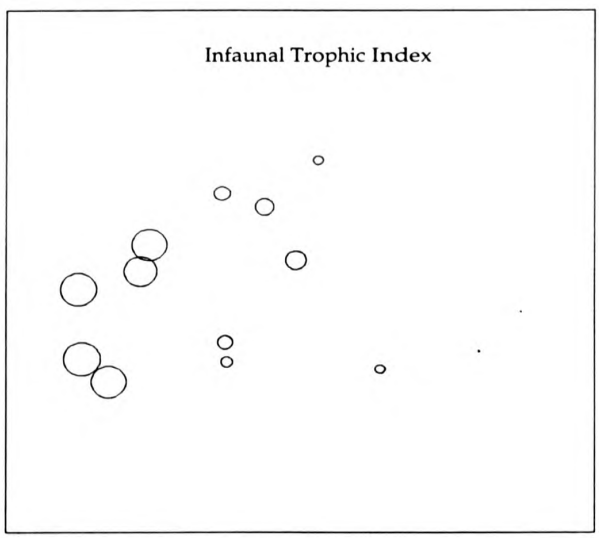


Fig. 41. As fig. 35 but station codes replaced by circles scaled in size according to respective mean ITI values.

ITI values for station A in August and September 1994, although higher than those for stations B and C, do show station A to be degraded or highly disturbed. The other uni-variate parameters and multi-variate results, however, show station A to be only moderately disturbed at the beginning of

the study (Table XV). The low ITI and thus the specific trophic structure of the benthic community at station A at these particular dates could be due to variables not directly related to the fish farm waste. This discordance with the other parameters was also observed for stations B and C as shown in table XV. Since organic enrichment alters the type and amount of food resources available to the benthos, it seems intuitively attractive to quantify enrichment effects by shifts in the proportions of various tropic guilds. There are, however, difficulties in assigning species to particular tropic groups such as (1) the lack of information and consistency in literature on species-specific feeding strategies and the potential error in family-level generalisations and (2) the mounting evidence for plasticity in feeding mode for many macrobenthic species depending upon environmental conditions (Burh & Winter, 1977; Fauchald & Jumars, 1979; Taghon *et al.*, 1980; Dauer *et al.*, 1981; Levinton, 1991). The interpretation of ITI as an indicator of the community disturbance is based on its correlation with sediment oxygen demand (Wrc plc, 1992) and the assumption that this variable is an indicator of the sediment condition. In this study a significant correlation ($R=-0.745$, $p<0.05$) was found between ITI and oxygen uptake. However, at station A this variable does not appear to explain satisfactorily the changes over time observed in the benthic community (Table XIII). For this reason and due to the non existence of a 'reference' site and to the high standard deviation encountered at the most disturbed station (station C), caution should be taken on (1) the interpretation of the pollution status of the stations based solely on this index, (2) on comparisons between stations

sampled at different times of the year and (3) on the use of this index on temporal changes of moderately disturbed communities.

Fallowing

A fish farm site may be left vacant for a short period of time (2 to 3 months) either for disease control (fallowing), or for a longer period (> 1 year - site rotation) in order to avoid the build up of sediments.

Fallowing for a few months has been reported to have a positive effect on fish growth and mortality (Bron *et al.*, 1993; Wheatley *et al.*, 1995). It appears that the interruption of parasitic life cycles, and/or pathogen survival outside the host, are, however, more important factors in determining that improvement than any possible benefits from a decrease in organic waste (Wheatley *et al.*, 1995). There is, furthermore, no correlation between fish health, number of years of production or site depth (Wheatley *et al.*, 1995), indicating that the build up of sediments may not be a crucial factor regarding fish health. The hypothesis that the build up of sediments under the fish cages could have a detrimental effect in fish health (Beveridge, 1987; Gowen & Rosenthal, 1993; Lumb, 1989) was based on the fact that reduced compounds released from anaerobic sediments, such as ammonium and hydrogen sulphide, are toxic to fish (Kiemer *at al.*, 1995; Black *et al.*, 1996). The bottom water beneath fish cages can also become depleted in oxygen for long periods (Brown *et al.*, 1987; Holmer & Kristensen, 1992). Upwelling of this oxygen depleted water through cages could be harmful to fish (Gowen & Bradbury, 1987). There is, however,

no clear evidence that farmed fish have suffered as a direct consequence of benthic pollution.

Mesocosm experiments have shown that recovery time scales of biological and chemical sediment characteristics differ depending on the lability of the input waste (M. Harvey, unpublished data). Toxic components that may be associated with fish farm waste may also affect recovery times. Hydrographic conditions of individual sites may also play an important role in larval availability and settling (Snelgrove & Butman, 1994). These facts make it difficult to predict recovery times for former fish farm sites and a long term study is needed. The present study, however, suggests that a two year rotation period is unlikely to lead to the complete recovery of the most affected sediment, and its associated benthic community, to pre-disturbance conditions. Although some recovery of the benthic community was observed during fallowing, the contamination in subsurface sediments persisted, suggesting a rapid return to pre-fallowing conditions on resumpting production.

Site rotation for a period of 2 years is not likely to lead to any clear benefits, either in terms of fish health where a shorter fallowing period is sufficient, or in terms of benefits to the environment. In low energy areas, like sea-lochs, the time scale of degradation of the sea bed environment is likely to be of the order of weeks whether or not the site has been previously farmed. For a company to be able to fallow a site without loss of production, a new site is required in a different basin or sea-loch system, increasing the total sea bed surface affected

by fish farming and introducing fish farming to otherwise unaffected areas. Further study is, however, required to assess which will be the most environmentally effective solution: having a lower impact over a wider area; or a higher impact in a confined, more easily monitored system.

5. CONCLUSION

In conclusion it can be said that, 14 months after the fish production ceased, the benthic environment, although improved, still showed effects of organic enrichment originating from the fish farm. These effects decreased with distance from the fish cage site. In addition, the following points were made evident by the study:

When using 0.5 mm collection sieves for pollution-related macrobenthic studies, the exclusion of nematodes from the uni- and multi-variate analyses used in this study appears to make no significant difference to the conclusions.

Recovery of benthic macrofaunal communities from a disturbance can occur over various time scales and may be significantly influenced by the seasonal timing of the disturbance, and not only by the recovery process itself. The speed of recovery decreases with increasing fallowing time.

Compared with the other biological and chemical variables, the use of indicator macrobenthic species and their relative abundance was found to be the univariate parameter which best describes sediment conditions and recovery development over the first year post-fallowing.

Prionospio fallax and *Mediomastus fragilis* were good indicators of moderately disturbed communities and *Capitella capitata* and *Malacocerus*

fuliginosus of highly disturbed ones. *Scalibregma inflatum* and *Melinna palmata* were not indicator species of either highly or moderately disturbed communities as indicated by other studies.

Combinations of different environmental parameters appear to affect different stages of recovery after a disturbance with sediment oxygen uptake as the main factor conditioning early stages of macrobenthic succession. Oxygen uptake and the depth of the RPD are important factors in the succession of moderately disturbed communities.

Sediment redox potential measurements at 2 and 4 cm depths were not found to be good indicators of the recovery process although correlated with distance from the fish farm site.

The bulk measurement of sediment organic carbon does not accurately reflect the amount of carbon that may be actually utilised by the macrobenthos and thus is not a significant indicator of recovery.

Although recovery was apparent in surface sediments, chemical contamination persisted over time in subsurface sediments, with possible consequences on the response to further disturbances, e.g. recomencement of farming or input from primary production.

The seasonal contribution of primary production to the pool of sediment organic carbon may significantly retard the recovery process.

Multivariate analysis was found to give a better description of the recovery process than univariate statistics.

Although the physical disturbance due to sedimentation of particulate material from the fish cages is expected to have a negative effect on the macrobenthos, sediment metabolism appeared to be the main constraint on the macrobenthic recovery, indicating that the chemical effect of the sedimented material was the essential factor of disturbance.

The UK Infaunal Trophic Index was not found to be a reliable indicator of recovery, especially when comparing stations subjected to different degrees of disturbance.

Mesocosm studies and long term field studies on chemical and biological parameters are needed to better understand cause-effect relationships and to establish recovery 'end points'.

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APPENDIX I

Different taxa found at the site sampled and respective identification keys. Also included trophic groups used in the determination of Infaunal Trophic Index (see footnote).

Taxon	Identification key	*Trophic group for ITI	Reference for trophic group
NEMATODA			
CRUSTACEA			
Copepod I	Hayward & Ryland, 1995		
Copepod II	Hayward & Ryland, 1995		
Copepod III	Hayward & Ryland, 1995		
Copepod IV	Hayward & Ryland, 1995		
Copepod V	Hayward & Ryland, 1995		
Copepod VI	Hayward & Ryland, 1995		
Tanaid	Hayward & Ryland, 1995	2	WRc plc, 1992
Caraid	Hayward & Ryland, 1995		
Amphipod	Hayward & Ryland, 1995		
Decapod	Hayward & Ryland, 1995		
MYSIDAE			
Erythrops elegans	Hayward & Ryland, 1995		
OPHIUROIDEA		2	WRc plc, 1992
ECHINODERMATA	Hayward & Ryland, 1995		
GASTROPODA	Hayward & Ryland, 1995		
PROSOBRANCHIA	Hayward & Ryland, 1995		
BIVALVIA			
Bivalvia I			
Bivalvia II			
Bivalvia III			
ANNELIDA			
Scalibregma inflatum	Mackie,1991	2	WRc plc, 1992
SPIONIDEA			
Prionospio fallax		2	WRc plc, 1992
Malacocerus fuliginosus		4	WRc plc, 1992
Prionospio multibranchiata		2	WRc plc, 1992
Prionospio cirrifera		2	WRc plc, 1992
Polydora paucibranchiata			
Spio decorata		1	WRc plc, 1992
Polydora complex	Fauvel, 1969		
Spionidea ind.	Fauchald, 1977	3	
PHOLOIDAE			
Pholoe synophthalmica	work sheet SEPA West	3	Fauchald & Jumars, 1979
PHYLLODOCIDAE	Pleijel, 1993	3	Fauchald & Jumars, 1979

Taxon	Identification key	Trophic group for ITI	Reference for trophic group
CAPITELLIDAE			
Capitella capitata	Warren, 1976	4	WRc plc, 1992
Mediomastus fragilis		2	WRc plc, 1992
Notomastus sp.		4	WRc plc, 1992
DORVILLEIDAE			
Ophryotrocha hartmanni	George & Hartmann-Schroder, 1985	4	WRc plc, 1992
Protodorvillea kefersteini	George & Hartmann-Schroder, 1985	4	WRc plc, 1992
Ophryotrocha sp.	George & Hartmann-Schroder, 1985	4	WRc plc, 1992
LUMBRINEREIDAE			
Lumbrineris sp.	George & Hartmann-Schroder, 1985	3	Fauchald & Jumars, 1979
SYLLIDAE			
Syllidae ind.		2	WRc plc, 1992
HESIONIDAE			
Hesionidae ind. I		3	Fauchald & Jumars, 1979
Hesionidae ind. II		3	Fauchald & Jumars, 1979
Nereimyra puntacta		3	Fauchald & Jumars, 1979
Hesionidae ind. III		3	Fauchald & Jumars, 1979
CIRRATULIDAE			
Chaetozone setosa		2	WRc plc, 1992
Caulleriella zetlandia		2	WRc plc, 1992
Caulleriella alata		2	WRc plc, 1992
Macrochaeta clavicornis		2	WRc plc, 1992
Cirratulidae ind.		2	WRc plc, 1992
GLYCERIDAE			
Glycera alba	Fauvel, 1969	3	WRc plc, 1992
Glycera sp.	Fauchald, 1977	3	Fauchald & Jumars, 1979
GONIADIDAE			
Goniadidae ind.	Fauchald, 1977	3	Fauchald & Jumars, 1979
OPHELLIDAE			
Ophelina acuminata	Fauvel, 1969	4	WRc plc, 1992
Ophelina modesta		4	
PECTINARIIDAE			
Pectinaria sp.	Holthe, 1977	3	Fauchald & Jumars, 1979
Pectinariidae ind.	Holthe, 1977	3	Fauchald & Jumars, 1979
NEREIDAE			
Nereis longissima	Chambers & Garwood, 1992	3	WRc plc, 1992

Taxon	Identification key	Trophic group for ITI	Reference for trophic group
SABELLIDAE			
Chone filicaudata	Fauvel, 1969	1	WRc plc, 1992
Sabellidae ind.	Fauvel, 1969	1	WRc plc, 1992
AMPHARETIDAE			
Melinna palmata	Holthe, 1977	3	WRc plc, 1992
Melina elizabethae	Holthe, 1977	3	Fauchald & Jumars, 1979
Ampharete sp.	Holthe, 1977	3	Fauchald & Jumars, 1979
Amphictheis gunneri	Holthe, 1977	3	Fauchald & Jumars, 1979
Ampharetidae ind.	Holthe, 1977	3	Fauchald & Jumars, 1979
PARAONIDAE			
Paraonis sp.	Fauvel, 1969	3	Fauchald & Jumars, 1979
TRICHOBRANCHIDAE			
Terebellides stroemi	Holthe, 1977	2	WRc plc, 1992
EUNICIDA			
Eunicida ind.	Fauchald, 1977	3	Fauchald & Jumars, 1979
SPHAERODORIDAE	Fauchald, 1974	2	Fauchald & Jumars, 1979
Sphaerodoridium claparedii			
ORBINIIDAE			
Scoloplos armiger	Fauvel, 1969	3	WRc plc, 1992
Orbiniidae ind.			
NEPHTHYDIDAE			
Nephthys sp.	Fauvel, 1969	3	Fauchald & Jumars, 1979
ANNELIDA IND			
SIPUNCULA			
KINORYNCHA	Higgins, 1985		

* Groups 1 to 4 defined on basis of food size and type and the location of food resource (Wrc plc, 1982):

Group 1 - Suspension feeders.

Group 2 - Organism feeds on organic/mineral aggregates, floc aggregates, or detritus. Particles always <100µm in size. Surface or burrowing detrital feeders.

Group 3 - Organism feeds on encrusted mineral aggregates, deposit particles, or biological remains. Particles are consistently >100µm. Surface or burrowing deposit feeders.

Group 4 - Feeding behaviour variable. Animals are adapted to live in sediment which is highly anaerobic.

APPENDIX II: Sediment particle size analysis (see footnote)

Date	Sample	Median Phi.	Diameter (mm)	Sorting coeff.	Skewness	Kurtosis	<63um (%)	Description
4/8/94	A:0-3							
	A:3-6	3.83	0.0705	1.9233	0.3466	1.1249	45.1	Poorly sorted very fine sand, strongly fine skewed leptokurtic
	A:6-9	4.34	0.0495	2.1184	0.1755	1.0718	55.2	Very poorly sorted coarse silt, fine skewed, mesokurtic
	B:0-3	3.87	0.0682	2.1288	0.1731	1.1342	47.1	Very poorly sorted very fine sand, fine skewed, leptokurtic
	B:3-6	3.32	0.1002	1.8491	0.1939	1.4755	30.0	Poorly sorted very fine sand, fine skewed, leptokurtic
	B:6-9	3.77	0.0732	2.0655	0.2855	1.1212	44.2	Very poorly sorted very fine sand, fine skewed, leptokurtic
	C:0-3	not sampled						
	C:3-6	not sampled						
	C:6-9	not sampled						
8/9/94	A:0-3	4.08	0.0591	2.2471	0.2516	0.9732	51.1	Very poorly sorted coarse silt, fine skewed, mesokurtic
	A:3-6	3.89	0.0673	1.9820	0.3009	1.1175	47.2	Poorly sorted very fine sand, strongly fine skewed leptokurtic
	A:6-9	4.71	0.0381	2.1309	0.0572	1.0668	61.1	Very poorly sorted coarse silt, symmetrical, mesokurtic
	B:0-3	3.73	0.0755	2.0751	0.2070	1.1877	43.3	Very poorly sorted very fine sand, fine skewed, leptokurtic
	B:3-6	3.70	0.0768	1.9187	0.2523	1.2912	41.8	Poorly sorted very fine sand, fine skewed, leptokurtic
	B:6-9	4.81	0.0355	2.2601	0.0535	1.0015	62.2	Very poorly sorted coarse silt, symmetrical, mesokurtic
	C:0-3	3.95	0.0648	2.2625	0.1561	0.9323	49.0	Very poorly sorted very fine sand, fine skewed, mesokurtic
	C:3-6	3.73	0.0752	2.1523	0.2380	1.0819	43.6	Very poorly sorted very fine sand, fine skewed, mesokurtic
	C:6-9	3.86	0.0690	1.9702	0.3188	1.1118	46.0	Poorly sorted very fine sand, strongly fine skewed leptokurtic

Date	Sample	Median Diameter (Phi)	(mm)	Sorting coeff.	Skewness	Kurtosis	<63um (%)	Description
28/10/94	A:0-3	3.90	0.0671	2.0379	0.2965	1.0802	47.4	Very poorly sorted very fine sand, fine skewed, mesokurtic
	A:3-6							
	A:6-9							
	B:0-3							
	B:3-6	3.86	0.0688	2.2691	0.2146	1.0041	47.0	Very poorly sorted very fine sand, fine skewed, mesokurtic
	B:6-9							
	C:0-3							
	C:3-6	3.60	0.0822	2.0798	0.2228	1.2224	39.7	Very poorly sorted very fine sand, fine skewed, mesokurtic
	C:6-9							
8/12/94	A:0-3	3.87	0.0684	2.1161	0.2632	1.1063	46.9	Very poorly sorted very fine sand, fine skewed, mesokurtic
	A:3-6	4.02	0.0618	2.0248	0.2278	1.1545	50.3	Very poorly sorted coarse silt, fine skewed, leptokurtic
	A:6-9	4.78	0.0364	1.9954	0.1498	0.8765	61.1	Poorly sorted coarse silt, fine skewed, platykurtic
	B:0-3	3.69	0.0777	2.2939	0.2952	0.9856	42.8	Very poorly sorted very fine sand, fine skewed, mesokurtic
	B:3-6	4.17	0.0555	2.1594	0.1974	1.0746	52.6	Very poorly sorted coarse silt, fine skewed, mesokurtic
	B:6-9	4.59	0.0415	2.2393	0.1220	0.9944	59.2	Very poorly sorted coarse silt, fine skewed, mesokurtic
	C:0-3	3.53	0.0863	2.0719	0.1902	1.2634	37.8	Very poorly sorted very fine sand, fine skewed, leptokurtic
	C:3-6	3.50	0.0881	1.9673	0.2433	1.3136	36.6	Poorly sorted very fine sand, fine skewed, leptokurtic
	C:6-9	3.65	0.0799	1.9565	0.2159	1.2398	40.4	Poorly sorted very fine sand, fine skewed, leptokurtic
26/1/95	A:0-3	3.91	0.0664	2.1026	0.2351	1.0998	47.9	Poorly sorted very fine sand, fine skewed, mesokurtic
	A:3-6	3.83	0.0702	1.9243	0.3493	1.0607	45.5	Poorly sorted very fine sand, strongly fine skewed mesokurtic
	A:6-9	4.24	0.0529	2.1981	0.1584	1.0552	53.7	Very poorly sorted coarse silt, fine skewed, mesokurtic
	B:0-3	3.73	0.0756	2.0258	0.2605	1.1979	42.7	Very poorly sorted very fine sand, fine skewed, leptokurtic

Date	Sample	Median Diameter (Phi)	(mm)	Sorting coeff.	Skewness	Kurtosis	<63um (%)	Description
26/1/94	B:3-6	3.71	0.0762	2.1615	0.2566	1.1040	43.1	Very poorly sorted very fine sand, fine skewed, mesokurtic
26/1/94	B:6-9	4.13	0.0570	2.1383	0.2398	1.0324	52.3	Very poorly sorted coarse silt, fine skewed, mesokurtic
	C:0-3	3.56	0.0845	1.8933	0.2393	1.2795	37.9	Very poorly sorted very fine sand, fine skewed, leptokurtic
	C:3-6	3.39	0.0956	2.0266	0.1352	1.3623	32.9	Very poorly sorted very fine sand, fine skewed, leptokurtic
	C:6-9	4.36	0.0487	2.0904	0.2172	0.9789	56.3	Very poorly sorted coarse silt, fine skewed, mesokurtic
27/2/95	A:0-3	4.04	0.0608	2.2425	0.2859	0.9248	50.5	Very poorly sorted coarse silt, fine skewed, mesokurtic
	A:3-6	3.99	0.0631	2.1093	0.3393	0.9205	49.7	Very poorly sorted very fine sand, strongly fine skewed, mesokurtic
	A:6-9	4.47	0.0450	2.1699	0.2168	0.8718	57.3	Very poorly sorted coarse silt, fine skewed, platykurtic
	B:0-3	4.46	0.0456	2.1562	0.0975	0.9557	57.1	Very poorly sorted coarse silt, symmetrical, mesokurtic
	B:3-6	4.34	0.0493	2.2382	0.1302	0.9422	54.8	Very poorly sorted coarse silt, fine skewed, mesokurtic
	B:6-9	4.53	0.0433	2.0081	0.2054	0.9531	59.8	Very poorly sorted coarse silt, fine skewed, mesokurtic
	C:0-3	3.55	0.0851	1.9904	0.2124	1.3308	37.8	Very poorly sorted very fine sand, fine skewed, mesokurtic
	C:3-6	3.67	0.0784	2.0869	0.2273	1.1980	41.7	Very poorly sorted very fine sand, fine skewed, leptokurtic
	C:6-9	3.85	0.0695	1.9576	0.2502	1.1997	45.7	Poorly sorted very fine sand, fine skewed, leptokurtic
12/4/95	A:0-3	3.96	0.0644	2.2557	0.2691	0.6454	49.0	Very poorly sorted very fine sand, fine skewed, mesokurtic
	A:3-6	3.91	0.0664	1.9258	0.3462	1.0065	47.7	Very poorly sorted very fine sand, strongly fine skewed, mesokurtic
	A:6-9	3.78	0.027	2.3493	0.2608	0.9911	44.9	Very poorly sorted very fine sand, fine skewed, mesokurtic
	B:0-3	4.46	0.0456	2.1775	0.1352	0.9071	56.6	Very poorly sorted very fine sand, fine skewed, mesokurtic

Date	Sample	Median Diameter (Phi)	(mm)	Sorting coeff.	Skewness	Kurtosis	<63um (%)	Description
12/4/95	B:3-6	3.97	0.0637	2.1842	0.2323	1.0165	49.4	Very poorly sorted very fine sand, fine skewed, mesokurtic
	B:6-9	4.41	0.0470	2.2083	0.1548	1.0061	56.6	Very poorly sorted very fine sand, fine skewed, mesokurtic
	C:0-3	3.82	0.0710	2.1581	0.2464	1.0155	45.7	Very poorly sorted very fine sand, fine skewed, mesokurtic
	C:3-6	3.74	0.0748	2.0494	0.3060	1.1041	43.2	Very poorly sorted very fine sand, strongly fine skewed, mesokurtic
	C:6-9	4.94	0.0327	1.9441	0.1811	0.8282	65.1	Very poorly sorted coarse silt, fine skewed, platykurtic

The particle diameter was measured as Median diameter (Md); Skewness was measured as Inclusive Graphic Skewness (Sk_I) and Sorting of sediments was measured as Inclusive Graphic Standard Deviation (σ_I) according to Folk (1968).

Appendix III Carbon deposition model predictions at Loch Creran

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July 1997

INTRODUCTION

A lagrangian particle tracking method was used to simulate the settling of waste food and faeces and their movement through the water column. This type of model releases many thousands of particles each with specified attributes which act to simulate dispersion of food and faecal particles. The model can predict the distribution of a particulate contaminant over an area of bed deposited during a trial period or predict longer term steady state solutions. For this study, the long term steady state model has been used.

The model processes are summarised below:

- settling of waste food and faeces vertically through the water column determined by a fall velocity
- advection of particles in water currents
- simulation of turbulence in three dimensions *via* a random walk model
- deposition of particles on the sea bed
- erosion, transport and deposition of particles around the grid area in a resuspension module
- consolidation of particles into the bed which are no longer available for resuspension

The model repeatedly uses one current velocity record with a minimum length of 1 spring–neap cycle for model predictions. No account is taken of wind–waves or flocculation in the model. Wind driven current is assumed to be measured in the current velocity record. This model has been developed from BenOss (Biological Effects and Organic Solids Sedimentation) (Cromey *et al.*, 1996, 1997) which is designed to forecast the deposition and biological effects of carbon from sewage discharges. The nature of organic solids such as fish food and faeces from fish farms allows the BenOss model to be applied to a problem of this nature.

METHODOLOGY

The model was set up to predict the dispersion of carbon arising from wastes from the fish farm. This assumes a continuous release of food over a 24 hour period and that the food and faeces are released close to the surface. The model input data used are described in this section.

Bathymetry and grid generation

A grid was generated for Loch Creran around the area of interest. The rectangular grid had a total size of 650 metres (x axis) by 450 metres (y axis) with individual grid cell dimensions of 25 metres by 25 metres. The grid was orientated with the x axis east to west and the y axis north to south with reference to true north. Depths at lowest astronomical tide were used and an adjustment of 1.65 metres was made for the mean tidal height in Loch Creran (Edwards and Sharples, unpublished). No changes in elevation were made through the simulations as the model is insensitive to elevation changes when long term simulations of a period of several months or more are undertaken. Charted depths in the grid ranged from 1.0 to 23.6 metres interpolated linearly from measured data with the depth being approximately 17 metres underneath the cages. No land points have been included in the grid and the grid is large enough to encompass the whole of the predicted deposition area around the cages. Ten cages and twelve sampling stations were positioned around the cages. Three of the sampling stations (A,B, and C) are analogous to those used in the main text of this thesis, the other nine stations (S1 to S9) were positioned in a transect across the cage group (from west to east) to allow predictions at specific points and distances from the cage group. Each station in the series S1 to S9 was positioned approximately 50 metres apart with S5 being in the centre of the cage group. Figure 1 shows the bathymetry generated in the grid and the positions of the sampling stations.

Tidal currents

The nineteen day current velocity record containing 20 minute measurements is assumed to be typical for the area around the cages. These data were obtained from three D2000 instruments deployed to the south of station B at depths of 2.5 metres, 9.5 metres and 14.5 metres below the surface in 18.5 metres of water depth. These data were implemented into the model as a three layer water column so that a particle's trajectory was changed as it moved down through the water column. The currents were assumed to be the same horizontally across the grid area.

Particle attributes

Food pellets were assumed to have a settling velocity of 9.5 cm s^{-1} and fish faeces a settling velocity of 4.3 cm s^{-1} (Gowen *et al.*, 1989).

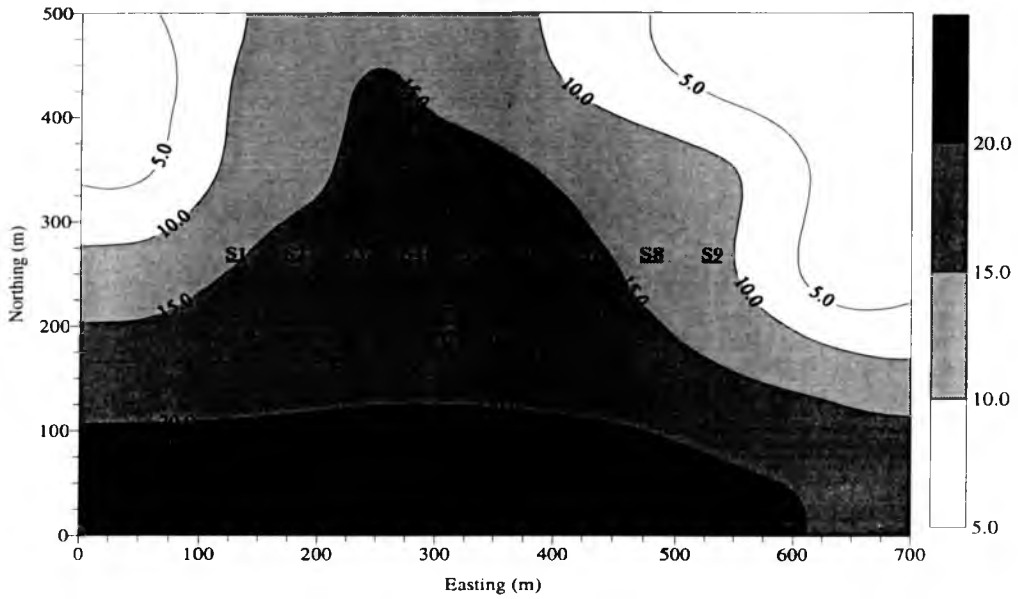

Figure 1. Depth array (LAT) of the Loch Creran site with 10 cages shown as □ and sampling stations.

Carbon deposition model loading rates

The following data were used to calculate feeding rates for use in the model:

Number of cages in trial	10
Waste food (carbon)	10.00% of C_{fed}
Waste faeces (carbon)	8.26% of C_{fed}

where C_{fed} is the amount of carbon fed to the fish in food pellets (dry weight). Food pellets are 91% dry weight and 49% of this dry weight is carbon. These data were taken from Figure 6 (main text).

The current version of the model does not have the capability to change food loading rates on a daily or monthly basis. It is therefore necessary to average food input data and undertake two separate simulation periods. Period 1 was taken as the first 12 months of the fallow period between April 1992 and March 1993 and period 2 was for the remaining period of fifteen months between April 1993 and June 1994. Food loadings of 1364 and 3427 kg d^{-1} for the whole cage group were used for these periods respectively. These figures were taken from the main text of this thesis.

Random walk model variables

The random walk model (Allen, 1982) simulates horizontal and vertical dispersion of solids. The model moves each particle in a random direction with a step length determined from dispersion coefficients of the area. As no dispersion coefficient data are available for Loch Creran, the following assumptions have been made:

Horizontal dispersion coefficient (k_h) = 200 cm s^{-1}
Vertical dispersion coefficient (k_z) = 1 cm s^{-1}

Values obtained from dye studies in a well mixed estuary such as the Firth of Forth are in the order of 450–750 cm s^{-1} and 2.5–33.0 cm s^{-1} for k_h and k_z respectively (FRPB 1982, 1993). The likely presence of some stratification at Loch Creran with poor exchange between the different density layers justifies a low k_z of 1 cm s^{-1}. A k_h of 200 cm s^{-1} assumes lower tidal mixing then that found in a well mixed estuary.

Resuspension model parameters

Cromey *et al.* (1997) review a number of resuspension models. Many resuspension models resuspend material when the ambient current speed exceeds a critical current speed for erosion and deposit material when the ambient current speed falls below a critical speed for deposition. In this model, these critical parameters are assumed to be similar to those measured for sewage particles as no data are available for fish food and faeces. The critical speed for erosion was taken as 15 cm s^{-1} (Burt and Turner, 1983) and the critical speed for deposition as 6.5 cm s^{-1} (Cromey *et al.*, 1997). SCCWRP (1992) used a critical deposition speed of 4.5 cm s^{-1}.

RESULTS

Table I shows BenOss predictions for the amount of carbon depositing and accumulating at the Loch Creran site arising from deposition from the fish cages defined as C_{avail} (g C m^{-2} yr^{-1}). These predictions show that in general deposition values are between 2 and 3 times greater for period 2 than for period 1.

Sampling stations A B and C exhibit some differences for both periods with sampling station C having a C_{avail} of approximately double that of sampling station B. Sampling station A is predicted as having no deposition from the fish cages. Predictions evaluated at station S1 and S9 indicate that deposition from the farm is within 150 metres to the west and 100 metres to the east of the cage group. Predicted C_{avail} values under the cages are generally greater than 5000 g C m^{-2} yr^{-1} for both periods. The sphere of influence around the cages for both periods is not directly centred around the cages but is displaced to WNW of the cages.

Table I. Carbon deposition predictions for the sampling stations at the Loch Creran fish farm site.

Stations	C_{avail} (g C m^{-2} yr^{-1}) Period 1	C_{avail} (g C m^{-2} yr^{-1}) Period 2
A	1	6
B	256	664
C	514	1369
S1	0	0
S2	0	2
S3	34	89
S4	1600	4144
S5	4107	10705
S6	174	451
S7	0	0
S8	0	0
S9	0	0

Note: Period 1 - April 1992 - March 1993; Period 2 - April 1993 - June 1994

The BenOss resuspension model was validated with dye studies undertaken at several UK long sea outfalls. The benthic model was validated with field data from UK sewage discharges by comparing benthic community field data with predicted C_{avail}. This validation process has allowed both quantitative interpretation of C_{avail} changing with numerous biological indices and qualitative interpretation of C_{avail} and its effect on the benthic community.

Table II. A qualitative interpretation used in BenOss for assessing the effects of carbon deposition on the benthic community in relation to control conditions for the area.

Qualitative interpretation of carbon loading rates and benthic effects C_{avail} (g C m^{-2} bed yr^{-1})	Qualitative interpretation in relation to control
< 250	little effect
250 – 750	some impact on the benthic community
> 750	significant impact / degraded conditions

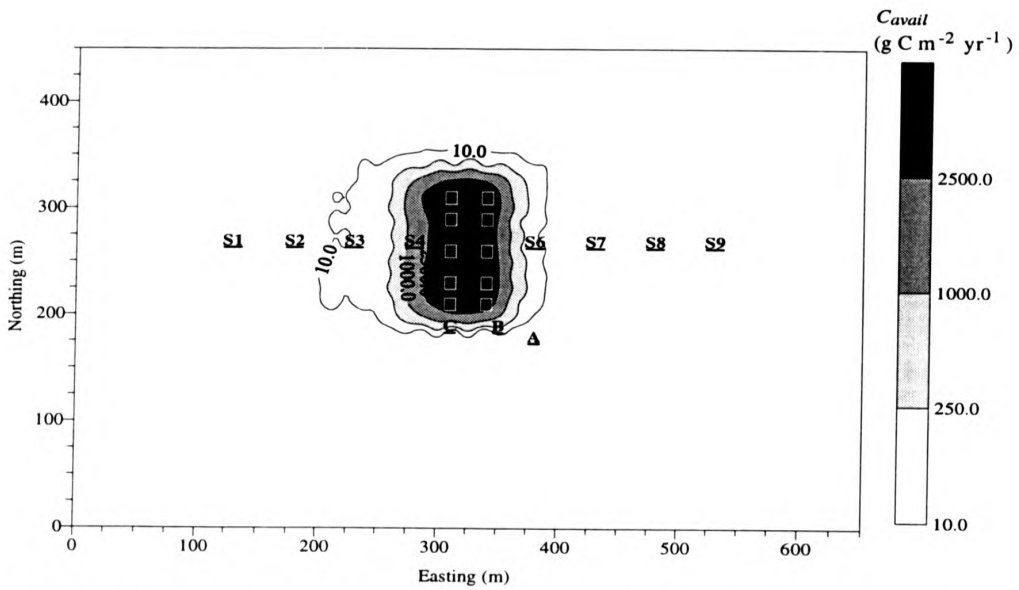

Figure 2. Carbon deposition predictions for Loch Creran for period 1 (April 1992 to March 1993). Food loading is 1364 kg d^{-1} for whole cage group.

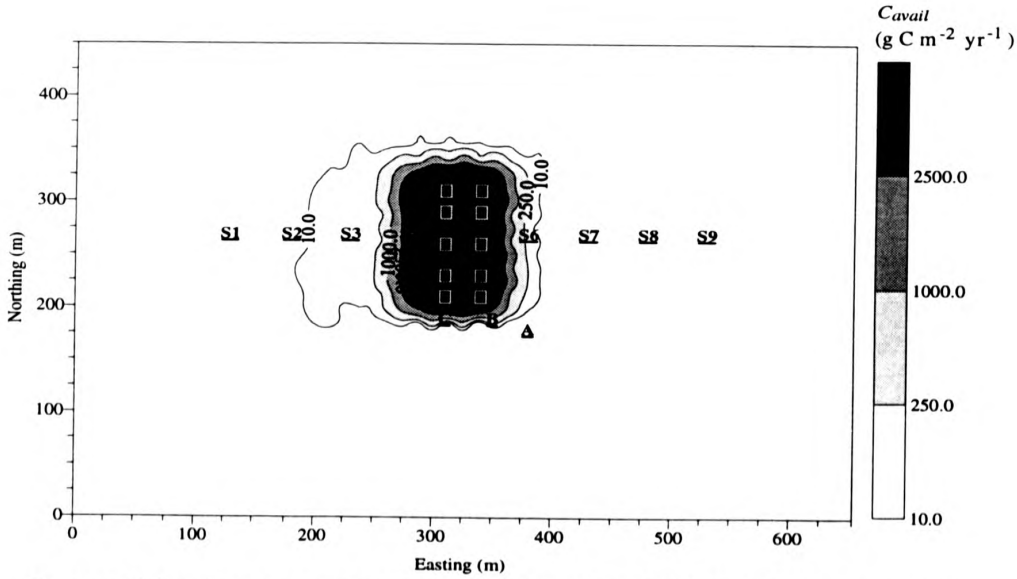

Figure 3. Carbon deposition predictions for Loch Creran for period 2 (April 1993 to June 1994). Food loading is 3437 kg d^{-1} for whole cage group.

DISCUSSION

Model predictions for Loch Creran suggest that the gradient of carbon on the bed is quite large over a spatial area of a few hundred metres. Despite the depth of water column under the cages, dispersion of waste food and faeces is quite low due to low current velocities especially close to the bed. This has led to reduced horizontal dispersion as well as minimal resuspension effects taking place in the model as the critical speed for resuspension was rarely exceeded.

The model suggests that a significant impact exists underneath the cages and at a radius of approximately 25 to 50 metres around the cages. The effect of deposition on the benthic community is predicted to decrease to a lesser at a radius of between 50 and 100 metres. Beyond 100 metres radius of the cages, no effect from deposition of solids from the cages is predicted.

Significant effects on the benthic community at station C are likely during period 2 but to a lesser extent in period 1. There is likely to be some impact on the benthic community at station B particularly during period 2. Station A is predicted to be outside the main area of deposition from the fish farm and no effects are predicted associated with deposition of waste solids.

Some limitations of the model are evident as the original model BenOss has been developed for long sea outfalls. The food loading rate is assumed to be continuous throughout a 24 hour period, constant over period 1 and 2 and not varied as the biomass of the fish farm changes. In this study as total particulate carbon is being predicted, these assumptions are acceptable as no references are made to different carbon fractions and their degradability. In a study where different degradable fractions are being examined, a continuous loading rate over the two periods would not be acceptable as the larger amounts of carbon being deposited towards the end of period 2 would represent a significant proportion of the available carbon at the end of the fallow period. A model is being developed at Dunstaffnage to allow such precise modelling capability of fish farm wastes.

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APPENDIX IV

Mean abundance (no. ind./m^{-2}) of the different taxa sampled at stations A, B and C at different sampling dates.

Station A (no. ind./m^{-2})

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	11-10-95
NEMATODA	484098	537826	396941	327785	344702
CRUSTACEA					
Copepod I	0	812	135	2707	1353
Copepod II	3654	2436	0	947	541
Copepod III	0	0	0	0	0
Copepod IV	1759	1083	135	406	1218
Copepod V	0	0	0	0	0
Copepod VI	0	271	0	0	0
Tanaid	271	1083	947	1083	1083
Caraid	0	0	0	0	0
Amphipod	947	677	271	271	271
Decapod	0	0	135	135	0
MYSIDAE					
Erythrops elegans	0	0	0	0	0
OPHIUROIDEA	0	0	0	135	0
ECHINODERMATA	0	0	0	0	0
GASTROPODA	0	0	0	0	271
PROSOBRANCHIA	135	0	0	0	0
BIVALVIA					
Bivalvia I	4060	1083	2301	2301	8662
Bivalvia II	0	0	0	271	541
Bivalvia III	0	0	0	0	135
ANNELIDA					
Scalibregma inflatum	812	271	677	4331	1759
SPIONIDEA					
Prionospio fallax	1759	947	1353	1218	6225
Malacocerus fuliginosus	0	0	0	0	0
Prionospio multibranchiata	0	135	0	0	0
Prionospio cirrifera	0	0	0	541	0
Polydora paucibranchiata	0	0	0	0	0
Spio decorata	0	135	135	0	0
Polydora complex	0	0	271	947	812
Spionidea ind.	0	271	135	406	1083
PHOLOIDAE					
Pholoe synophthalmica	1353	947	271	2707	1218
PHYLLODOCIDAE					
Phyllodocidae ind.	1083	1353	135	271	1353
CAPITELLIDAE					
Capitella capitata	2436	3113	0	0	135
Mediomastus fragilis	3654	7037	2977	12316	14210
Notomastus sp.	271	0	135	0	0
DORVILLEIDAE					
Ophryotrocha hartmanni	16511	17594	0	0	0
Protodorvillea kefersteini	2030	135	135	271	0
Ophryotrocha sp.	0	135	0	0	0
LUMBRINEREIDAE					
Lumbrineris sp.	541	271	0	135	135
SYLLIDAE					
Syllidae ind.	947	2301	541	1489	2301

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	11-10-95
HESIONIDAE					
Hesionidae ind. I	0	0	0	0	271
Hesionidae ind. II	135	0	0	0	0
Nereimyra puntacta	0	0	0	0	135
Hesionidae ind. III	0	135	0	0	0
CIRRATULIDAE					
Chaetozone setosa	135	0	0	0	0
Caulleriella zetlandia	0	271	0	0	135
Caulleriella alata	0	0	0	0	135
Macrochaeta clavicornis	0	0	0	0	406
Cirratulidae ind.	0	135	135	541	541
GLYCERIDAE					
Glycera alba	0	135	0	271	0
Glycera sp.	0	0	271	135	135
GONIADIDAE					
Goniadidae ind.	0	0	0	0	0
OPHELLIDAE					
Ophelina acuminata	0	0	0	0	0
Ophelina modesta	0	0	0	135	0
PECTINARIIDAE					
Pectinaria sp.	0	0	0	0	135
Pectinariidae ind.	0	135	0	0	0
NEREIDAE					
Nereis longissima	135	0	0	0	0
SABELLIDAE					
Chone filicaudata	0	0	0	271	0
Sabellidae ind.	0	0	271	135	135
AMPHARETIDAE					
Melinna palmata	0	0	135	135	135
Melina elizabethae	0	0	0	0	0
Ampharete sp.	0	0	135	0	0
Amphictheis gunneri	0	0	0	0	135
Ampharetidae ind.	0	0	271	271	2165
PARAONIDAE					
Paraonis sp.	0	0	0	135	0
TRICHOBRANCHIDAE					
Terebellides stroemi	0	0	0	135	0
EUNICIDA					
Eunicida ind.	0	0	0	135	271
SPHAERODORIDAE					
Sphaerodoridium claparedii	0	0	0	0	135
ORBINIIDAE					
Scoloplos armiger	0	0	0	135	0
Orbiniidae ind.	135	0	0	135	0
NEPHTHYDIDAE					
Nephthys sp.	0	0	0	0	135
ANNELIDA IND.	0	0	0	135	135
SIPUNCULA	0	0	135	0	0
KINORYNCHA	0	0	271	677	271

Station B (no. ind./m^{-2})

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	11-10-95
NEMATODA	1731763	2434024	646908	564488	522533
CRUSTACEA					
Copepod I	0	0	677	677	135
Copepod II	0	406	0	271	0
Copepod III	0	271	0	135	0
Copepod IV	3113	6090	1895	677	1083
Copepod V	271	812	0	0	0
Copepod VI	0	1489	0	0	0
Tanaid	0	271	271	0	0
Caraid	0	0	0	0	0
Amphipod	0	271	0	0	406
Decapod	0	0	0	0	0
MYSIDAE					
Erythrops elegans	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0
GASTROPODA	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0
BIVALVIA					
Bivalvia I	1489	0	2571	1083	5413
Bivalvia II	0	0	677	677	947
Bivalvia III	0	0	0	0	0
ANNELIDA					
Scalibregma inflatum	135	0	677	541	0
SPIONIDEA					
Prionospio fallax	0	0	0	2030	4060
Malacocerus fuliginosus	13669	15834	0	0	135
Prionospio multibranchiata	0	0	0	0	0
Prionospio cirrifera	0	0	0	135	135
Polydora paucibranchiata	0	0	0	0	271
Spio decorata	0	0	271	406	135
Polydora complex	0	0	135	0	135
Spionidea ind.	1218	0	135	271	406
PHOLOIDAE					
Pholoe synophthalmica	135	0	0	406	406
PHYLLODOCIDAE					
Phyllodocidae ind.	10962	135	0	0	271
CAPITELLIDAE					
Capitella capitata	21924	47909	8256	677	541
Mediomastus fragilis	12045	812	947	3654	4195
Notomastus sp.	0	0	0	0	0
DORVILLEIDAE					
Ophryotrocha hartmanni	17864	19353	812	0	0
Protodorvillea kefersteini	0	0	0	135	0
Ophryotrocha sp.	0	0	0	0	0
LUMBRINEREIDAE					
Lumbrineris sp.	0	0	0	0	0
SYLLIDAE					
Syllidae ind.	271	0	1083	677	1218

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	11-10-95
HESIONIDAE					
Hesionidae ind. I	135	947	0	0	0
Hesionidae ind. II	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0
CIRRATULIDAE					
Chaetozone setosa	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0
Caulleriella alata	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0
Cirratulidae ind.	135	0	0	0	0
GLYCERIDAE					
Glycera alba	0	0	0	135	0
Glycera sp.	0	0	135	0	0
GONIADIDAE					
Goniadidae ind.	0	0	0	0	0
OPHELLIDAE					
Ophelina acuminata	0	0	135	0	0
Ophelina modesta	0	0	0	271	0
PECTINARIIDAE					
Pectinaria sp.	0	0	135	0	0
Pectinariidae ind.	0	0	0	0	0
NEREIDAE					
Nereis longissima	0	0	0	0	0
SABELLIDAE					
Chone filicaudata	0	0	0	0	0
Sabellidae ind.	0	0	541	0	0
AMPHARETIDAE					
Melinna palmata	0	0	0	135	0
Melina elizabethae	0	0	0	0	0
Ampharete sp.	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0
PARAONIDAE					
Paraonis sp.	0	0	0	0	0
TRICHOBRANCHIDAE					
Terebellides stroemi	0	0	0	0	0
EUNICIDA					
Eunicida ind.	0	0	0	0	0
SPHAERODORIDAE					
Sphaerodoridium claparedii	0	0	0	0	0
ORBINIIDAE					
Scoloplos armiger	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0
NEPHTHYDIDAE					
Nephthys sp.	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0
SIPUNCULA	0	0	0	0	0
KINORYNCHA	0	271	0	271	0

Station C (no. ind. /m^{-2})

SAMPLING DATE	8-9-94	6-3-95	21-8-95	13-10-95
NEMATODA	2558939	1380836	502639	848288
CRUSTACEA				
Copepod I	0	0	947	6902
Copepod II	406	406	135	271
Copepod III	677	0	0	541
Copepod IV	3789	2301	2571	6631
Copepod V	1624	0	0	0
Copepod VI	271	0	0	0
Tanaid	0	0	135	0
Caraid	0	0	0	0
Amphipod	0	0	541	0
Decapod	0	0	0	0
MYSIDAE				
Erythrops elegans	0	0	0	271
OPHIUROIDEA	0	0	0	0
ECHINODERMATA	0	0	0	0
GASTROPODA	0	0	0	0
PROSOBRANCHIA	0	0	0	0
BIVALVIA				
Bivalvia I	0	947	135	4466
Bivalvia II	0	135	0	0
Bivalvia III	0	0	0	0
ANNELIDA				
Scalibregma inflatum	0	271	0	0
SPIONIDEA				
Prionospio fallax	0	0	271	271
Malacocerus fuliginosus	13128	0	0	2165
Prionospio multibranchiata	0	0	0	0
Prionospio cirrifera	0	0	0	0
Polydora paucibranchiata	0	0	0	0
Spio decorata	0	0	0	0
Polydora complex	0	0	0	0
Spionidea ind.	0	0	135	271
PHOLOIDAE				
Pholoe synophthalmica	0	0	0	0
PHYLLODOCIDAE				
Phyllodocidae ind.	0	135	0	135
CAPITELLIDAE				
Capitella capitata	58465	7443	3113	2842
Mediomastus fragilis	0	406	2707	3925
Notomastus sp.	0	0	0	0
DORVILLEIDAE				
Ophryotrocha hartmanni	812	135	0	0
Protodorvillea kefersteini	0	0	0	0
Ophryotrocha sp.	0	0	0	0
LUMBRINEREIDAE				
Lumbrineris sp.	0	0	0	0
SYLLIDAE				
Syllidae ind.	135	541	271	135

SAMPLING DATE	8-9-94	6-3-95	21-8-95	11-10-95
HESIONIDAE				
Hesionidae ind. I	0	0	0	0
Hesionidae ind. II	0	0	0	0
Nereimyra puntacta	0	0	0	0
Hesionidae ind. III	0	0	0	0
CIRRATULIDAE				
Chaetozone setosa	0	0	0	0
Caulleriella zetlandia	0	0	0	0
Caulleriella alata	0	0	0	0
Macrochaeta clavicornis	0	0	0	0
Cirratulidae ind.	0	0	0	135
GLYCERIDAE				
Glycera alba	0	135	0	0
Glycera sp.	0	0	0	0
GONIADIDAE				
Goniadidae ind.	0	0	0	0
OPHELLIDAE				
Ophelina acuminata	0	271	0	0
Ophelina modesta	0	0	0	0
PECTINARIIDAE				
Pectinaria sp.	0	0	0	0
Pectinariidae ind.	0	0	0	0
NEREIDAE				
Nereis longissima	0	0	0	0
SABELLIDAE				
Chone filicaudata	0	0	0	0
Sabellidae ind.	0	271	0	0
AMPHARETIDAE				
Melinna palmata	0	0	0	0
Melina elizabethae	0	0	0	0
Ampharete sp.	0	0	0	0
Amphictheis gunneri	0	0	0	0
Ampharetidae ind.	0	0	0	0
PARAONIDAE				
Paraonis sp.	0	0	0	0
TRICHOBRANCHIDAE				
Terebellides stroemi	0	0	0	0
EUNICIDA				
Eunicida ind.	0	0	0	0
SPHAERODORIDAE				
Sphaerodoridium claparedii	0	0	0	0
ORBINIIDAE				
Scoloplos armiger	0	0	0	0
Orbiniidae ind.	0	0	0	0
NEPHTHYDIDAE				
Nephthys sp.	0	0	0	0
ANNELIDA IND.	0	0	0	0
SIPUNCULA	0	0	0	0
KINORYNCHA	0	0	0	0

APPENDIX V

Mean biomass (mg ww.m^{-2}) of the different taxa sampled at stations A, B and C at different sampling dates.

Station A (mg ww. m^{-2})

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	13-10-95
NEMATODA	5644.9	6692.4	4624.4	3823.3	4033.0
CRUSTACEA					
Copepod	0.0	0.0	0.0	0.0	0.0
Tanaid	0.0	0.0	0.0	106.9	0.0
Caraid	0.0	0.0	0.0	0.0	0.0
Amphipod	0.0	0.0	135.3	0.0	0.0
Decapod	0.0	0.0	0.0	0.0	0.0
MYSIDAE					
Erythrops elegans	0.0	0.0	43.3	0.0	0.0
OPHIUROIDEA	0.0	0.0	0.0	0.0	0.0
ECHINODERMATA	0.0	0.0	0.0	0.0	0.0
GASTROPODA	0.0	0.0	0.0	0.0	0.0
PROSOBRANCHIA	0.0	0.0	0.0	0.0	0.0
BIVALVIA	0.0	4329.4	5805.9	557.6	4939.8
ANNELIDA					
Scalibregma inflatum	30687.5	14264.4	18150.0	4242.8	5776.2
SPIONIDEA					
Prionospio fallax	983.9	583.3	1300.6	1.4	2668.8
Malacocerus fuliginosus	0.0	0.0	0.0	0.0	0.0
Prionospio multibranchiata	0.0	0.0	0.0	0.0	0.0
Prionospio cirrifera	0.0	55.5	0.0	494.0	0.0
Polydora paucibranchiata	0.0	0.0	0.0	0.0	0.0
Spio decorata	0.0	10.8	0.0	0.0	0.0
Polydora complex	0.0	0.0	0.0	937.9	175.9
Spionidea ind.	0.0	0.0	97.4	0.0	0.0
Spionidea frag.	0.0	54.1	20.3	0.0	0.0
PHOLOIDAE					
Pholoe synophthalmica	510.2	119.1	28.4	96.1	0.0
PHYLLODOCIDAE					
Phyllodocidae ind.	498.0	0.0	12.2	0.0	194.9
CAPITELLIDAE					
Capitella capitata	12.2	422.2	0.0	0.0	0.0
Mediomastus fragilis	2304.8	3175.0	301.8	1452.2	839.1
Notomastus sp.	23322.5	0.0	0.0	0.0	0.0
capitellidae frag.	2196.5	10296.4	82.6	586.0	12017.9
DORVILLEIDAE					
Ophryotrocha hartmanni	469.6	485.9	0.0	0.0	0.0
Protodorvillea kefersteini	227.4	0.0	0.0	0.0	0.0
Ophryotrocha sp.	0.0	0.0	0.0	0.0	0.0
LUMBRINEREIDAE					
Lumbrineris sp.	2425.2	383.0	0.0	324.8	0.0
SYLLIDAE					
Syllidae ind.	0.0	0.0	0.0	0.0	0.0
HESIONIDAE					
Hesionidae ind. I	353.2	236.8	0.0	0.0	0.0
Hesionidae ind. II	0.0	0.0	0.0	0.0	0.0
Nereimyra puntacta	0.0	0.0	0.0	0.0	150.2
Hesionidae ind. III	0.0	0.0	0.0	0.0	83.9

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	13-10-95
CIRRATULIDAE					
Chaetozone setosa	136.7	0.0	0.0	0.0	0.0
Caulleriella zetlandia	0.0	441.2	0.0	0.0	0.0
Caulleriella alata	0.0	0.0	0.0	0.0	0.0
Macrochaeta clavicornis	0.0	0.0	0.0	0.0	0.0
Cirratulidae ind.	0.0	0.0	0.0	0.0	0.0
GLYCERIDAE					
Glycera alba	0.0	2478.0	0.0	445.3	0.0
Glycera sp.	0.0	0.0	108.3	0.0	0.0
GONIADIDAE					
Goniadidae ind.	0.0	117.7	0.0	0.0	0.0
OPHELLIDAE					
Ophelina acuminata	0.0	0.0	0.0	0.0	0.0
Ophelina modesta	0.0	0.0	0.0	0.0	0.0
PECTINARIIDAE					
Pectinaria sp.	0.0	0.0	0.0	0.0	144.8
Pectinariidae ind.	0.0	0.0	0.0	0.0	0.0
NEREIDAE					
Nereis longissima	18099.9	0.0	0.0	0.0	0.0
SABELLIDAE					
Chone filicaudata	0.0	0.0	0.0	115.0	0.0
Sabellidae ind.	0.0	0.0	0.0	0.0	0.0
AMPHARETIDAE					
Melinna palmata	0.0	0.0	2077.4	415.5	918.9
Melina elizabethae	0.0	0.0	0.0	0.0	0.0
Ampharete sp.	0.0	0.0	0.0	0.0	0.0
Amphictheis gunneri	0.0	0.0	0.0	0.0	4758.4
Ampharetidae ind.	0.0	0.0	0.0	0.0	0.0
PARAONIDAE					
Paraonis sp.	0.0	0.0	0.0	98.8	134.0
TRICHOBRANCHIDAE					
Terebellides stroemi	0.0	0.0	0.0	2685.1	0.0
EUNICIDA					
Eunicida ind.	0.0	0.0	0.0	0.0	0.0
SPHAERODORIDAE					
Sphaerodoridium claparedii	0.0	0.0	0.0	0.0	0.0
ORBINIIDAE					
Scoloplos armiger	0.0	0.0	0.0	0.0	0.0
Orbiniidae ind.	2.7	0.0	0.0	0.0	385.7
NEPHTHYDIDAE					
Nephthys sp.	0.0	0.0	0.0	0.0	0.0
ANNELIDA IND.	0.0	0.0	0.0	0.0	0.0
SIPUNCULA	0.0	0.0	0.0	0.0	0.0
KINORYNCHA	0.0	0.0	0.0	0.0	0.0
UNIDENT. FRAG.	33273.8	16479.9	1274.9	4426.9	12714.8

Station B (mg ww. m^{-2})

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	13-10-95
NEMATODA	21808.1	27365.0	7554.5	6475.8	6064.4
CRUSTACEA					
Copepod	0.0	0.0	0.0	0.0	0.0
Tanaid	0.0	0.0	0.0	0.0	0.0
Caraid	0.0	0.0	0.0	0.0	0.0
Amphipod	0.0	0.0	0.0	0.0	0.0
Decapod	0.0	0.0	0.0	0.0	0.0
MYSIDAE					
Erythrops elegans	0.0	0.0	0.0	0.0	0.0
OPHIUROIDEA	0.0	0.0	0.0	0.0	0.0
ECHINODERMATA	0.0	0.0	0.0	0.0	0.0
GASTROPODA	0.0	0.0	0.0	0.0	0.0
PROSOBRANCHIA	0.0	0.0	0.0	0.0	0.0
BIVALVIA	0.0	0.0	349.2	234.1	2839.4
ANNELIDA					
Scalibregma inflatum	5716.6	0.0	12873.2	483.2	0.0
SPIONIDEA					
Prionospio fallax	0.0	0.0	0.0	111.0	232.8
Malacocerus fuliginosus	54447.2	14864.0	0.0	0.0	0.0
Prionospio multibranchiata	0.0	0.0	0.0	0.0	0.0
Prionospio cirrifera	0.0	0.0	0.0	0.0	0.0
Polydora paucibranchiata	0.0	0.0	0.0	0.0	0.0
Spio decorata	0.0	0.0	6.8	0.0	0.0
Polydora complex	0.0	0.0	0.0	0.0	1.4
Spionidea ind.	2723.0	0.0	460.1	0.0	0.0
Spionidea frag.	17121.4	4000.5	0.0	0.0	43.3
PHOLOIDAE					
Pholoe synophthalmica	355.9	0.0	0.0	224.7	0.0
PHYLLODOCIDAE					
Phyllodocidae ind.	12836.6	0.0	0.0	0.0	0.0
CAPITELLIDAE					
Capitella capitata	29851.1	24405.2	143.5	0.0	46.0
Mediomastus fragilis	2752.7	58.2	9.5	0.0	120.4
Notomastus sp.	31.1	0.0	0.0	0.0	0.0
capitellidae frag.	189.5	9036.4	0.0	0.0	0.0
DORVILLEIDAE					
Ophryotrocha hartmanni	483.2	357.3	0.0	0.0	0.0
Protodorvillea kefersteini	0.0	0.0	0.0	0.0	0.0
Ophryotrocha sp.	0.0	0.0	0.0	0.0	0.0
LUMBRINEREIDAE					
Lumbrineris sp.	0.0	0.0	0.0	0.0	0.0
SYLLIDAE					
Syllidae ind.	0.0	0.0	0.0	0.0	0.0
HESIONIDAE					
Hesionidae ind. I	0.0	14.9	0.0	0.0	0.0
Hesionidae ind. II	0.0	0.0	0.0	0.0	0.0
Nereimyra puntacta	0.0	0.0	0.0	0.0	0.0
Hesionidae ind. III	0.0	0.0	0.0	0.0	0.0

SAMPLING DATE	4-8-94	8-9-94	6-3-95	21-8-95	13-10-95
CIRRATULIDAE					
Chaetozone setosa	0.0	0.0	0.0	0.0	0.0
Caulleriella zetlandia	0.0	0.0	0.0	0.0	0.0
Caulleriella alata	0.0	0.0	0.0	0.0	0.0
Macrochaeta clavicornis	0.0	0.0	0.0	0.0	0.0
Cirratulidae ind.	47.4	0.0	0.0	0.0	0.0
GLYCERIDAE					
Glycera alba	0.0	0.0	0.0	334.3	0.0
Glycera sp.	0.0	0.0	0.0	0.0	0.0
GONIADIDAE					
Goniadidae ind.	0.0	0.0	0.0	0.0	0.0
OPHELLIDAE					
Ophelina acuminata	0.0	0.0	0.0	0.0	0.0
Ophelina modesta	0.0	0.0	0.0	0.0	0.0
PECTINARIIDAE					
Pectinaria sp.	0.0	0.0	0.0	0.0	0.0
Pectinariidae ind.	0.0	0.0	10966.3	0.0	0.0
NEREIDAE					
Nereis longissima	0.0	0.0	0.0	0.0	0.0
SABELLIDAE					
Chone filicaudata	0.0	0.0	0.0	0.0	0.0
Sabellidae ind.	0.0	0.0	0.0	0.0	0.0
AMPHARETIDAE					
Melinna palmata	0.0	0.0	0.0	0.0	0.0
Melina elizabethae	0.0	0.0	0.0	0.0	0.0
Ampharete sp.	0.0	0.0	0.0	0.0	0.0
Amphictheis gunneri	0.0	0.0	0.0	0.0	0.0
Ampharetidae ind.	0.0	0.0	0.0	0.0	0.0
PARAONIDAE					
Paraonis sp.	0.0	0.0	0.0	0.0	0.0
TRICHOBRANCHIDAE					
Terebellides stroemi	0.0	0.0	0.0	0.0	0.0
EUNICIDA					
Eunicida ind.	0.0	0.0	0.0	0.0	0.0
SPHAERODORIDAE					
Sphaerodoridium claparedii	0.0	0.0	0.0	0.0	0.0
ORBINIIDAE					
Scoloplos armiger	0.0	0.0	0.0	0.0	0.0
Orbiniidae ind.	0.0	0.0	0.0	0.0	0.0
NEPHTHYDIDAE					
Nephthys sp.	0.0	0.0	0.0	0.0	0.0
ANNELIDA IND.	0.0	0.0	0.0	0.0	0.0
SIPUNCULA	0.0	0.0	0.0	0.0	0.0
KINORYNCHA	0.0	0.0	0.0	0.0	0.0
UNIDENT. FRAG.	14353.8	687.5	0.0	0.0	208.4

Station C (mg ww. m^{-2})

SAMPLING DATE	8-9-94	6-3-95	21-8-95	13-10-95
NEMATODA	29933.7	16122.6	6471.8	9910.7
CRUSTACEA				
Copepod	0.0	0.0	0.0	0.0
Tanaid	0.0	0.0	0.0	0.0
Caraid	0.0	0.0	0.0	0.0
Amphipod	0.0	0.0	200.3	0.0
Decapod	0.0	0.0	0.0	0.0
MYSIDAE				
Erythrops elegans	0.0	0.0	0.0	0.0
OPHIUROIDEA	0.0	0.0	0.0	0.0
ECHINODERMATA	0.0	0.0	0.0	0.0
GASTROPODA	0.0	0.0	0.0	0.0
PROSOBRANCHIA	0.0	0.0	0.0	0.0
BIVALVIA	0.0	0.0	0.0	2756.8
ANNELIDA				
Scalibregma inflatum	0.0	5833.0	0.0	0.0
SPIONIDEA				
Prionospio fallax	0.0	0.0	97.4	0.0
Malacocerus fuliginosus	7057.8	0.0	0.0	163.8
Prionospio multibranchiata	0.0	0.0	0.0	0.0
Prionospio cirrifera	0.0	0.0	0.0	0.0
Polydora paucibranchiata	0.0	0.0	0.0	0.0
Spio decorata	0.0	0.0	0.0	0.0
Polydora complex	0.0	0.0	0.0	0.0
Spionidea ind.	0.0	0.0	0.0	0.0
Spionidea frag.	970.4	0.0	0.0	0.0
PHOLOIDAE				
Pholoe synophthalmica	0.0	0.0	0.0	0.0
PHYLLODOCIDAE				
Phyllodocidae ind.	0.0	0.0	0.0	0.0
CAPITELLIDAE				
Capitella capitata	12219.5	250.4	105.6	71.7
Mediomastus fragilis	0.0	24.4	0.0	144.8
Notomastus sp.	0.0	0.0	0.0	0.0
capitellidae frag.	734.9	0.0	0.0	0.0
DORVILLEIDAE				
Ophryotrocha hartmanni	0.0	0.0	0.0	0.0
Protodorvillea kefersteini	0.0	0.0	0.0	0.0
Ophryotrocha sp.	0.0	0.0	0.0	0.0
LUMBRINEREIDAE				
Lumbrineris sp.	0.0	0.0	0.0	0.0
SYLLIDAE				
Syllidae ind.	0.0	0.0	0.0	0.0
HESIONIDAE				
Hesionidae ind. I	0.0	0.0	0.0	0.0
Hesionidae ind. II	0.0	0.0	0.0	0.0
Nereimyra puntacta	0.0	0.0	0.0	0.0
Hesionidae ind. III	0.0	0.0	0.0	0.0

SAMPLING DATE	8-9-94	6-3-95	21-8-95	13-10-95
CIRRATULIDAE				
Chaetozone setosa	0.0	0.0	0.0	0.0
Caulleriella zetlandia	0.0	0.0	0.0	0.0
Caulleriella alata	0.0	0.0	0.0	0.0
Macrochaeta clavicornis	0.0	0.0	0.0	0.0
Cirratulidae ind.	0.0	0.0	0.0	10.8
GLYCERIDAE				
Glycera alba	0.0	912.2	0.0	0.0
Glycera sp.	0.0	0.0	0.0	0.0
GONIADIDAE				
Goniadidae ind.	0.0	0.0	0.0	0.0
OPHELLIDAE				
Ophelina acuminata	0.0	0.0	0.0	0.0
Ophelina modesta	0.0	0.0	0.0	0.0
PECTINARIIDAE				
Pectinaria sp.	0.0	0.0	0.0	0.0
Pectinariidae ind.	0.0	0.0	0.0	0.0
NEREIDAE				
Nereis longissima	0.0	0.0	0.0	0.0
SABELLIDAE				
Chone filicaudata	0.0	0.0	0.0	0.0
Sabellidae ind.	0.0	0.0	0.0	0.0
AMPHARETIDAE				
Melinna palmata	0.0	0.0	0.0	0.0
Melina elizabethae	0.0	0.0	0.0	0.0
Ampharete sp.	0.0	0.0	0.0	0.0
Amphictheis gunneri	0.0	0.0	0.0	0.0
Ampharetidae ind.	0.0	0.0	0.0	0.0
PARAONIDAE				
Paraonis sp.	0.0	0.0	0.0	0.0
TRICHOBRANCHIDAE				
Terebellides stroemi	0.0	0.0	0.0	0.0
EUNICIDA				
Eunicida ind.	0.0	0.0	0.0	0.0
SPHAERODORIDAE				
Sphaerodoridium claparedii	0.0	0.0	0.0	0.0
ORBINIIDAE				
Scoloplos armiger	0.0	0.0	0.0	0.0
Orbiniidae ind.	0.0	0.0	0.0	0.0
NEPHTHYDIDAE				
Nephthys sp.	0.0	0.0	0.0	0.0
ANNELIDA IND.	0.0	0.0	0.0	0.0
SIPUNCULA	0.0	0.0	0.0	0.0
KINORYNCHA	0.0	0.0	0.0	0.0
UNIDENT. FRAG.	27.1	0.0	0.0	280.1

APPENDIX VI

Abundance (no. ind./core slice) of the different taxa sampled at stations A, B and C at different sampling dates.

Key: I - Replicate I
II - Replicate II
III - Replicate III
1 - 0 to 3 cm depth horizon
2 - 3 to 6 cm depth horizon
3 - 6 to 9 cm depth horizon

Station: A
Date: 4-8-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	810	1214	1065	184	9	280	3	6	6
CRUSTACEA									
Copepod I	0	0	0	0	0	0	0	0	0
Copepod II	1	8	13	0	0	5	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	1	6	1	0	0	5	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	2	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	3	3	0	0	1	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	1	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	4	4	6	12	2	2	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	1	1	1	1	1	0	0	1
SPIONIDEA									
Prionospio fallax	7	1	4	0	0	1	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	1	3	3	2	0	1	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	1	2	3	0	0	2	0	0	0
CAPITELLIDAE									
Capitella capitata	3	0	1	13	0	1	0	0	0
Mediomastus fragilis	1	2	0	0	9	5	5	0	5
Notomastus sp.	0	0	0	1	0	1	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	52	33	37	0	0	0	0	0	0
Protodorvillea kefersteini	3	3	7	0	0	2	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	1	2	0	1	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	4	2	1	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	1	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	1	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	1	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	1	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: A
Date: 8-9-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	1122	1369	1006	292	126	47	5	1	6
CRUSTACEA									
Copepod I	4	1	1	0	0	0	0	0	0
Copepod II	8	8	2	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	4	2	2	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	1	0	0	1
Tanaid	3	0	5	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	1	0	4	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	1	2	3	2	0	0	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	1	1	0	0	0	0
SPIONIDEA									
Prionospio fallax	2	2	3	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	1	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	1	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	2	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	2	3	2	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	2	3	5	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	6	16	0	0	1	0	0	0
Mediomastus fragilis	2	5	14	12	6	8	4	1	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	51	16	60	2	1	0	0	0	0
Protodorvillea kefersteini	0	0	0	1	0	0	0	0	0
Ophryotrocha sp.	0	1	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	1	1	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	5	2	9	0	0	1	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	1	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	2	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	1	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	1	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	1	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: A
Date: 6-3-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	2163	411	164	55	59	55	11	8	7
CRUSTACEA									
Copepod I	1	0	0	0	0	0	0	0	0
Copepod II	0	0	0	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	0	1	0	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	4	3	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	1	0	1	0	0	0	0	0	0
Decapod	0	0	1	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	3	3	11	0	0	0	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	4	0	0	1	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	2	3	5	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	1	0	0	0	0	0	0	0
Polydora complex	0	0	2	0	0	0	0	0	0
Spionidea ind.	1	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	1	1	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	1	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0	0	0	0
Mediomastus fragilis	5	3	2	4	6	1	1	0	0
Notomastus sp.	0	0	1	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	1	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	1	1	2	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	1
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	1	0	1	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	2	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	1	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	1	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	2	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	1
KINORYNCHA	1	1	0	0	0	0	0	0	0

Station: A
Date: 21-8-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	243	1488	506	46	91	41	2	2	3
CRUSTACEA									
Copepod I	5	4	9	0	0	1	1	0	0
Copepod II	1	3	3	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	2	1	0	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	3	0	5	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	1	1	0	0	0	0	0	0
Decapod	0	1	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	1	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	4	7	6	0	0	0	0	0	0
Bivalvia II	0	1	1	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	7	5	20	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	4	5	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	1	0	3	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	1	3	3	0	0	0	0	0	0
Spionidea ind.	1	1	1	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	12	1	7	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	2	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0	0	0	0
Mediomastus fragilis	27	29	14	9	5	7	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	1	1	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	1	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	3	4	4	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	2	1	1	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	1	0	0	1	0	0	0	0
Glycera sp.	1	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	1	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	2	0	0	0	0	0	0
Sabellidae ind.	1	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	1	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	2	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	1	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	1	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	1	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	1	0	0	0	0	0	0
Orbiniidae ind.	0	0	1	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	1	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	2	2	1	0	0	0	0	0	0

Station: A
Date: 13-10-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	356	497	1309	56	117	173	15	11	13
CRUSTACEA									
Copepod I	4	2	3	1	0	0	0	0	0
Copepod II	0	1	3	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	5	3	1	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	4	3	1	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	1	0	1	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	1	1	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	18	18	26	1	0	1	0	0	0
Bivalvia II	0	4	0	0	0	0	0	0	0
Bivalvia III	0	0	1	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	5	3	2	1	0	2	0	0	0
SPIONIDEA									
Prionospio fallax	19	14	13	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	3	3	0	0	0	0	0	0
Spionidea ind.	4	3	1	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	4	3	2	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	3	4	3	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	1	0	0	0	0	0	0	0	0
Mediomastus fragilis	21	7	21	27	23	4	1	1	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	1	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	5	3	9	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	1	0	1	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	1	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	1	0	0	0	0	0	0	0
Caulleriella alata	1	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	3	0	0	0	0	0	0	0
Cirratulidae ind.	3	0	1	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	1	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	1	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	1	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	1	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	1	0	0	0
Ampharetidae ind.	10	3	3	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	1	1	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	1	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	1	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	1
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	1	1	0	0	0	0	0	0

Station: B
Date: 4-8-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	3231	1329	2079	2266	2067	1384	91	110	239
CRUSTACEA									
Copepod I	0	0	0	0	0	0	0	0	0
Copepod II	0	0	0	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	9	1	0	11	1	1	0	0	0
Copepod V	0	0	1	1	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	4	3	4	0	0	0	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	1	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	15	36	13	9	6	12	2	2	6
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	3	6	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	1	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	25	5	45	4	1	0	0	0	1
CAPITELLIDAE									
Capitella capitata	19	63	20	20	26	7	1	1	5
Mediomastus fragilis	3	4	8	30	1	24	3	0	16
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	42	1	84	3	1	1	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	0	2	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	1	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	1	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: B
Date: 8-9-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	1503	3887	3580	1833	2318	3051	284	954	575
CRUSTACEA									
Copepod I	0	0	0	0	0	0	0	0	0
Copepod II	0	0	1	0	2	0	0	0	0
Copepod III	1	0	0	0	0	1	0	0	0
Copepod IV	9	17	6	1	6	1	1	4	0
Copepod V	1	1	0	0	0	2	0	2	0
Copepod VI	1	0	0	0	3	3	0	4	0
Tanaid	1	1	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	1	1	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	0	0	0	0	0	0	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	31	26	44	8	4	2	0	0	2
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	1	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	90	84	97	27	11	15	14	13	3
Mediomastus fragilis	0	3	3	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	78	13	52	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	1	0	1	2	1	1	0	0	1
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	1	1	0	0	0	0	0	0	0

Station: B
Date: 6-3-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	1242	674	1575	241	499	473	21	35	20
CRUSTACEA									
Copepod I	1	1	3	0	0	0	0	0	0
Copepod II	0	0	0	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	4	5	4	0	0	1	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	1	1	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	8	5	6	0	0	0	0	0	0
Bivalvia II	2	2	1	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	1	1	0	1	2	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	2	0	0	0	0	0	0
Polydora complex	0	1	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	1
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	43	5	12	0	1	0	0	0	0
Mediomastus fragilis	0	2	2	0	1	2	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	1	2	3	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	1	6	1	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	1	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	1	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	1	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	1	3	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: B
Date: 21-8-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	651	1269	768	621	526	307	9	17	3
CRUSTACEA									
Copepod I	2	2	0	0	0	1	0	0	0
Copepod II	1	1	0	0	0	0	0	0	0
Copepod III	0	1	0	0	0	0	0	0	0
Copepod IV	3	2	0	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	3	2	3	0	0	0	0	0	0
Bivalvia II	3	2	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	2	0	2	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	5	10	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	1	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	2	1	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	1	0	1	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	2	0	0	0	0	0	1	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	1	2	0	1	0	1	0	0	0
Mediomastus fragilis	7	5	6	3	2	4	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	1	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	2	2	0	0	0	1	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	1	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	1	1	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	1
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	2	0	0	0	0	0	0	0	0

Station: B
Date: 13-10-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	716	625	988	476	681	344	14	13	4
CRUSTACEA									
Copepod I	0	0	1	0	0	0	0	0	0
Copepod II	0	0	0	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	0	2	6	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	3	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	17	14	8	0	0	1	0	0	0
Bivalvia II	2	1	3	0	0	1	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	3	9	17	0	0	1	0	0	0
Malacocerus fuliginosus	1	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	1	0	0	0	0	0	0	0
Polydora paucibranchiata	2	0	0	0	0	0	0	0	0
Spio decorata	1	0	0	0	0	0	0	0	0
Polydora complex	0	0	1	0	0	0	0	0	0
Spionidea ind.	0	2	1	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	2	1	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	2	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	1	1	0	2	0	0	0	0	0
Mediomastus fragilis	0	4	12	0	6	8	0	0	1
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	1	2	6	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: C
Date: 8-9-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	1501	6173	4608	2184	2644	1669	43	70	16
CRUSTACEA									
Copepod I	0	0	0	0	0	0	0	0	0
Copepod II	1	0	2	0	0	0	0	0	0
Copepod III	4	1	0	0	0	0	0	0	0
Copepod IV	17	6	3	1	1	0	0	0	0
Copepod V	3	3	5	0	1	0	0	0	0
Copepod VI	0	0	0	0	0	2	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	0	0	0	0	0	0	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	46	18	26	3	2	2	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	225	74	108	12	4	5	2	2	0
Mediomastus fragilis	0	0	0	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	5	1	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	1
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: C
Date: 6-3-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	3054	2546	4042	16	291	218	13	12	11
CRUSTACEA									
Copepod I	0	0	0	0	0	0	0	0	0
Copepod II	1	1	1	0	0	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	3	3	10	0	0	0	0	0	1
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	3	2	2	0	0	0	0	0	0
Bivalvia II	0	0	1	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	1	0	0	1	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	1	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	2	17	7	0	0	0	29	0	0
Mediomastus fragilis	1	1	1	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	1	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	0	2	2	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	1	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	1	0	0	0	0	1	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	1	0	0	0	1	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: C
Date: 21-8-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	742	1403	735	202	518	107	6	1	0
CRUSTACEA									
Copepod I	5	1	1	0	0	0	0	0	0
Copepod II	0	0	0	0	1	0	0	0	0
Copepod III	0	0	0	0	0	0	0	0	0
Copepod IV	10	9	0	0	0	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	1	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	3	0	0	1	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	1	0	0	0	0	0	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	1	1	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	1	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	9	4	10	0	0	0	0	0	0
Mediomastus fragilis	5	13	2	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	1	1	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

Station: C
Date: 13-10-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	1950	1219	1073	706	933	344	6	35	2
CRUSTACEA									
Copepod I	8	22	18	0	3	0	0	0	0
Copepod II	0	0	2	0	0	0	0	0	0
Copepod III	0	0	2	0	0	1	0	0	1
Copepod IV	17	20	11	0	1	0	0	0	0
Copepod V	0	0	0	0	0	0	0	0	0
Copepod VI	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	1	1	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA									
Bivalvia I	9	10	11	1	1	1	0	0	0
Bivalvia II	0	0	0	0	0	0	0	0	0
Bivalvia III	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	2	0	0	0	0	0	0
Malacocerus fuliginosus	2	12	1	0	1	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	2	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	1	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	3	14	4	0	0	0	0	0	0
Mediomastus fragilis	13	2	11	1	0	2	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
SYLLIDAE									
Syllidae ind.	0	0	1	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	1	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melina elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0

APPENDIX VII

Biomass (mg ww/core slice) of the different taxa sampled at stations A, B and C at different sampling dates.

Key: I - Replicate I
II - Replicate II
III - Replicate III
1 - 0 to 3 cm depth horizon
2 - 3 to 6 cm depth horizon
3 - 6 to 9 cm depth horizon

Station: A
Date: 4-8-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	9.39	17.8	13.1	0.65	0	0.72	0	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	22.3	6.84	95.9	37.7	13.8	0	0	50.3
SPIONIDEA									
Prionospio fallax	5.57	0.22	1.1	0	0	0.38	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0.78	0.23	2.07	0	0.69	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0.02	1.15	0	0	2.51	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0.09	0	0	0
Mediomastus fragilis	0	0.17	0	7.57	5.35	1.21	0	0	2.73
Notomastus sp.	0	0	0	156	0	13.6	2.31	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	16.2
DORVILLEIDAE									
Ophryotrocha hartmanni	1.07	1.01	1.39	0	0	0	0	0	0
Protodorvillea kefersteini	0	0.31	0	0	0	1.37	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	6.09	10.7	0	1.1	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	2.61	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	1.01	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	134	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0.02	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	12.2	11.8	19.6	35.6	2.92	40.2	22.8	0	100

Station: A
Date: 8-9-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	11.18	21.77	11.07	3.41	1.47	0.55	0	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0.79	4.36	20.93	5.91	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	40.34	65.06	0	0	0
SPIONIDEA									
Prionospio fallax	1.24	1.89	1.18	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0.41	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0.08	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0.4	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0.88	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	1.76	0.38	0	0	0.98	0	0	0
Mediomastus fragilis	0	0.49	1.23	8.24	7.14	5.26	1.1	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	1.27	1.01	0	67.21	3.04	3.55	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	1.88	0.49	1.22	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	2.24	0.59	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	1.75	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	3.26	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	18.31	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0.87	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	4.97	11.96	2.74	4.63	97.38	0	0.09	0	0

Station: A
Date: 6-3-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	25.31	4.81	1.92	0.69	0.7	0.64	0.1	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	1	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0.32	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	7.94	34.96	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	116.2	0	0	8.02	0	0	9.87	0	0
SPIONIDEA									
Prionospio fallax	1.3	6.16	2.15	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0.72	0	0	0	0	0	0	0	0
Spionidea frag.	0	0.15	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0.21	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0.09	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0	0	0	0
Mediomastus fragilis	0	0	0	0.66	1.24	0	0.33	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0.61	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0.8	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	15.35	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	1.92	0	2.47	0	0	0	5.03	0	0

Station: A
Date: 21-8-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	2.84	17.41	5.92	0.54	1.06	0.48	0	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0.79	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	4.12	0	0	0	8.56	0	0	0	0
ANNELIDA									
Scalibregma inflatum	4.82	9.03	17.5	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0.01	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	3.65	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	6.77	0.16	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0.13	0	0.58	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0	0	0	0
Mediomastus fragilis	0.34	0	1.29	3.32	1.3	4.48	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	1.36	0	0.23	1.59	0	1.15	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	2.4	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	3.29	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0.85	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	3.07	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0.73	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	19.84	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0.88	9.12	0.72	8.04	2.56	11.39	0	0	0

Station: A
Date: 13-10-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	4.16	5.81	15.32	0.66	1.37	2.02	0.18	0.13	0.15
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	6.91	7.61	10.7	11.28	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	15.1	5.47	6.38	1.35	0	14.38	0	0	0
SPIONIDEA									
Prionospio fallax	9.6	6.22	3.9	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0.7	0.6	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	1.44	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0	0	0	0
Mediomastus fragilis	0.49	0.41	0.91	2.27	1.83	0.29	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	37.76	0	0	0	0	0	0	50.95	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	*	*	*	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	1.11	0	0	0	0	0	0
Hesionidae ind. III	0	0	0.62	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	1.07	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	6.79	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	35.16	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0.19	0	0.8	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	2.85	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	21.71	1.22	7.85	0.57	57.27	4.61	0	0.72	0

Station: B
Date: 4-8-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	37.4	36.9	23.1	19.9	24.8	16.9	0.67	1.4	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	42.2	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	42.9	63.9	12.9	75.8	31.4	92.9	13.9	17.6	50.9
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0.33	5.32	0	0	0	0	14.5	0	0
Spionidea frag.	0	5.14	0	0	52.5	14.2	0	0	54.7
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	2.63	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	21.8	2.02	70.9	0.16	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	35.2	21.7	12.1	51.9	69.4	6.48	5.53	2.26	15.9
Mediomastus fragilis	0	0.03	0.67	7.54	0.05	5.32	0.25	0	6.48
Notomastus sp.	0	0	0	0	0.23	0	0	0	0
capitellidae frag.	0	0	0	0	0	0.78	0.62	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0.4	0	3.17	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0.35	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	16.8	12.1	3.0	54.4	1.25	2.54	3.69	8.56	3.66

Station: B
Date: 8-9-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	17.58	45.48	41.89	21.45	27.12	35.7	1.45	7.42	4.11
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	7.81	8.46	10.41	32.36	21.47	12	0	0	17.32
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0.47	0.41	0.67	8.98	0.6	18.43	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	2.1	6.26	3.87	27.84	37.17	11.61	34.64	46.36	10.48
Mediomastus fragilis	0	0.43	0	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	5.54	0.33	0	31.83	7.07	0	22	0
DORVILLEIDAE									
Ophryotrocha hartmanni	1.57	0.22	0.85	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllis cornuta	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0.11
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	2.65	0	0	0	0	0	1.45	0.98	0

Station: B
Date: 6-3-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	14.53	7.89	18.43	2.8	5.84	5.53	0.2	0.4	0.2
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	2.58	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	43.95	5.8	0	26.24	19.13	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0.05	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	3.4
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	1.06	0	0	0	0	0	0	0	0
Mediomastus fragilis	0	0	0	0	0.07	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	2.25	0	0	78.78	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0	0	0	0	0	0	0	0	0

Station: B
Date: 21-8-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	7.62	14.85	8.99	7.3	5.5	3.59	0	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	1.15	0	0.58	0	50.7	0	0	99.66	0
ANNELIDA									
Scalibregma inflatum	2.62	0	0.95	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0.82	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	1.66	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0	0	0	0	0	0
Mediomastus fragilis	0	0	0	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	2.47	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0	0	0	0	0	0	0	0	0

Station: B
Date: 13-10-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	8.38	7.31	11.56	5.57	7.97	4.02	0	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	1.11	1.62	10.28	0	0	7.97	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0.07	0.47	1.18	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0.01	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0.15	0	0.17	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	*	*	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0	0	0.34	0	0	0	0	0
Mediomastus fragilis	0	0	0.41	0	0.15	0.33	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	*	*	*	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0	0.43	1.11	0	0	0	0	0	0

Station: C
Date: 8-9-94

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	17.56	72.22	53.9	25.55	30.93	19.5	0.5	0.82	0.2
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	7.32	7.93	5.58	9.14	2.87	19.31	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0.31	6.86	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	10.97	5.52	7.14	19.8	4.45	0	24.05	18.36	0
Mediomastus fragilis	0	0	0	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	2.57	0	0	2.29	0.57	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0.2	0	0	0	0	0	0	0	0

Station: C
Date: 6-3-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	35.7	29.79	47.29	0.2	3.4	2.55	0.2	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	4.78	0	0	38.32	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0.79	0.66	0	0	0	0.4	0	0
Mediomastus fragilis	0	0.18	0	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	6.74	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0	0	0	0	0	0	0	0	0

Station: C
Date: 21-8-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	8.7	16.42	12.94	2.4	6.06	1.3	0	0	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	1.27	0	0	0.21	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	0	0	0	0	0	0	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0.72	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	0	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0.28	0.5	0	0	0	0	0	0
Mediomastus fragilis	0	0	0	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	0	0	0	0	0	0	0	0	0

Station: C
Date: 13-10-95

	I1	II1	III1	I2	II2	III2	I3	II3	III3
NEMATODA	22.84	14.25	12.55	8.23	10.95	4	0	0.41	0
CRUSTACEA									
Copepod	0	0	0	0	0	0	0	0	0
Tanaid	0	0	0	0	0	0	0	0	0
Caraid	0	0	0	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0	0	0	0
Decapod	0	0	0	0	0	0	0	0	0
MYSIDAE									
Erythrops elegans	0	0	0	0	0	0	0	0	0
OPHIUROIDEA	0	0	0	0	0	0	0	0	0
ECHINODERMATA	0	0	0	0	0	0	0	0	0
GASTROPODA	0	0	0	0	0	0	0	0	0
PROSOBRANCHIA	0	0	0	0	0	0	0	0	0
BIVALVIA	6.67	0.91	12.56	0.11	0.04	0.08	0	0	0
ANNELIDA									
Scalibregma inflatum	0	0	0	0	0	0	0	0	0
SPIONIDEA									
Prionospio fallax	0	0	0	0	0	0	0	0	0
Malacocerus fuliginosus	0	1.21	0	0	0	0	0	0	0
Prionospio multibranchiata	0	0	0	0	0	0	0	0	0
Prionospio cirrifera	0	0	0	0	0	0	0	0	0
Polydora paucibranchiata	0	0	0	0	0	0	0	0	0
Spio decorata	0	0	0	0	0	0	0	0	0
Polydora complex	0	0	0	0	0	0	0	0	0
Spionidea ind.	0	0	0	0	0	0	0	0	0
Spionidea frag.	0	0	0	0	0	0	0	0	0
PHOLOIDAE									
Pholoe synophthalmica	0	0	0	0	0	0	0	0	0
PHYLLODOCIDAE									
Phyllodocidae ind.	0	0	0	0	0	0	0	0	0
CAPITELLIDAE									
Capitella capitata	0	0.53	0	0	0	0	0	0	0
Mediomastus fragilis	0.78	0	0.29	0	0	0	0	0	0
Notomastus sp.	0	0	0	0	0	0	0	0	0
capitellidae frag.	0	0	0	0	0	0	0	0	0
DORVILLEIDAE									
Ophryotrocha hartmanni	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	0	0	0	0	0	0	0	0	0
Ophryotrocha sp.	0	0	0	0	0	0	0	0	0
LUMBRINEREIDAE									
Lumbrineris sp.	0	0	0	0	0	0	0	0	0
SYLLIDAE									
Syllidae ind.	0	0	0	0	0	0	0	0	0
HESIONIDAE									
Hesionidae ind. I	0	0	0	0	0	0	0	0	0
Hesionidae ind. II	0	0	0	0	0	0	0	0	0
Nereimyra puntacta	0	0	0	0	0	0	0	0	0
Hesionidae ind. III	0	0	0	0	0	0	0	0	0

	I1	II1	III1	I2	II2	III2	I3	II3	III3
CIRRATULIDAE									
Chaetozone setosa	0	0	0	0	0	0	0	0	0
Caulleriella zetlandia	0	0	0	0	0	0	0	0	0
Caulleriella alata	0	0	0	0	0	0	0	0	0
Macrochaeta clavicornis	0	0	0	0	0	0	0	0	0
Cirratulidae ind.	0.08	0	0	0	0	0	0	0	0
GLYCERIDAE									
Glycera alba	0	0	0	0	0	0	0	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0
GONIADIDAE									
Goniadidae ind.	0	0	0	0	0	0	0	0	0
OPHELLIDAE									
Ophelina acuminata	0	0	0	0	0	0	0	0	0
Ophelina modesta	0	0	0	0	0	0	0	0	0
PECTINARIIDAE									
Pectinaria sp.	0	0	0	0	0	0	0	0	0
Pectinariidae ind.	0	0	0	0	0	0	0	0	0
NEREIDAE									
Nereis longissima	0	0	0	0	0	0	0	0	0
SABELLIDAE									
Chone filicaudata	0	0	0	0	0	0	0	0	0
Sabellidae ind.	0	0	0	0	0	0	0	0	0
AMPHARETIDAE									
Melinna palmata	0	0	0	0	0	0	0	0	0
Melinna elizabethae	0	0	0	0	0	0	0	0	0
Ampharete sp.	0	0	0	0	0	0	0	0	0
Amphictheis gunneri	0	0	0	0	0	0	0	0	0
Ampharetidae ind.	0	0	0	0	0	0	0	0	0
PARAONIDAE									
Paraonis sp.	0	0	0	0	0	0	0	0	0
TRICHOBRANCHIDAE									
Terebellides stroemi	0	0	0	0	0	0	0	0	0
EUNICIDA									
Eunicida ind.	0	0	0	0	0	0	0	0	0
SPHAERODORIDAE									
Sphaerodoridium claparedii	0	0	0	0	0	0	0	0	0
ORBINIIDAE									
Scoloplos armiger	0	0	0	0	0	0	0	0	0
Orbiniidae ind.	0	0	0	0	0	0	0	0	0
NEPHTHYDIDAE									
Nephthys sp.	0	0	0	0	0	0	0	0	0
ANNELIDA IND.	0	0	0	0	0	0	0	0	0
SIPUNCULA	0	0	0	0	0	0	0	0	0
KINORYNCHA	0	0	0	0	0	0	0	0	0
UNIDENT. FRAG.	2.07	0	0	0	0	0	0	0	0