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MEIOFAUNAL ASSEMBLAGES OF THE THAMES ESTUARY

April 1989 - March 1990

Modules I - III

A Study of the Meiofaunal Communities Present in Sediment Samples Collected by the National Rivers Authority, Thames Region

by

M.W. Trett[1,2] B.Sc., Ph.D., F.L.S.

and

R.L. Feil[1] B.Sc., Ph.D., F.L.S.

in collaboration with

S.J. Forster[1] B.Sc., G.I.Biol.

[1] *Physalia Ltd.*, 76 - 80 Victoria Road, Great Yarmouth, Norfolk NR30 3AZ

[2] Centre for Research in Aquatic Biology, University of London, Mile End Road, London E1 4NS

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The Meiofaunal Assemblages of the Thames Estuary

April 1989 - March 1990

Module I

EXECUTIVE SUMMARY

by

M.W. Trett[1,2] B.Sc., Ph.D., F.L.S.

and

R.L. Feil[1] B.Sc., Ph.D., F.L.S.

in collaboration with

S.J. Forster[1] B.Sc., G.I.Biol.

[1] *Physalia Ltd.*, **76 - 80 Victoria Road, Great Yarmouth, Norfolk NR30 3AZ**

[2] **Centre for Research in Aquatic Biology, University of London, Mile End Road, London E1 4NS**

1. The aim of the study reported here is to examine the use of the assemblages of meiofaunal organisms (sediment-dwelling species measuring less than 1 mm in length) to assess the pollution status of the Thames Estuary and the possible effects of reduced freshwater flow and mechanical disturbance. It also demonstrates the value of meiofaunal techniques as a sensitive means of longer-term monitoring of changes in conditions that occur within the Tideway. A number of parameters and methods of examining the data were used to make inferences on the environmental quality within the Estuary and these are described and discussed in detail. These include information on the tolerance of different species to pollution or other forms of environmental stress, effects on the numbers of species present in different communities (species richness), effects on the densities of individuals and on the trophic structure of the communities (the relative abundances of different feeding types). These parameters were also used to assess the effects of reduced freshwater flow and mechanical disturbance.

2. Meiofauna offer many distinct advantages in the study of environmental conditions. Being nearer to the base of food webs in aquatic ecosystems than larger invertebrate animals, meiofauna respond more rapidly to any changes in environmental conditions that affect the quality and nature of their food supply. Unlike other animals, the less mobile meiofauna are subjected continuously to the effects and constraints of any "foreign" materials that enter their environment and this is reflected in the composition of their communities.

Other advantages of using meiofauna as biological indicator organisms for assessing and monitoring environmental conditions can be summarised as follows:

i. meiofaunal populations are inherently stable, that is, under similar environmental conditions similar meiofaunal populations will develop (similar species complements, densities, species richness and trophic structure). This enables changes in the structure of meiofaunal assemblages to be related more easily to changes in environmental conditions;

ii. the short generation times of certain species and high diversity of species present in a given habitat, especially in the case of the Nematoda, enable communities to respond more rapidly than larger invertebrates (macrofauna) to changing conditions;

iii. certain meiofaunal species are amongst the last to survive in grossly polluted conditions; consequently meiofaunal indices can be used to assess changes in conditions in the entire range of stressed and polluted habitats;

iv. the high densities of meiofaunal species in a given environment make statistically valid sampling simpler than for other groups; sampling macrofauna on a comparable scale would itself have a marked impact on the ecology of area under examination;

v. given the equivalent effort required to produce the same resolution using macrofaunal indices, the costs of meiofaunal surveys and analyses in terms of time, effort and expenditure are relatively low. This has proved to be an important consideration where industries and authorities have had to strike a balance between competing demands on limited resources.

3. Sediment samples were collected by NRA (Thames Region) staff as part of the Thames Estuary Benthic Programme from intertidal and subtidal sites between Teddington and Shoeburyness between April 1989 and March 1990. This programme included examination of macrofauna and sediment chemistry. The sediment samples were fixed at the time of collection or shortly after with formaldehyde solution. In the laboratory, meiofaunal organisms were elutriated and concentrated using polymer density gradient solutions. Harpacticoid copepods were removed for dissection (necessary for accurate identification). Halacarid mites were also removed and were cleared in polyvinyl lactophenol. Remaining meiofaunal groups, principally Nematoda, were processed to glycerol and mounted on slides for identification and enumeration. All specimens were examined using Nomarski differential interference contrast microcopy and identification confirmed using the meiofaunal reference collections held at *Physalia*.

4. k-Dominance plots examine the number of species present in a given habitat and their relative abundance. These were used to provide information about fundamental changes that occurred in dominance:diversity characteristics of assemblages at each sampling site. In meiofaunal communities, dominance often reflects prevailing environmental conditions. Consequently, the degree of dominance and changes in this value can provide a valuable indication of ambient conditions.

The trophic structure of each community was determined and the relative abundances of selective epigrowth feeders, diatomivorous species, microbivorous species, non-selective deposit feeders (detritivores) and predators/omnivores documented. Changes in conditions are often reflected directly in the nature and quality of the food supply, especially in populations of sediment bacteria, fungi and algae. These are difficult to assess directly. However, populations of certain meiofaunal species that feed on these groups are a convenient way in which such changes can be detected and monitored.

Species-richness (numbers of species present) and densities of individuals combined with a knowledge of the biology of the species (including reproductive strategies and sensitivity to stress/disturbance), were used throughout the study to assess conditions at the stations sampled.

The results of the surveys are summarised briefly below.

5. Amongst the principal meiofaunal groups, a total of 207 nematode species, 49 harpacticoid copepod species and 6 acarine species were observed during the course of the survey. Species from 10 further meiofaunal phyla were also recorded along with the larval and juvenile stages of several macrofaunal species (see Module IV).

6. Principal *natural* factors governing the structure of species assemblages were salinity, sediment granulometry, position relative to intertidal zone and season (see Module IV).

i. Salinity

The estuary supported marine, estuarine and freshwater meiofauna and encompassed species capable of tolerating broad changes in salinity (euryhaline species) through to those that are restricted to narrow salinity ranges (stenohaline species). Euryhaline species were ubiquitous and predominated at the mid-estuary sampling stations. The distributions of these species formed overlapping, successional series along the Tideway. The stenohaline species were located at either end of the estuary and formed characteristic assemblages of freshwater or marine species.

ii. Sediment Granulometry

Sediment types ranged from coarse grained sands that contained stones and shell fragments to compacted clay muds and flocculant, high silt-clay fraction sediments. In general, the coarse sediments supported a high diversity of meiofaunal species (up to 98 taxa; Chapman Buoy) at low densities. In these habitats dominance was usually low. The mud communities were less species-rich than those of neighbouring sands but were capable of supporting exceptionally high meiofaunal densities (greater than 153,000 individuals litre^{-1} sediment; Southend intertidal site). Dominance was often high in these sediments. Amongst the nematodes, selective epigrowth feeding species and diatomivorous species predominated in the coarser substrates which also favoured interstitial harpacticoid copepods. In contrast, non-selective deposit feeding nematodes and epibenthic harpacticoid copepods predominated in the Thames muds.

iii. Proximity to Intertidal Zone.

With few exceptions, the intertidal sites sampled in the Thames supported higher densities and numbers of meiofaunal species than equivalent subtidal sites. The reasons for this phenomenon are discussed.

iv. Season

Successions of species were found to occur at given sampling sites at different times of the year. This was largely related to the trophic mode of the species and is thought to be dependent on ambient water temperatures, availability of food and competition pressure. Within different groups, opportunist species (r-strategists) with high natural rates of increase and K-strategists with longer life-cycles could be recognised.

7. Against this background of *natural* variation, the effects of external, anthropogenic stresses and perturbations were documented. These stresses included diffuse, non-specific pollution, discharge of sewage effluents, reduced freshwater flows resulting from high levels of water abstraction during dry periods and mechanical disturbance.

i. Non-specific Pollution

With reference to the status of meiofaunal assemblages at neighbouring sampling stations, attention is drawn to depressed meiofaunal densities and diversities of species at certain estuarine sites. Possible causes are considered and potential changes in the meiofaunal assemblages resulting from worsening or improving conditions postulated with a view to aiding monitoring of the status of the Tideway (see Module II).

ii. Sewage Effluents

Two different effects of sewage effluents were noted that related to the position of the treatment works within the estuary. At Beckton and Crossness sewage works meiofaunal densities and species richness were depressed around the outfalls in comparison to neighbouring sampling stations. Tolerant, euryhaline non-selective detritivores persisted along with low salinity microbivorous species in species-poor communities at sites at which macrofauna was either absent or impoverished. At Southend, salinity effects of the sewage effluent appeared to be secondary as marine species were present throughout the year. Dominance, however, was high for a sandy sediment (up to 40%) exceeding that of the muddier intertidal sediments. Examination of the species complements revealed the dominant species to be a non-selective deposit feeding nematode commonly found in association with elevated levels of organic material. Densities of this species may provide a useful indicator of the effects of this outfall in the higher salinity outer reaches of the estuary (see Module II).

iii. Reduced Freshwater Flow

Direct effects of decreased freshwater flows were the reduction in densities of stenohaline freshwater species at the head of the estuary (Teddington and Kew), the extended colonisation of upstream stations by euryhaline mid-estuary species and the ingression of marine species into the outer estuary. Increased sedimentation leading to changes in sediment types from coarse grained to finer substrates along the Tideway may have been an indirect effect of reduced flow that produced associated changes in meiofaunal communities outlined in 4 ii above (see Module III).

iv. Mechanical Disturbance

Some evidence of mechanically disturbed or unstable sediments was derived from meiofaunal indices. These were based on the ability of the more mobile epibenthic harpacticoid copepods to recolonise disturbed sediments more rapidly than nematodes. The value of this index is considered in terms of monitoring conditions in the Thames Estuary (see Module III).

8. The adoption of a routine meiofaunal sampling programme would greatly enhance the sensitivity of existing faunal surveys in the establishment and monitoring of the pollution status of the Thames Estuary. Comparatively small improvements in prevailing conditions in certain reaches could be documented and attention drawn at an early stage to the onset of adverse conditions. The effects of reduced freshwater flow and mechanical disturbance could also be assessed. Multivariate techniques for the analysis of complex meiofaunal communities in the existing data sets are suggested as a means of defining key species assemblages at each of the sampling stations at different times in the year. This would facilitate the detection of changes in benthic communities in response to altered environmental conditions (see Modules II and III). The multivariate analyses could be integrated with those of the macrofaunal surveys and correlated with the physical and chemical parameters of the sediments. This would greatly improve our understanding of the factors that regulate populations of meio- and macrofaunal species and could strengthen existing pollution management strategies for the Thames Estuary.

The Meiofaunal Assemblages of the Thames Estuary

April 1989 - March 1990

Module II

An Assessment of the Pollution Status of the Thames Estuary as Revealed by its Meiofaunal Assemblages

by

M.W. Trett[1,2] B.Sc., Ph.D., F.L.S.

and

R.L. Feil[1] B.Sc., Ph.D., F.L.S.

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S.J. Forster[1] B.Sc., G.I. Biol.

[1] *Physalia Ltd.*, 76 - 80 Victoria Road, Great Yarmouth, Norfolk NR30 3AZ

[2] Centre for Research in Aquatic Biology, University of London, Mile End Road, London E1 4NS

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1. Summary

Examination of the meiofauna indicated that sites sampled at the Teddington and seaward ends of the Thames Estuary supported comparatively healthy assemblages and densities of infaunal species. The communities at these sites were characterised by the presence of several pollution-intolerant invertebrate species. At the freshwater end of the estuary, these included rhizopod amoebae, microbivorous nematodes, tardigrades, halacarid and hydracarine mites and freshwater harpacticoid copepods. At the outer estuarine sites, clean, unstressed conditions were indicated by the presence of marine ciliates, gastrotrichs, kinorhynchs, oxystominid and desmoscolecid nematodes and interstitial harpacticoid copepods.

Meiofaunal dominance and diversity proved to be useful indicators of stressed conditions within the Estuary. Depressed species-richness and increased dominance were apparent at certain sites in the mid-estuary that were in close proximity to the two sewage treatment works (Beckton and Crossness). Here the subtidal sites appeared to be most strongly affected, with reduced populations of selective epigrowth and diatom feeding species (nematodes and copepods). Amongst the nematodes, non-selective, euryhaline detritivores predominated and secernentean species, more usually associated with freshwater habitats, were also noted.

Reduced densities of meiofauna also appeared to correlate with stressed conditions. At the subtidal sites at Southend and Sea Reach No. 2 Buoy, for example, densities of harpacticoid copepods and nematodes were lower than at surrounding stations. These comparatively species rich communities comprised a modified assemblage of species and were dominated throughout the year by a single nematode species. The latter was present at low densities only at other sampling sites. It is believed that the modified assemblages and reduced densities might relate to the Southend sewage outfall.

Nematode:copepod ratios were not thought to be useful indices of pollution status owing to the wide variations in densities of both meiofaunal groups in response to natural factors such as granulometry and salinity.

2. The Value of Meiofauna in the Determination of Pollution Status

Meiofauna are sediment-dwelling species that measure less than 1 mm. They are of fundamental importance in aquatic ecosystems, forming food for macrofaunal invertebrates as well as fish and possibly certain avifauna (e.g. waders). They also offer many distinct advantages in the study of prevailing environmental conditions. Essentially, being nearer to the base of food webs in aquatic ecosystems they respond rapidly to any changes in environmental conditions that affect the quality and nature of their food supply. Unlike other animals, the less mobile meiofauna are subjected continuously to the effects and constraints of any "foreign" materials that enter their environment and this is reflected in the composition of their communities.

The advantages of using meiofauna as biological indicator organisms in monitoring environmental conditions can be summarised as follows:

1. the existence of inherently stable populations enables changes in the structure of meiofaunal assemblages to be related more easily to changes in environmental conditions;

2. short generation times and high species diversity, especially in the Nematoda, enable communities to respond more rapidly than macrofauna to changing conditions;

3. certain meiofaunal species are amongst the last to survive in grossly polluted conditions; consequently meiofaunal indices can be used to assess the entire range of polluted conditions;

4. the high densities of certain meiofaunal species in a given environment make statistically valid sampling simpler than for other groups; sampling macrofauna on a comparable scale would itself have a marked impact on benthic communities;

5. given the equivalent effort required to produce the same resolution of using macrofaunal indices, the costs of meiofaunal surveys and analyses in terms of time, effort and expenditure are relatively low. This has proved to be an important consideration where industries and authorities have had to strike a balance between competing demands on limited resources.

Meiofaunal studies have gained acceptance throughout the world for the delineation of impact zones of pipe-borne effluents (Newell *et al.*, 1990a and b). *Physalia* undertakes annual examination of meiofaunal assemblages associated with industrial outfalls in Britain (Humber and Tees Estuaries), France, Holland, Spain, Italy, Canada (St. Lawrence River), Malaysia, Southern Africa and Tasmania. These surveys form a key part of the environmental audit for the industries concerned and enables them to assess the efficacy of their recovery and treatment processes. Other meiofaunal projects have included the accurate delineation of the impact zones of marine sewage outfalls, where macrofaunal studies had failed to reveal effects (Irish Sea), the detection of impacts of fish farm effluents, the assessment of the effects of drainage from mining operations and the evaluation of the effects of constructional activity on aquatic ecosystems.

Until now, there have been almost no studies or published information on the meiofaunal assemblages of the Thames Estuary. Feil (1989) includes some observations on meiofaunal communities at the mouth of the estuary in relation to the biology of O-group Dover sole, *Solea solea* and Trett, Feil and Forster (unpublished) have examined meiofaunal communities of a limited number of sites as part of an engineering consultancy for the location of a thermo-electric power station.

This section of the report considers the pollution status of the Thames Estuary in the light of the findings outlined in Module IV.

3. Interpretation of Meiofaunal Results

i. General Comments

As in other estuarine systems, the meiofaunal communities were dominated by nematodes. However, the harpacticoid copepods that are usually the main sub-dominant meiofaunal group were poorly represented, especially in the middle reaches of the Estuary. The reason for this is unknown but it might reflect general pollution stress. Many of the larger epibenthic harpacticoid copepods are episammic species that browse epigrowth from sediment particles. Consequently, any factor that affects the microbiology of sediments may influence the populations of these species.

Abundance of individuals, species richness and dominance are inter-related characteristics of meiofaunal communities that can provide important information concerning prevailing environmental conditions. These factors, along with the trophic structure of the meiobenthic assemblages, are discussed in connection with the pollution status of the Estuary in the following sections.

ii. Species Richness and Abundance

In general, species richness at a given salinity is highest in coarse grained sediments and lowest in high silt-clay fraction muds. This may relate to the heterogeneity of habitats present in coarse sediments that can be exploited by interstitial fauna. The converse situation is true of total densities of meiofauna; muds can support considerably higher densities of meiofauna than sands.

Examination of the results of the 4 meiofaunal surveys, presented in Module IV, suggests that both the Teddington and seaward ends of the Estuary support relatively healthy assemblages and densities of the smaller aquatic invertebrates. In comparison to marine and estuarine systems, there is little published information on the meiofauna of freshwater sediments. However, surveys that we have undertaken of lake and river meiofauna throughout the world have established that unpolluted freshwater sediments usually sustain moderate densities of a comparatively small number of meiofaunal species. The freshwater sediments sampled between Teddington to Cadogan Pier supported a high diversity of predominantly freshwater meiofauna. Many of these species are pollution intolerant. These groups included rhizopod amoebae, such as *Centropyxis* and *Euglypha* species, microbivorous nematodes (type 1A species) including species of *Rhabditis* and *Alaimus*, hydracarine mites and freshwater harpacticoids, such as *Bryocamptus* and *Moraria* species. Consequently, pollution stress on these sediment assemblages would appear to be minimal. However, evidence for changes in their communities with respect to altered freshwater flow was noted and is considered in detail in Module III.

At the seaward end of the estuary, the coarser grained, high salinity sediment assemblages are exceptionally species rich comprising, for example, up to 98 principal meiofaunal species (i.e. species of Nematoda, harpacticoid Copepoda and Acari). This is all the more notable given the high densities of meiofauna recorded; in the January - March 1990 survey, 153,403 nematodes litre^{-1} sediment were observed at the intertidal site at Southend (19i) and 125,012 nematodes litre^{-1} sediment at Shoeburyness East (21).

Again, 'pollution-sensitive' species and groups were present at the outermost stations. In this particular habitat these species included representatives of marine ciliates, kinorhynchs, gastrotrichs, oxystominid and desmoscolecid nematodes and interstitial harpacticoid species. With certain possible exceptions (see below), there is little evidence to suggest that these communities are pollution stressed or impacted.

In most of the estuaries that have been studied, meiofaunal diversity and densities rise with increasing mean salinity ranges (see Platt and Warwick, 1980). In practice this means that species numbers and abundances increase progressively towards the mouth of an estuary. The numbers of nematode and harpacticoid species observed at each sampling site in the Thames throughout the study are illustrated in Figures 1 to 4. Whilst there is a general trend for increased species richness towards the mouth of the estuary, sites are present at which diversity is lower than in neighbouring, upstream assemblages. These centre around the mid-tideway, although other examples can be seen at certain stations in the outer estuary. In several cases sites with reduced numbers of species exhibited reduced densities of meiofauna (Figures 5 to 8). However, in one or two instances this could also be explained by scouring effects of currents and changes in sediment types (see Module III).

In the mid-estuary, sampling stations between Woolwich (8) and Purfleet (11) supported depauperate meiofaunal communities throughout the survey. This correlated with the location and potential sphere of influence of the Beckton (9) and Crossness (10) sewage treatment works. Examination of the species complements present at each of the stations highlights the fact that the subtidal sites are most severely affected. In each case, the dominance and trophic structure of the communities are modified (see below). Euryhaline species, such as *Sabatieria punctata* and species of *Daptonema*, were the most resilient of those present and were, on occasion, the only species to be observed at these stations. Both groups are euryhaline and readily tolerate alternating periods of reduced and high salinity and, consequently, may be pre-adapted to survive in the mobile, low salinity effluent plumes of the treatment works. Secementean nematode species, commonly seen in the freshwater samples at the Teddington end of the estuary, were also common components of the meiofauna in this reach of the Thames although present at low densities. These were represented by microbivorous species such as *Mononchoides striatus* and members of the family Diplogasteridae. Where species richness rose during the year, this usually related to the appearance of a few individuals of marine nematode species. Copepod densities and numbers of species were low at each of the stations in this region with the exception of Purfleet (11) where estuarine, epibenthic detritivorous species were noted.

Densities and diversity of meiofauna were routinely lower at Grain Flats (20) than at its neighbouring stations (see Figures 1 to 8). Again dominance was also affected (see below). Taken together, these factors indicate a stressed community. The reasons for this stress are not entirely obvious. Direct influence of effluent from the Southend outfall is not seen as a likely explanation and, although *Richtersia inaequalis* was present at this site in three of the surveys, it was never dominant. The low similarities between the species assemblages and the reduced numbers of harpacticoid species (3 species identified over the year; see Module IV) suggests that conditions at this site were not stable. A progressive change in sediment type from a sand (April - June) to a mud (October - December) before returning to a muddy sand in the final survey was noted. It is possible that this southern shore station is affected by the backed up outflow of the Medway Estuary (see Module IV; Figure 1). Lower salinity water and allochthonous organic material from the Medway might account for the dominance of euryhaline, non-selective detritivore nematodes at Grain Flats (*Daptonema tenuispiculum* and *Sabatieria punctata*). However, the toxic effects of domestic and industrial material originating from the Medway cannot be ruled out. Whatever the cause, the changes in community structure are clearly reflected in the k-dominance plots (see below).

A further area of note in terms of modified species richness and abundance was the South Bank Centre (5). In each of the surveys, sediments at this station supported fewer species and lower densities of meiofauna than at either of the neighbouring stations (Cadogan Pier (4) and London Bridge (6); see Module IV; Appendix I, Section 2). The variability of the species complements at this station suggests that the sediment or prevailing environmental conditions may have been unstable but without detailed knowledge of the locality of the habitat sampled it is impossible to speculate further. The sediment type varied slightly from a coarse-fine sand mix to a sand with low silt content. This alone would not account for the reduced densities and numbers of species observed and indicates the operation of other factors that might include localised pollution.

Throughout the surveys it was noted that halacarid mite densities (and possibly diversity) were lower than observed in similar estuarine systems. In the Humber, *Thalassarachna baltica* and *Copidognathus* species exhibit high densities even around industrial and sewage outfalls where they may thrive in impoverished communities as a result of reduced competition and/or reduced predation (Newell *et al.*, 1989a). It is not impossible that improved conditions within the Thames would allow such species to breed here if introduced, their absence reflecting zoological history rather than current pollution status.

iii. Dominance

In meiofaunal assemblages, knowledge of dominance *per se* is of little value in determining the pollution status of a sampling station. Dominance varies naturally from site to site and tends, for example, to be highest in fine sediments and lowest in sands. Information on the biology of the dominant species and the numbers of species present in the assemblage can provide a better insight into prevailing conditions. Further, changes in dominance with time can indicate modification of communities in response to an environmental stress. This is well illustrated at several sites in the Thames Estuary where increased dominance in sediments of a given type and at similar salinities are accompanied by reductions in species richness. k-Dominance curves are a convenient way in which to express and assess these changes over time. For example, in comparison with other sites, dominance amongst the nematode populations was elevated during the first 3 surveys at Grain Flats (20; see above and Figures 9 to 12).

At the mouth of the Estuary, 2 subtidal sampling sites, Southend (19s) and Sea Reach No. 2 Buoy (22), whilst possessing seemingly high diversities of nematode species, supported lower numbers of species and densities of both nematodes and harpacticoid copepods than surrounding stations. Again, examination of their species complements shows them to have possessed modified assemblages which might relate to the Southend sewage outfall. At both stations the dominant nematode *throughout the year* was the selachinematid *Richtersia inaequalis*. This species accounted for between 26 and 45% of the nematode population at Southend and between 33 and 64% at Sea

Reach No. 2 Buoy. In both cases dominance was highest during the 2nd. survey (July - September 1989). *R. inaequalis* is a non-selective deposit feeder (type 1B species; see Module IV, Appendix II) and is usually present at nominal densities in subtidal marine sediments often occurring in meiofaunal assemblages at the mouths of British estuaries (Trett, pers. obsvn.). Circumstantial evidence indicates that this elevated dominance and modified species assemblage relates to the impact of discharged sewage at these sites; sediments from both stations at different times of the year yielded high densities of fine, optically active fibres[1]. Paper fibres commonly arise from pulped toilet papers, although other sources include paper mill effluents. Similar densities of paper fibres were not found at other sites in the Estuary. It is of interest to note that *R. inaequalis* was a recognised as a key species in multivariate analyses of meiofaunal assemblages in a study undertaken by Trett *et al.* (1990) of the benthos associated with the Fylde Coast sewage outfalls. In this instance it was dominant in stable muds. In the present survey, however, both Southend and Sea Reach No. 2 Buoy were characterised by muddy sands.

The modified nature of the meiofaunal communities observed at Sea Reach No. 2 Buoy is graphically illustrated by the k-dominance plots for this station (see Module VI, Figure 15). Dominance in sandy sediments is usually low. In the 2nd., 3rd. and 4th. surveys the dominance of *R. inaequalis* was exceptionally high correlating with its highest densities and a decline to less than half the total number of species observed at this station during the 1st. survey. Possible explanations include a concentration effect of effluent during the drier periods experienced between July 1989 and early 1990.

iv. Trophic Structure of Communities

Amongst meiofaunal assemblages, pollution stress is commonly reflected in a change in the trophic structure of the community. In the present study, specialist feeding types, such as selective epigrowth and diatom feeding nematodes (type 2A species; see Module IV, Appendix I, Section 5), were poorly represented in the more modified nematode assemblages. Non-selective deposit feeding species (type 1B species) predominated along with certain, lower salinity microbivorous nematodes. At Beckton (9) and Crossness (10), for example, the non-selective detritivores *Sabatieria punctata* and species of *Daptonema* were usually the dominant species and, on occasion, the only species observed in these assemblages. It was also apparent that relatively few type 1A species were present throughout the Estuary (see Module IV, Appendix I, Sections 1 and 2). These species are thought to be microbivorous or selective deposit feeders and each has a narrow, unarmed buccal cavity (Module IV, Appendix I). Evidence from studies of point source industrial discharges suggests that the populations of these species may be sensitive to changes in sediment microbiology (Trett and Forster, pers. obsvns.). Densities of microbivorous species belonging to the families Desmoscolecidae, Trefusiidae, Leptolaimidae and Oxystominidae were all lower in the Thames Estuary than those observed in other estuaries, including the Humber and Tees (Trett in Newell *et al.*, 1989a, 1989b; see also Warwick, 1971). Whether this reflects adverse changes in sediment microbial populations is uncertain. Similar factors may account for the reduced densities of interstitial ameirid and laophontid harpacticoid copepod species in

[1] The lignified structure of paper fibres from toilet papers or paper mills rotates the plane of transmitted light and between the crossed polar filters that form part of the Nomarski differential interference contrast optics produce bright coloured images in and amongst the meiofauna. Colour photomicrographs of this phenomenon can be supplied if required.

the mid- and outer estuarine sediments.

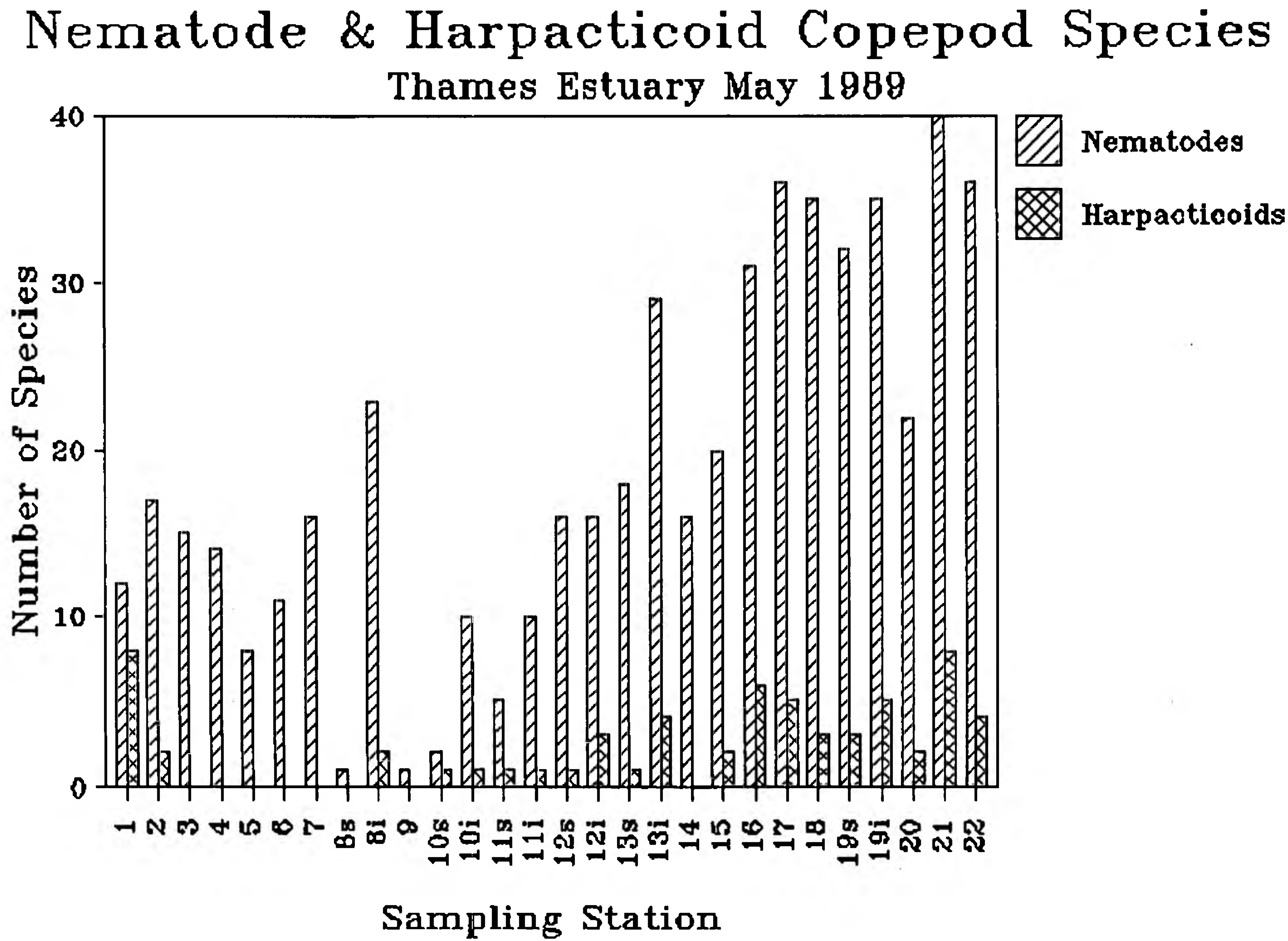
v. Nematode:Copepod Ratios

Nematode:copepod ratios (Raffaelli and Mason, 1981) have not been used as indicators of pollution status as doubt has been cast on their value in the detection of polluted sediments (Lambshead, 1984). However, they may be of some value in the detection of mechanically disturbed sediments (Trett and Feil, pers. obsvn.) and this is discussed in the Module III.

4. Further Analyses of Data

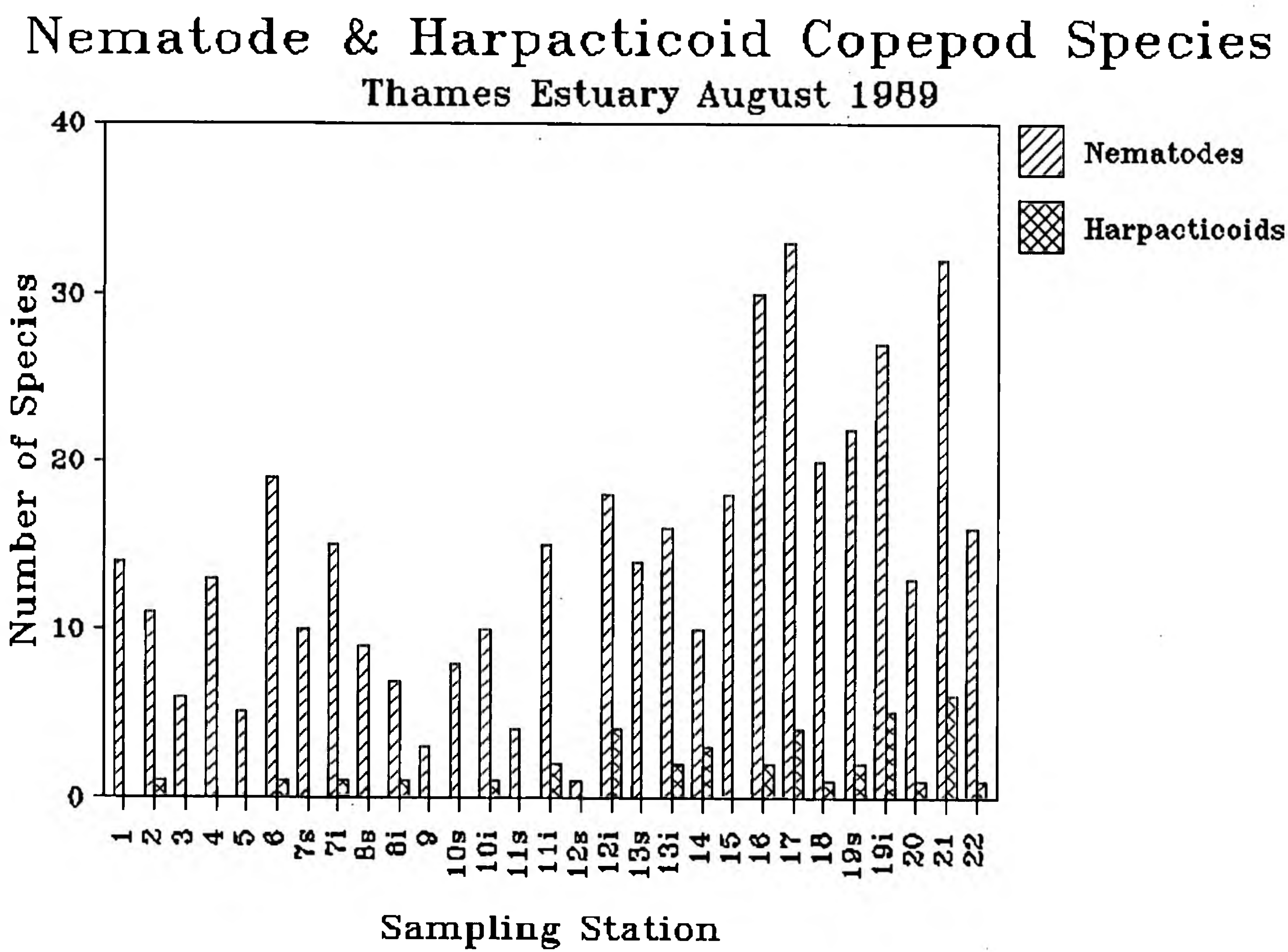
Multivariate analyses of the data sets for each of the sampling stations would enable characteristic ("key") meiofaunal species groupings to be identified within the Estuary. These could typify stressed or unstressed, mud or sand meiobenthic communities in the upper, mid- and outer estuary depending on the species present and their relative abundances. Similar studies using meiofaunal data have been used to assess the pollution status of subtidal sediments in relation to sewage and industrial outfalls (see Trett *et al.*, 1990; Newell *et al.*, 1989a, b, 1990a, b). Combined with macrofaunal data, this would provide a sensitive tool with which to detect and monitor changes in the Thames Estuary. Clustering techniques could also be used to examine correlations between physical and chemical parameters and the faunal complements present at each site. For several industries, this has proved to be an important means of documenting improvements in their effluent quality. Accurate detection and delineation of impact zones using multivariate techniques to identify groupings of sampling stations based solely on their meiofaunal assemblages is of central importance in such studies. In the Thames Estuary, the affinities of meiobenthic communities can be compared with those of preceding years to assess changes in the quality of the Tideway.

Figure 1. Total numbers of nematode and harpacticoid copepod species observed in the Thames Estuary, April - June 1989.



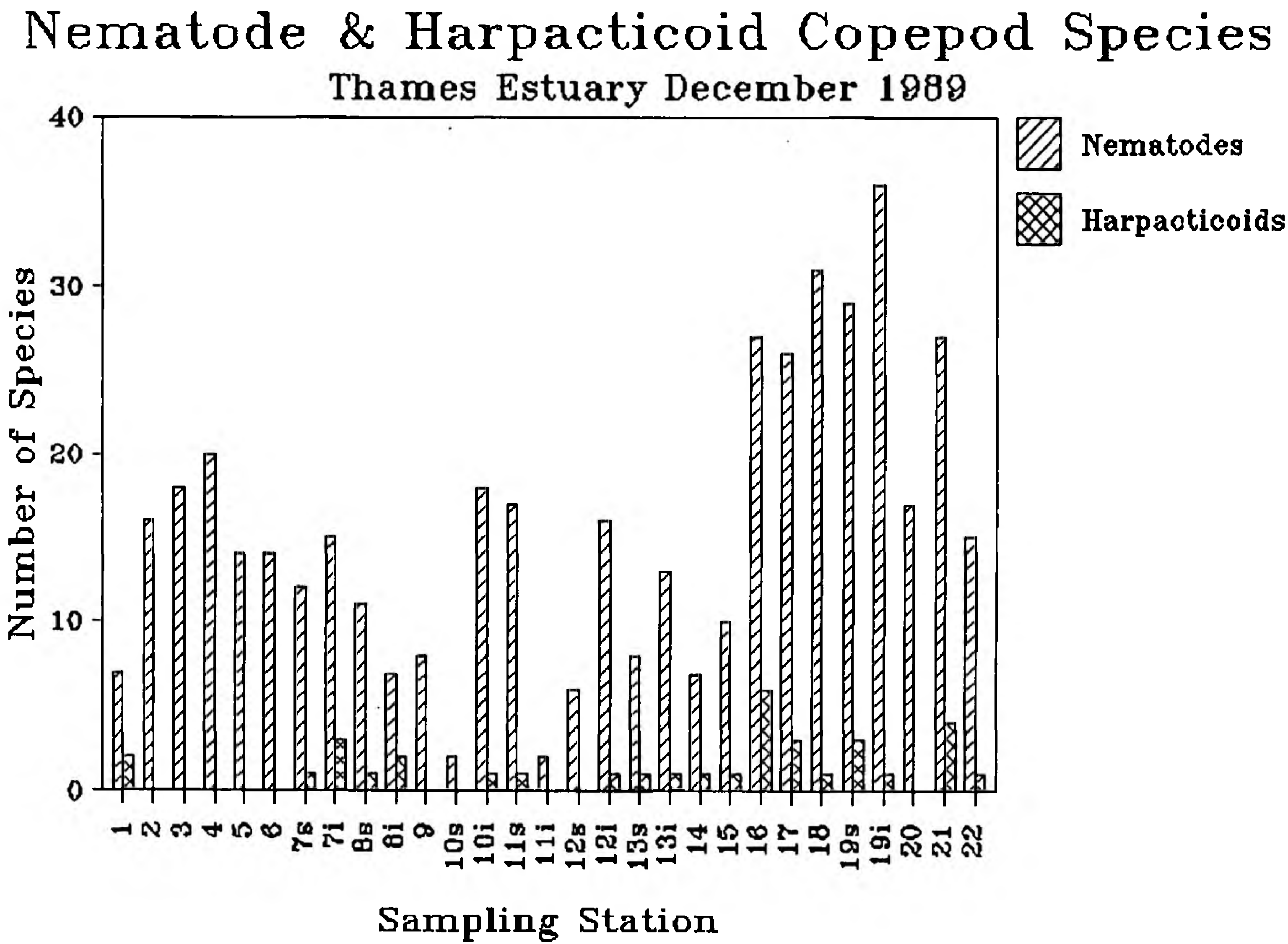
Nematode & Harpacticoid Copepod Species
Thames Estuary May 1989
Number of Species
0
10
20
30
40
Nematodes
Harpacticoids
1 2 3 4 5 6 7 8s 8i 9 10s 10i 11s 11i 12s 12i 13s 13i 14 15 16 17 18 19s 19i 20 21 22
Sampling Station

Figure 2. Total numbers of nematode and harpacticoid copepod species observed in the Thames Estuary, July - September 1989.



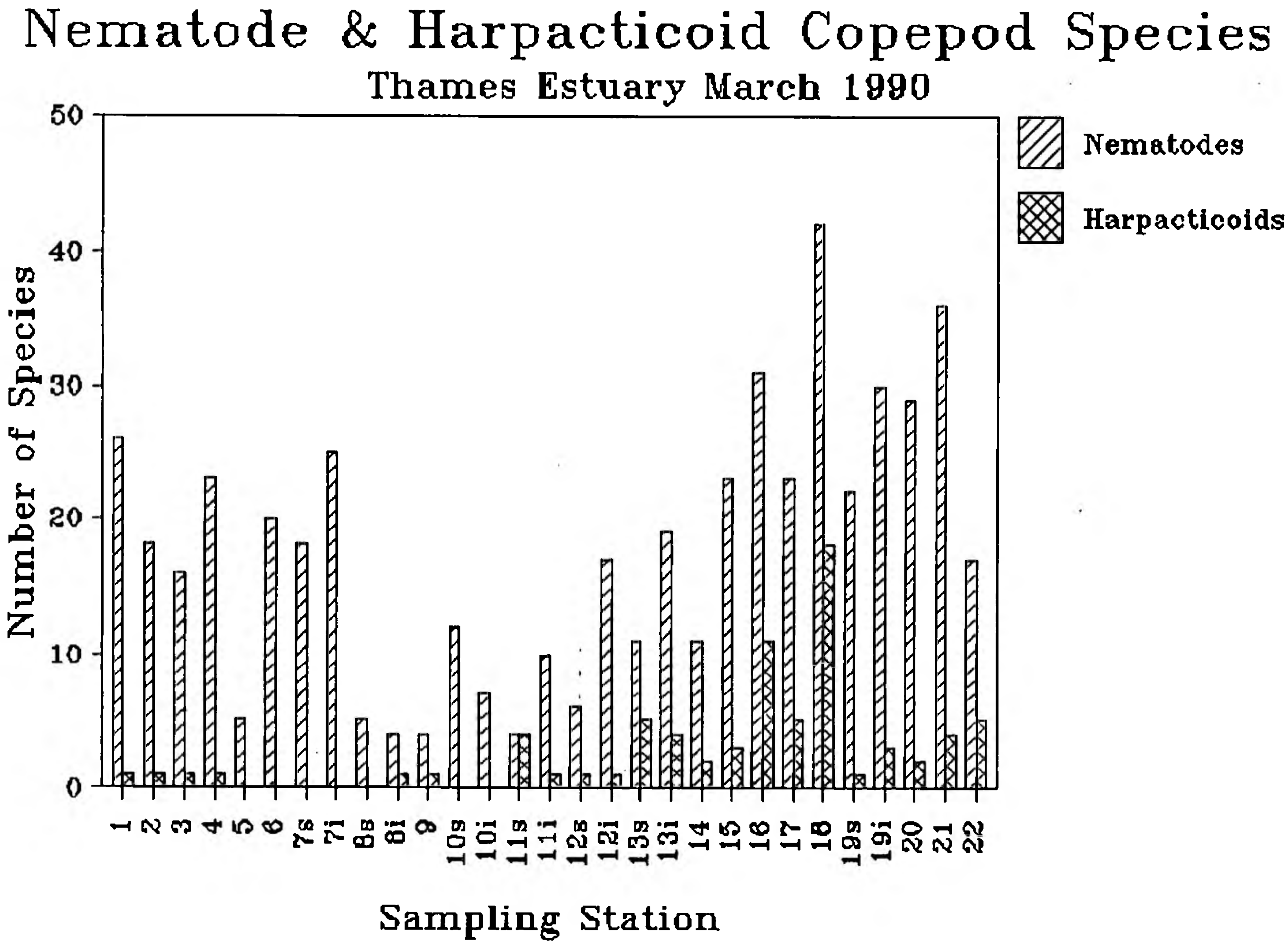
Nematode & Harpacticoid Copepod Species
Thames Estuary August 1989
Number of Species
0
10
20
30
40
Nematodes
Harpacticoids
1 2 3 4 5 6 7s 7i 8s 8i 9 10s 10i 11s 11i 12s 12i 13s 13i 14 15 16 17 18 19s 19i 20 21 22
Sampling Station

Figure 3. Total numbers of nematode and harpacticoid copepod species observed in the Thames Estuary, October - December 1989.



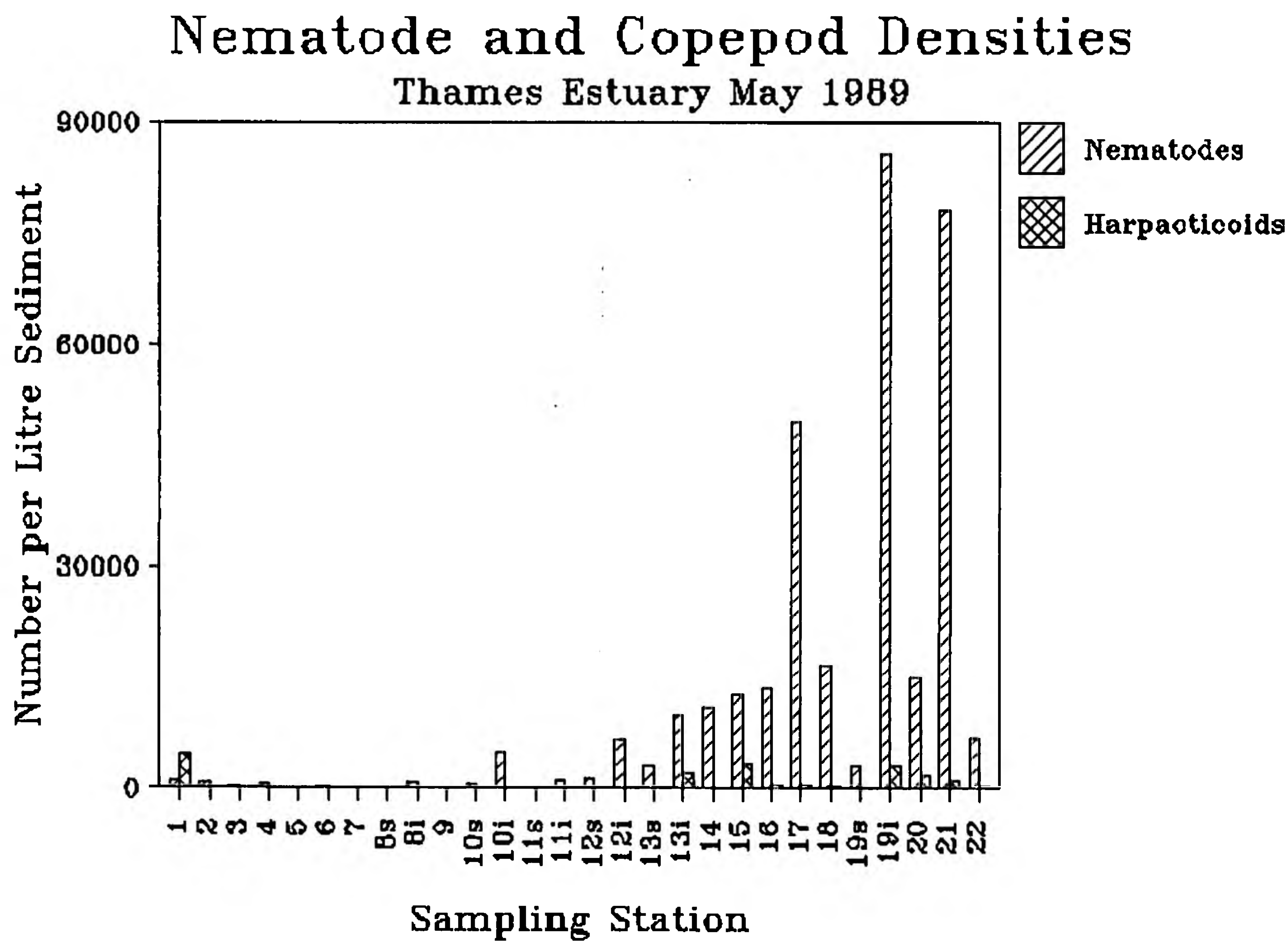
Nematode & Harpacticoid Copepod Species
Thames Estuary December 1989
Number of Species
0
10
20
30
40
Nematodes
Harpacticoids
1 2 3 4 5 6 7s 7i 8s 8i 9 10s 10i 11s 11i 12s 12i 13s 13i 14 15 16 17 18 19s 19i 20 21 22
Sampling Station

Figure 4. Total numbers of nematode and harpacticoid copepod species observed in the Thames Estuary, January - March 1990.



Nematode & Harpacticoid Copepod Species
Thames Estuary March 1990
Number of Species
0
10
20
30
40
50
Nematodes
Harpacticoids
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 5. Total densities of nematode and harpacticoid copepod species observed in the Thames Estuary, April - June 1989.



Nematode and Copepod Densities
Thames Estuary May 1989
Number per Litre Sediment
90000
60000
30000
0
Nematodes
Harpacticoids
1
2
3
4
5
6
7
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 6. Total densities of nematode and harpacticoid copepod species observed in the Thames Estuary, July - September 1989.

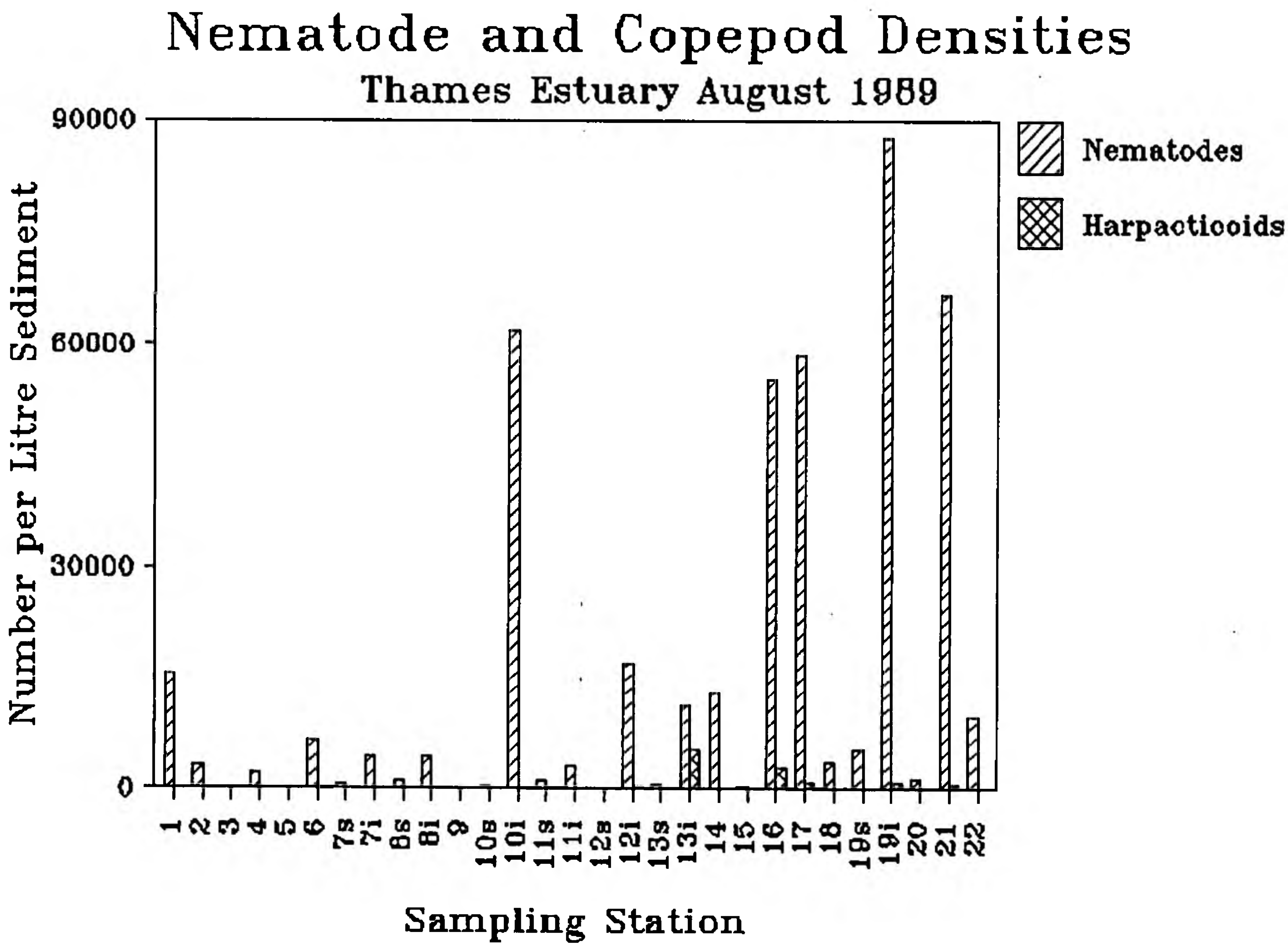
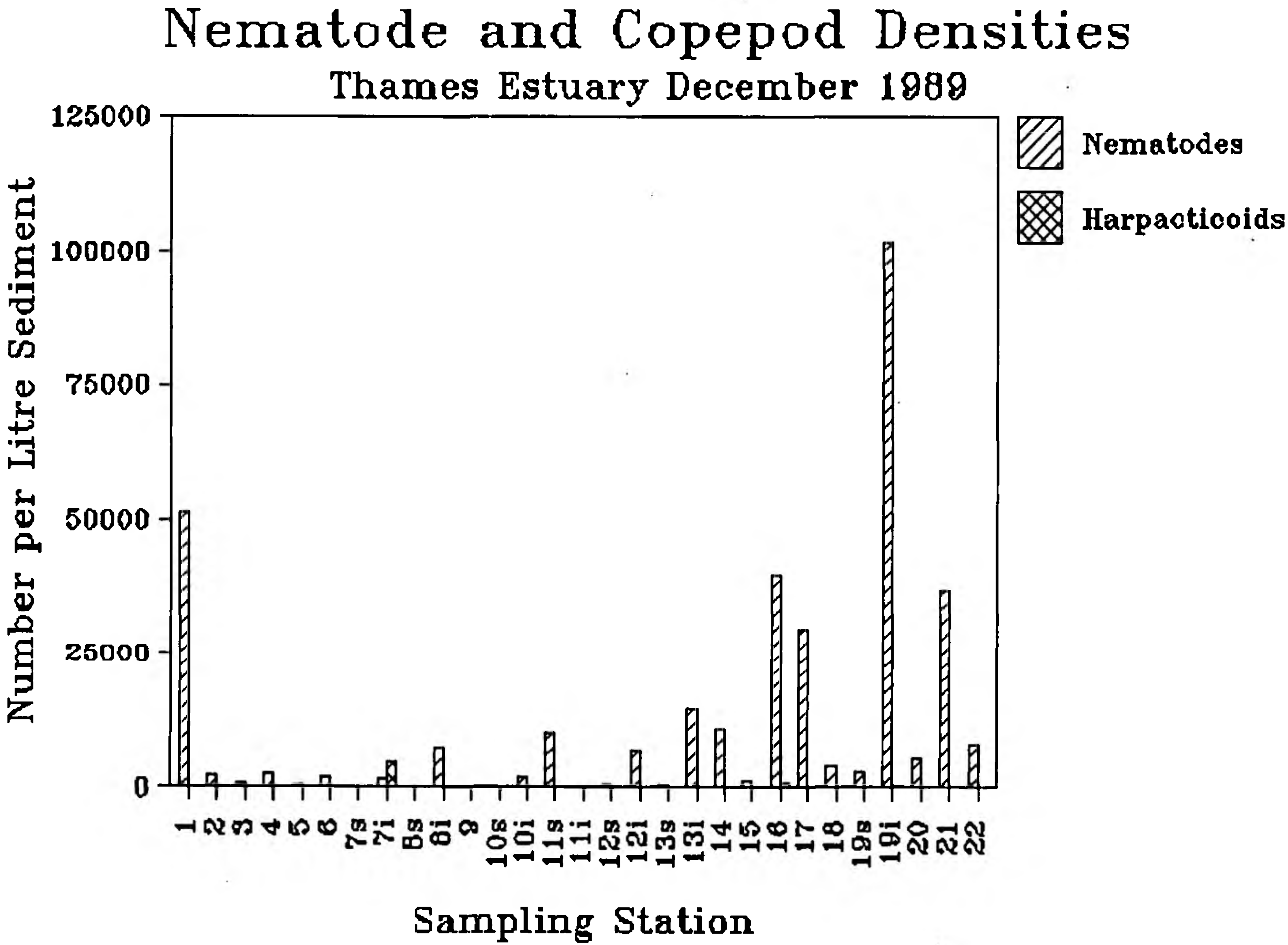

Nematode and Copepod Densities
Thames Estuary August 1989
Number per Litre Sediment
90000
60000
30000
0
Nematodes
Harpacticoids
1 2 3 4 5 6 7s 7i 8s 8i 9 10s 10i 11s 11i 12s 12i 13s 13i 14 15 16 17 18 19s 19i 20 21 22
Sampling Station

Figure 7. Total densities of nematode and harpacticoid copepod species observed in the Thames Estuary, October - December 1989.



Nematode and Copepod Densities
Thames Estuary December 1989
Number per Litre Sediment
125000
100000
75000
50000
25000
0
Nematodes
Harpacticoids
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 8. Total densities of nematode and harpacticoid copepod species observed in the Thames Estuary, January - March 1990.

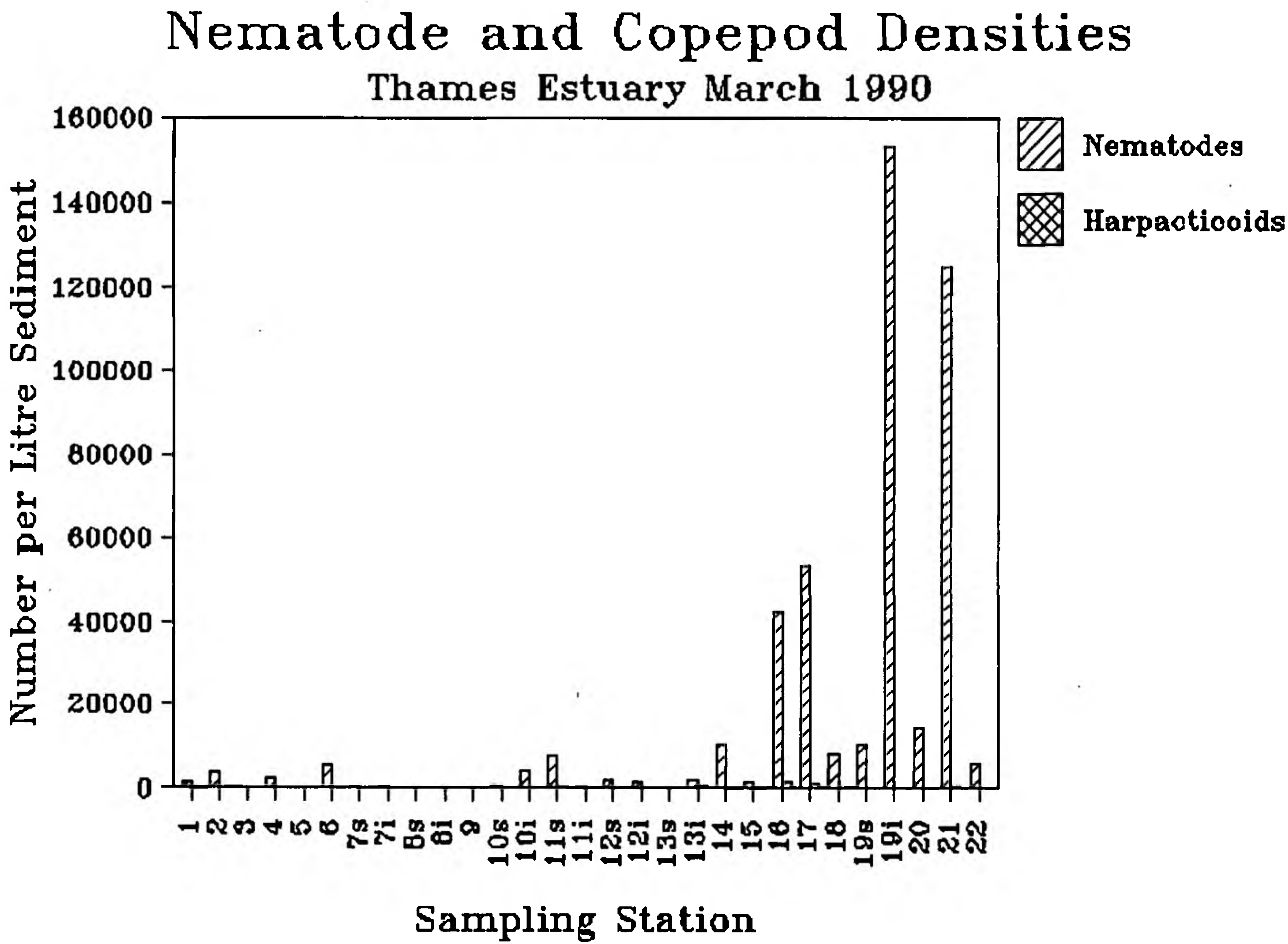
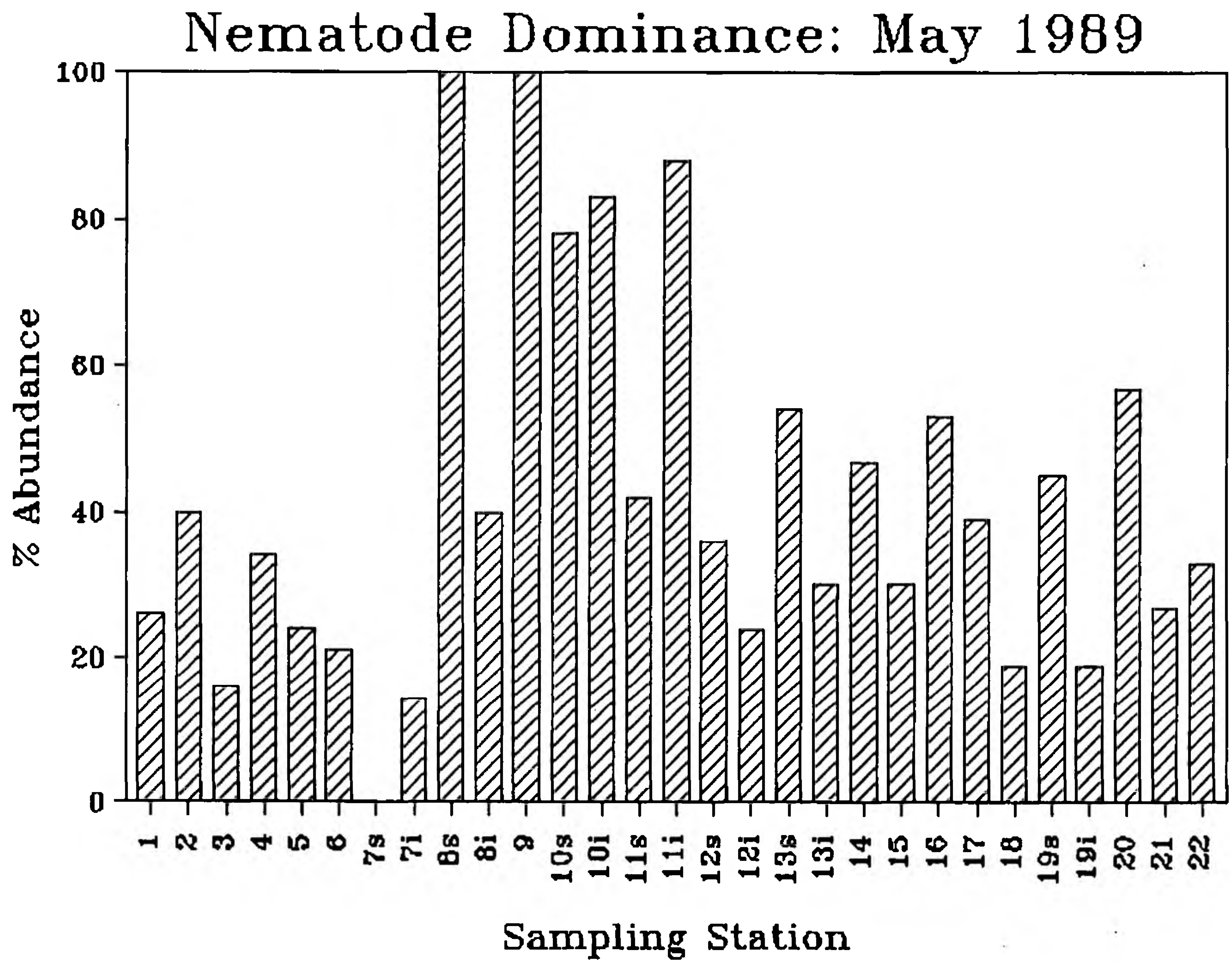
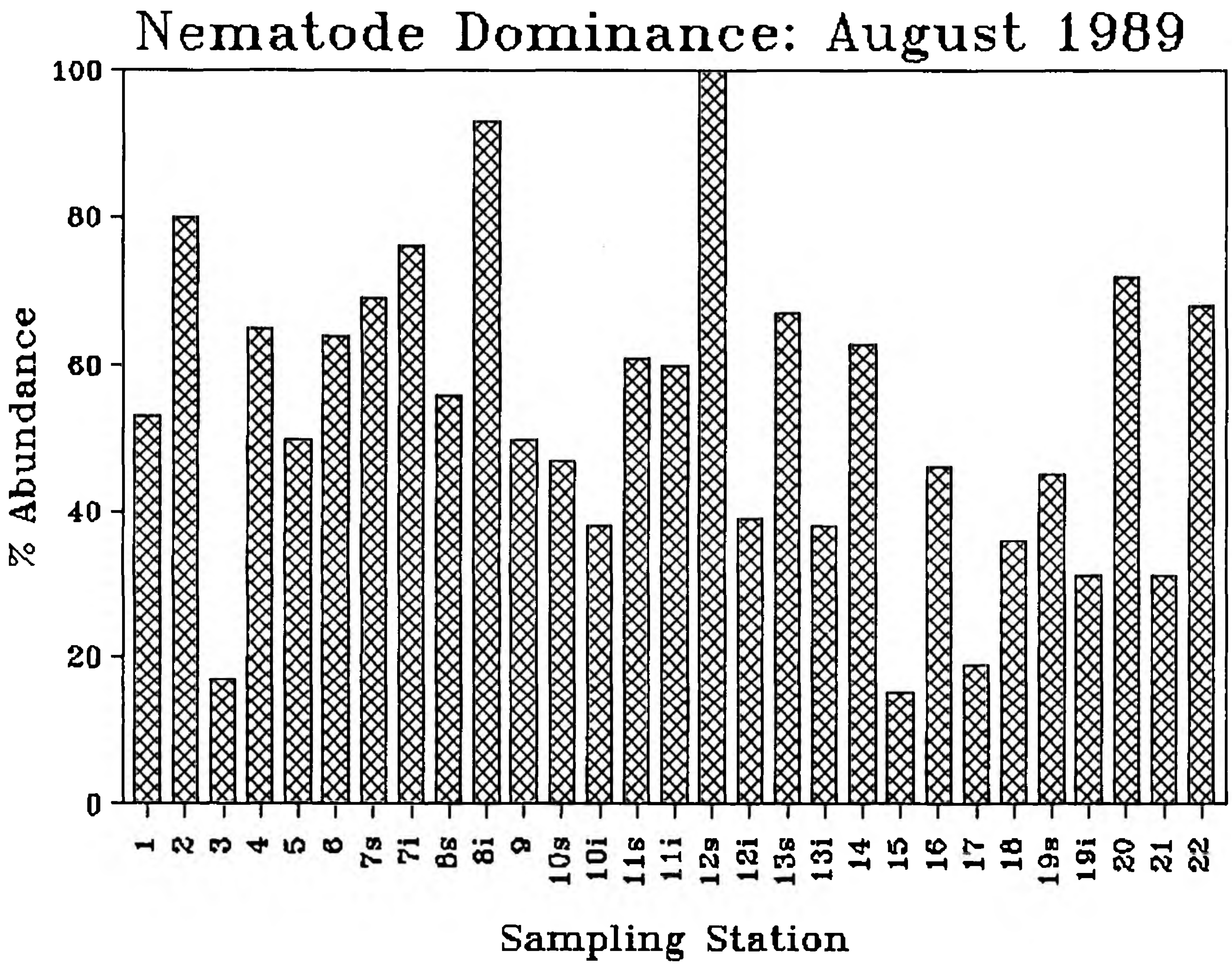

Nematode and Copepod Densities
Thames Estuary March 1990
Number per Litre Sediment
160000
140000
120000
100000
80000
60000
40000
20000
0
Nematodes
Harpacticoids
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 9. Maximum observed dominance in nematode assemblages, Thames Estuary, April - June 1989.



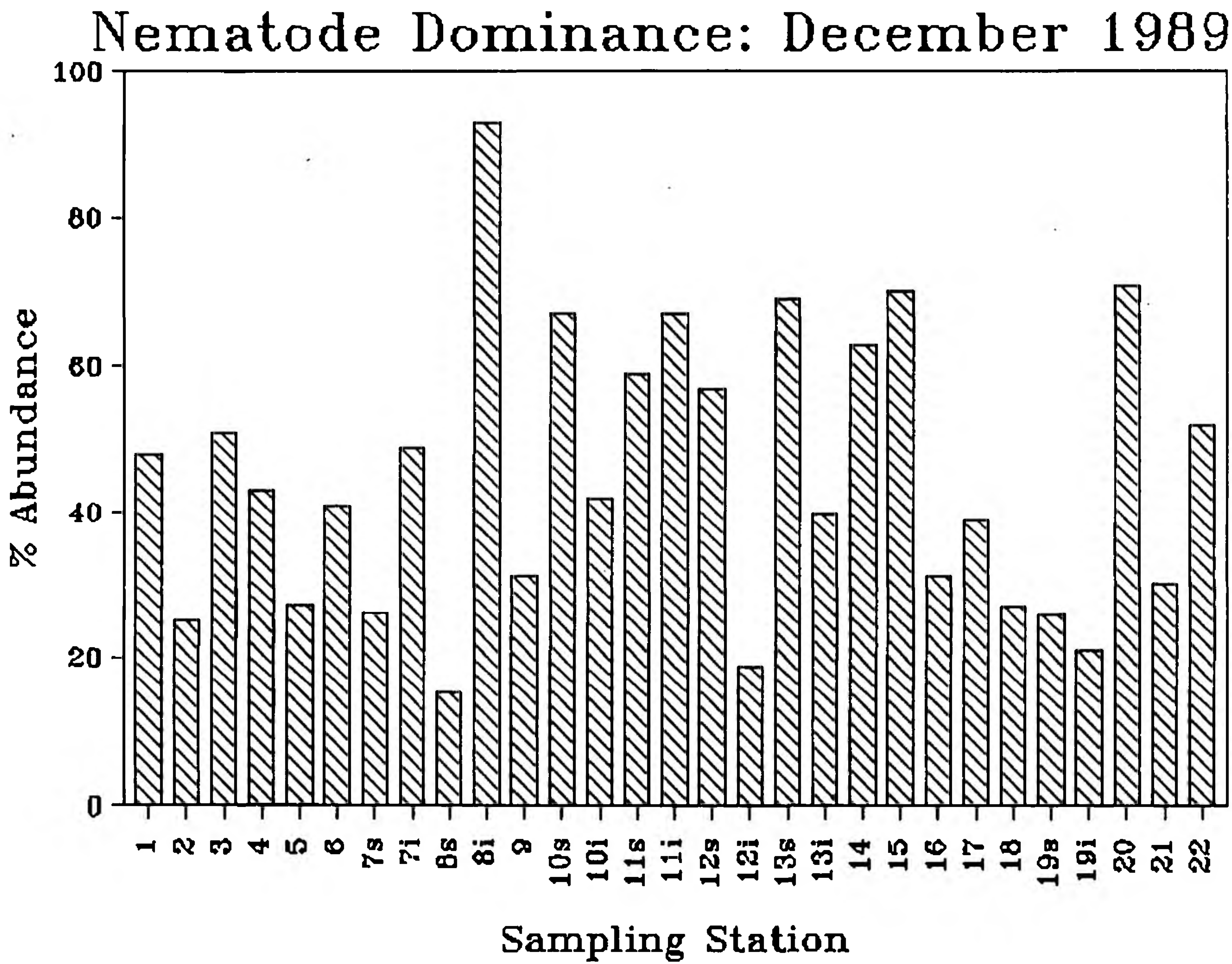
Nematode Dominance: May 1989
% Abundance
0
20
40
60
80
100
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 10. Maximum observed dominance in nematode assemblages, Thames Estuary, July - September 1989.



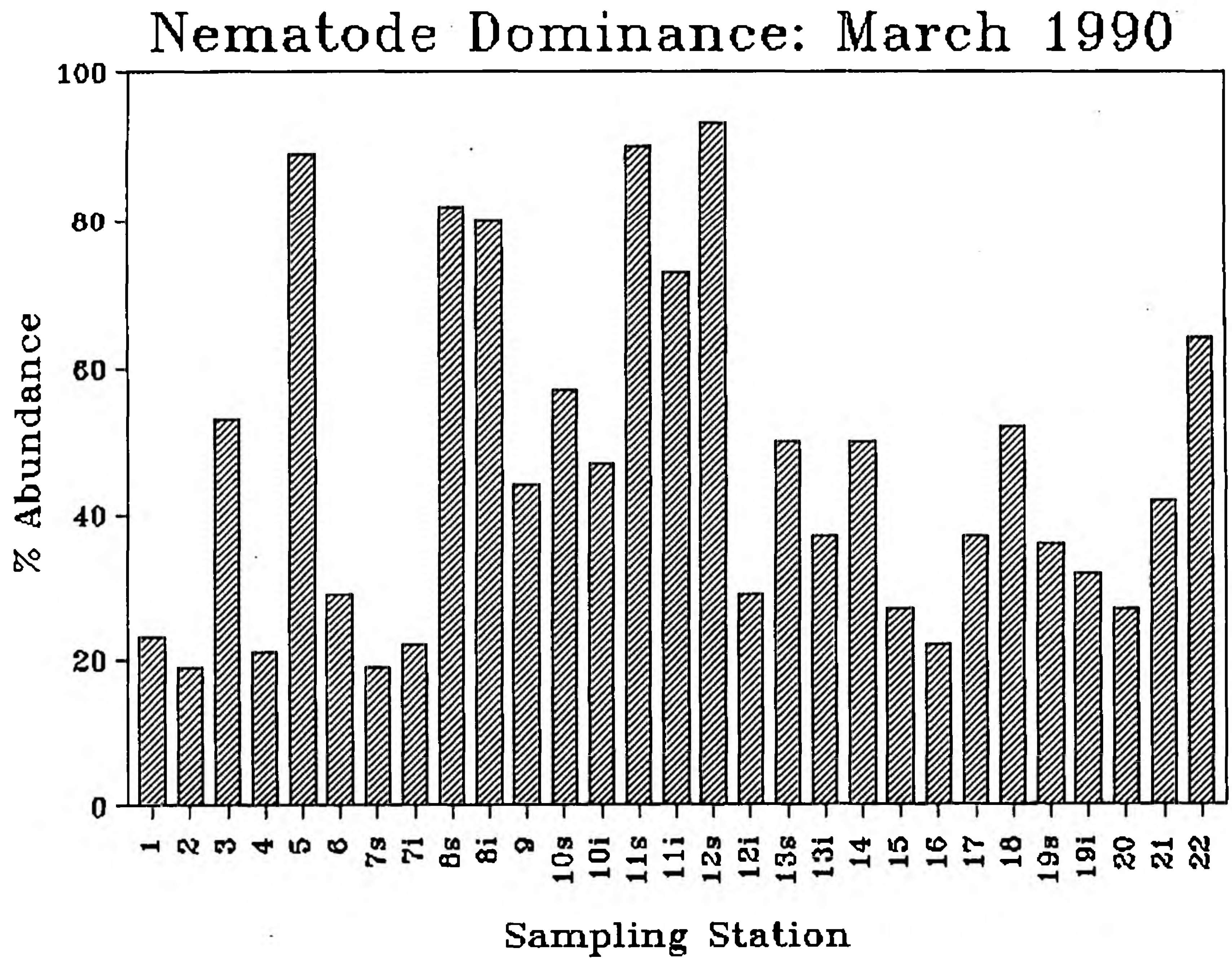
Nematode Dominance: August 1989
% Abundance
100
80
60
40
20
0
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 11. Maximum observed dominance in nematode assemblages, Thames Estuary, October - December 1989.



Nematode Dominance: December 1989
% Abundance
0
20
40
60
80
100
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 12. Maximum observed dominance in nematode assemblages, Thames Estuary, January - March 1989.


Nematode Dominance: March 1990
% Abundance
0
20
40
60
80
100
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

The Meiofaunal Assemblages of the Thames Estuary

April 1989 - March 1990

Module III

An Assessment of the Impact of Lowflow and Mechanical Disturbance on the Thames Estuary as Revealed by its Meiofaunal Assemblages

by

M.W. Trett[1,2] B.Sc., Ph.D., F.L.S.

and

R.L. Feil[1] B.Sc., Ph.D., F.L.S.

in collaboration with

S.J. Forster[1] B.Sc., G.I.Biol.

[1] *Physalia Ltd.*, 76 - 80 Victoria Road, Great Yarmouth, Norfolk NR30 3AZ

[2] Centre for Research in Aquatic Biology, University of London, Mile End Road, London E1 4NS

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1. Summary

Examination of the meiofaunal species complements at the intertidal and subtidal sampling sites within the Estuary was used to assess the effects of reduced freshwater flow from the catchment and to detect the impacts of mechanical disturbance of sediments. Reduction in densities of stenohaline meiofaunal species, intolerant of elevated salinities, at the head of the Estuary was noted following the onset of the drought period (2nd. and 3rd. quarters, 1989). This was accompanied by an extended colonisation of upstream stations by more euryhaline, mid-estuary species and the ingression of true marine taxa into the outer Estuary.

Evidence of increased sedimentation and the deposition of finer particles, possibly as a result of reduced freshwater flow, was noted throughout the mid- and upper Estuary. This exerted a fundamental effect on the meiofaunal assemblages with increased dominance of non-selective detritivore species and reduction in species richness. The changes in these communities was also reflected in the nematode 1B:2A feeding type ratios; populations of type 2A, selective epigrowth and diatom feeding species declined with the increase in fine silt-clay fraction in the sediments. There was some suggestion of increased total meiofaunal densities within the Estuary during this period which, again, is usually associated with finer sediments. However, it was not possible to differentiate this effect reliably from natural seasonal variation in this particular study.

Examples of three different classes of modified meiofaunal community were suggested to indicate mechanically disturbed conditions in the Thames Estuary. These included muddy sediments with low densities of species, residual sands with low diversities of meiofauna and sandy sediments with exceptionally low meiofaunal densities. Cases are discussed from the upper, mid- and outer Estuary. In many cases these were accompanied by a change in granulometry from finer to coarser sediments.

Whilst nematode:copepod ratios have been discounted as useful indices of pollution stress, especially in differing sediment types (see Module II), the ratios were examined in connection with mechanical disturbance effects. The absence of harpacticoid copepods from several sites at different times of the year hindered an accurate assessment of the technique. However, a predominance of low nematode:copepod ratios at certain mid- and outer estuarine sites during the first survey followed by higher ratios in subsequent surveys is suggested to indicate mechanical disturbance. Whether this related to higher freshwater flows and stronger tidal scouring in the early part of the survey could not be determined.

2. The Value of Meiofauna in the Detection of Physical Changes

i. Physical Changes and their Associated Stresses

In the present section, physical changes are taken to include altered freshwater flow rates, caused by reduced rainfall and increased abstraction of water upstream of Teddington Lock, as well as mechanical disturbance resulting natural scouring of currents and from Man's activities.

The consequences of reducing freshwater inputs into an estuarine system are far reaching and undermine the fundamental processes of an estuary. Reducing freshwater inputs will have direct effects on stenohaline freshwater species as higher salinity waters will ingress further into the estuary. Densities of these species, intolerant of the osmotic stress created by the higher salinity water, will be reduced and their distribution patterns downstream severely modified. Euryhaline species, characteristic of mid-estuarine reaches, are also directly dependent on the continuity of freshwater entering the head of the estuary. Although capable of tolerating higher salinities, their ability to survive in a given habitat may be reduced as they are out-competed by other, less euryhaline species that migrate in from the marine environment. A more direct effect on specialist feeders might be the disappearance of preferred food substrates such as single species of algae.

The oxygen carrying capacity of freshwater, at a given temperature, is higher than saline waters. At 5 °C, for example, freshwater saturated with air holds approximately 13 ppm oxygen. Full strength seawater (salinity ca. 35 ppt) at the same temperature will hold less than 10 ppm oxygen. In an estuary, such as the Thames, these seemingly small differences may be critical, especially where low oxygen tension storm waters and sewage effluents are discharged to the tideway. Species within the estuary will exhibit different tolerances to low oxygen tensions and the more sensitive species will be eliminated if deoxygenated waters are repeatedly backed up into fresher water reaches.

A further consequence of reduced freshwater flows will be altered sedimentation and deposition patterns within the estuary. Sedimentation rates in fresh and saline waters differ. Silt has a mean specific gravity of 2.65 and a given diameter particle would normally sink more slowly in seawater than freshwater. However, clumping of silt particles in saline water results in a "salting out" type process. The relative position of the zone of mixing is therefore one factor that determines silt deposition. Another relates to the fact that finer silt particles are also re-suspended on spring tides and carried seaward on the ebb. These are then transported back into the estuary and re-deposited on the surface of lower energy shores or banks. In low flow conditions this may occur further into the estuary than normal. The erosion and accretion of finer particulate sediments over a period of one or two months can severely affect the populations of estuarine species with life cycles that exceed this length of time.

This consequence of reduced freshwater flow is not unrelated to mechanical disturbance and scouring. Where artificial re-suspension of finer sediments occurs this can lead to smothering of coarse sediment benthic communities at more distant sites. It can, of course, have catastrophic effects on the assemblages of species present in the disturbed sediments. This is commonly seen where dredging activity has occurred. A further consequence of mechanical disturbance may be the disturbance of reduced toxic materials from deeper within sediments. Depending on currents, these materials can exert effects on organisms at considerable distances from the site of the original disturbance.

ii. Meiofauna as Indicators of Physical Disturbances

As sensitive indicators of prevailing environmental conditions (see Module II), the composition, dominance-diversity characteristics and trophic structure of meiofaunal communities can be used directly to assess changes in physical conditions. Specific meiofaunal groups are associated with freshwater ecosystems and many are intolerant of elevated salinities. Successions of euryhaline estuarine species mediate between the freshwater communities and those of marine species in the outer estuary. The differing biologies and physiologies of each species in each these groups, combined with their high densities and diversities, provide a potentially sensitive method for the assessment of changes in the salinity that might be expected to occur within the estuary under conditions of reduced freshwater flow.

Mechanical disturbance can exert several different effects on meiofaunal communities. Where disturbance leads to a change in the granulometry of sediments, characteristic complements of species develop. In general, muds support comparatively few species at high densities whereas coarser grained sediments support lower numbers of individuals representing a larger number of species. Dominance is also usually higher in muddy sediments than in sands. Thus can be examined using k-dominance analyses. Changes also occur in the feeding guilds of species with larger numbers of specialist feeding types occurring in coarser grained sediments than in muds (see Appendix I, Module IV). In this way, it is possible to monitor physical changes that result in even the subtlest changes in sediment particle size distributions.

The nematode:copepod ratio has also proved to be of some use in the detection of mechanically disturbed sediments, although its value as a means of determining pollution status has been largely undermined (see Module II). Studies of marine sediments (Trett and Feil, pers. obsvn.) have indicated that the more mobile epibenthic harpacticoid copepods re-colonise disturbed sediments more readily than nematodes. Consequently, low nematode:copepod ratios in comparison to assemblages in similar sediment types can provide an indication of recent disturbance. This is especially true where dredging has occurred.

3. Reduced Freshwater Flow

This section deals with the direct effects on the meiobenthos of reduced freshwater input into the Thames Estuary from the catchment. Changes in granulometry of sediments within the Tideway that might result from low freshwater flow and altered sedimentation rates are considered in section 4, below, along with stability of sediments and the effects of mechanical disturbance.

i. Opportunistic Species

With reduction in the flushing rate of the upper Thames Estuary associated with the onset of low freshwater flow conditions, the potential for influence of brackish waters at the head of the Estuary is increased. This can exert profound effects on populations of stenohaline freshwater species, intolerant of increased salinities and enable more euryhaline, opportunist (r-selected) species to establish. Evidence for this can be seen in the meiofaunal assemblages. At the Teddington end of the estuary, meiofaunal species assemblages comprised freshwater species (see Module IV). Examination of these assemblages reveals changes in the complements present at each station during each of the surveys. The percentage faunal similarities (calculated using a presence:absence index; Jaccard) between the species present during each of the 4 surveys at the upstream stations are shown in the table below. At Teddington, similarity between consecutive surveys ranged from 23%, between the 1st. and 2nd. surveys, to 47%, between the 2nd. and 3rd.

	SURVEY				
	1st.	2nd.	3rd.	4th.	
Station:					Ref. No.
Teddington	23%	47%	30%		1
Kew	42%	45%	41%		2
Hammersmith B.	19%	8%	18%		3
Cadogan Pier	44%	18%	23%		4
South Bank C.	15%	11%	21%		5
London Bridge	13%	30%	35%		6
Greenwich	7%	41%	45%		7i

Table of Percentage Faunal Similarities Between Species Assemblages in Consecutive Surveys at Upstream Sampling Stations, Thames Estuary, April 1989 - March 1990.

Uniformly high similarity values existed between the meiofaunal assemblages observed at Kew suggesting more that conditions were more stable at this station over the year. However, communities at stations from Hammersmith Bridge to the South Bank Centre were much more variable in composition, exhibiting higher species turnover values. The meiofaunal communities present in the 2nd. and 3rd. surveys at Hammersmith Bridge, for example, showed a similarity of only 8%. If the species present during these surveys at Hammersmith are compared, it is seen that the 3rd. survey contained many more representatives of euryhaline estuarine species. Amongst the Nematoda, these opportunistic species included *Daptonema setosa*, *Leptolaimus* species, *Anoplostoma viviparum*, *Theristus* species and *Dichromadora geophila*. Higher salinity, outer estuarine species were also present including *Axonolaimus paraspinosus*, *Odontophora villoti* and *Daptonema furcata*. The same general effect can be seen between the 1st. and 2nd. surveys *but* the transition did not occur as dramatically and it is displaced downstream to between the South Bank Centre and London Bridge sampling stations. This is undoubtedly the direct effect of higher salinity waters extending further into the upper reaches of the estuary due to reduced flow and displacing stenohaline freshwater meiofaunal species. Beyond Greenwich other effects begin to appear that may relate to the reduced salinity centred around Beckton (9) and Crossness (10) sewage treatment works rather than reduced flow; in some instances there is evidence to suggest that the sewage treatment works may even stabilise the community structure but in a severely modified form (see Module II).

Evidence for the effects of reduced flow throughout the remainder of the estuary are difficult to separate from seasonal effects relating to increased population sizes of given species extending naturally into more marginal habitats. However, an example discussed in Module IV is worthy of note. This relates to the distribution of the *Sabatieria punctata* population (see Module IV, Section 4.1). The distribution charts show that this euryhaline species progressively extended its upstream range into the estuary from Woolwich (8) to Hammersmith Bridge (3). It did not retreat as might have been expected with the decline in its population densities. This again is seen as an effect of reduced freshwater flow favouring euryhaline species in the upper reaches of the estuary. In the outer estuary, evidence for the increased ingression of more marine species is contentious. Some examples of extended oxystominid distributions can be seen but the distributions of predominantly marine families such as the Desmodoridae extended into the estuary *less* during the presumed periods of low flow than at other times of the year. It might be postulated that this pollution sensitive group was responding not to increased salinity but to the increased concentrations of poorly mixed pollutants - however, there is no evidence to support this suggestion.

ii. Dominance and Species Richness

Further indications of stress that may relate to periods of reduced flow are seen in the increased maximum dominance that occurs in the nematode assemblages at stations between Teddington (1) and Greenwich intertidal (7i) observed during the second survey. These are illustrated in Module II, Figure 10. There is evidence to suggest that stressed nematodes assemblages exhibit increased dominance followed by reduced species complements before new, more stable communities establish (pers. obsvn.). In the present study, the increased dominance indicates that reduced freshwater flow may have exerted effects between July and September before the lowest faunal similarities were observed between species assemblages in the 2nd. and 3rd. surveys. This illustrates the potential value of dominance analyses in the early detection of stress that will ultimately lead to a change in species richness of meiobenthic communities and altered abundances. It also emphasises the sensitivity of the populations of individual species to changes in prevailing conditions. It is not possible to determine the seaward limit of the effects of reduced flow in the Thames Estuary; dominance at Woolwich (8) was high throughout the year, possibly as a result of the influence of the Beckton and Crossness sewage treatment works (see Module II). In this connection, there is no evidence to indicate whether the sphere of influence of the sewage works extended further into the estuary during the periods of low freshwater flow.

4. Stability of Sediments and Mechanical Disturbance

i. K- and r-selected Species

A broad spectrum of K- and r-selected species of meiofauna were recorded in the Thames Estuary over the year (see Module IV). The low densities and patchy distribution of the larger predatory and omnivorous nematode species (type 2B) were notable, especially amongst the order Enoplida (e.g. families Enoplidae, Thoracostomopsidae, Oncholaimidae and Enchelidiidae). Populations of these species are slow to establish and may take several years to reach equilibrium. Many species employ sticky eggshells and caudal cement glands to prevent displacement from the sediments. Where these groups were present, they were usually found in littoral muds and muddy sands and, in one case (Chapman Buoy (18)), in sublittoral sands. In each instance, the sediments that supported these species can be classified as "mechanically stable". Examples of this include intertidal sites at Gravesend (13i) and Southend (19i).

By default, sediments that do not support well established populations of these species might be classified as unstable. Indeed, in the Thames many of these sediments were colonised by populations of opportunist, r-selected species that have short life-cycles and produce large numbers of eggs/offspring. Amongst the Nematoda, these include members of the families Comesomatidae, Xyalidae and Monhysteridae that are predominantly non-specialist feeding types. Examples of stations at which this type of meiofaunal community have been observed include the South Bank Centre (5) and several of the subtidal stations in the outer estuary such as Grain Flats (20). These are discussed in more detail below.

ii. Dominance and Species Richness

In general, coarse grained sediments support higher numbers of meiofaunal species at lower densities than muds at equivalent salinities and vice versa. Mechanical disturbance caused, for example, by scouring currents will often reduce meiofaunal densities as finer sediment fractions are re-suspended and transported up or downstream. However, species richness may remain relatively unaffected by this process. Consequently, muds with low densities of meiofauna, residual sands with low diversities of meiofauna and sandy sediments with exceptionally low meiofaunal densities may all be indicative of recent mechanical disturbance. In the Thames Estuary there were examples of all of these categories. Throughout the year, for example, the sands at the South Bank Centre (5) supported lower numbers of meiofaunal species than might have been expected (see Module II and Module IV) and the subtidal muds at West Thurrock (12s) yielded one species of meiofauna at low density (<40 litre^{-1}) in the 2nd. survey and comparatively low densities of meiofauna in the following survey. The difficulty lies in determining whether these observations relate to pollution incidents or physical disturbance. The presence of certain more specialist species at the South Bank Centre might undermine the pollution explanation, adding strength to the mechanical disturbance hypothesis. Diatomivorous and microbivorous nematodes present at low densities at this site might not be expected to tolerate pollutants that would affect their food sources. A similar argument could be advanced for the species present at the subtidal site at West Thurrock during the 3rd. survey with *Monhystera* and *Leptolaimus* species (type 1A, microbivorous species) occurring at low densities. However, the observation of a single species, *S. punctata*, at low density in the previous survey is less easy to interpret.

Changes in sediment type were noted between consecutive surveys that might indicate mechanical activity and deposition. Grain Flats (20) is a good example of this (see Modules II and IV). The increased fine fractions in the sediments correlated directly with a decrease in meiofaunal species along the lines that would be predicted for an outer estuarine site. These changes were accompanied by an increase in dominance during the first 3 surveys (Module II, Figure 9 to 11). Elsewhere, changes in sediment types were also noted during the survey (see for example Cadogan Pier) which might relate to reduced flow (see also Module IV).

Meiofaunal dominance-diversity curves for stable communities examined at different times of the year exhibit a high degree of congruence. Once equilibrium is reached, the habitat will support a climax community consisting of a finite number of permanent species with a reduced turnover. This, in turn, reflects stability of the substrate. Examples of this were seen at the intertidal site at West Thurrock (12i), Allhallows (17) and Shoeburyness East (21).

iii. Nematode:Copepod Ratio

Whilst doubts have been raised concerning the value of nematode:copepod ratios in detecting pollution stress (Lambshead, 1984), they may be of some value in the detection of mechanically disturbed sediments (Trett and Feil, pers. obsvn.). Exceptionally low ratios can result where there has been an influx of mobile epibenthic harpacticoid copepods before nematode populations have been able to re-establish. The failure to observe copepods at certain stations was a serious drawback to this approach. However, the lowest ratios (those less than 10.0) are given in the table below.

The values might indicate greater general instability of sediments during the early part of 1989, possibly linked to higher flow levels. However, this is more than a little conjectural. The value for Grain Flats is of some interest given the discussions above. The lowest ratio observed (Greenwich intertidal, 3rd. survey) reflects an exceptionally high density of harpacticoids present during this survey - epibenthic species dominated by a *Microarthridion* species. However, there is little evidence to support the suggestion that this habitat had been physically disturbed. Indeed, considerably lower densities of nematodes were observed in the 1st. and last surveys at this site than in the 3rd. survey. Unfortunately, copepods were not observed at The South Bank Centre throughout the year or at the subtidal West Thurrock site during the 2nd. and 3rd. surveys preventing comparison of the nematode:copepod ratios with sites for which some evidence for disturbance might already exist.

	SURVEY			
	1st.	2nd.	3rd.	4th.
Station:				
London Bridge	6.8			
Greenwich (i)			0.3	
Woolwich (i)				2.9
Gravesend (s)				1.6
Gravesend (i)	4.6			3.7
Blythe Sands	3.8			
Grain Flats	7.9			

Table of lowest (<10.0) nematode:copepod ratios observed in the Thames Estuary, April 1989 - March 1990. (s - subtidal site; i - intertidal).

In summary, the nematode:copepod ratio probably provides less information about the stability of sediments in the Thames Estuary than meiofaunal similarity studies owing principally to the patchy occurrence of harpacticoids and their low densities. On the basis of faunal similarities, higher salinity sites such as Purfleet (13) become of interest where 0% similarity exists between certain consecutive meiofaunal surveys (3rd. and 4th. surveys, station 11i). Copepods were also absent from the muds at this site during the 3rd. survey.

5. Future Studies

A particular area of interest is the extent to which seasonally expanding populations of marine species of meiofauna will penetrate into the Thames Estuary under normal conditions of freshwater flow. This may be difficult to assess with trends towards drier summer months and ever increasing demands on water supplies in the Thames catchment. A sampling programme along the lines of that undertaken in the present study would provide valuable information about this aspect of estuarine recruitment if rainfall in future summers was sufficiently different from that of 1989. In terms of mechanical disturbance, increased freshwater flow during the winter months might increase the scouring action of tides on the ebb. Examination of changes in subtidal meiobenthic communities could confirm this and add considerably to our understanding of the dynamics of meiofaunal populations in estuarine systems. Attention might also be focused on sites at which constructional activity affects the Tideway. In such instances, it would be of interest to determine whether disturbance of toxic materials, formerly buried in sediments, exerted direct effects on meiofaunal communities that could be detected and monitored. Dredging activities in Dutch estuaries have already been implicated in this type of impact on macro- and meiofaunal assemblages (Trett, pers. obsvn.).

THE MEIOFAUNAL ASSEMBLAGES

OF THE THAMES ESTUARY

April 1989 - March 1990

Module IV

by

M.W. Trett[1,2] B.Sc., Ph.D., F.L.S.

and

R.L. Feil[1] B.Sc., Ph.D., F.L.S.

in collaboration with

S.J. Forster[1] B.Sc., G.I.Biol.

[1] *Physalia Ltd.*, **76 - 80 Victoria Road, Great Yarmouth, Norfolk NR30 3AZ**

[2] **Centre for Research in Aquatic Biology, University of London, Mile End Road, London E1 4NS**

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1. Summary

Meiofauna was examined by staff at *Physalia Ltd.* in 28 sediment samples collected by the National Rivers Authority, Thames Region, from 22 intertidal and subtidal sites in the Thames Estuary. Samples were collected in the second, third and fourth quarters of 1989 and the first quarter of 1990. From east to west, the sites sampled were located at Teddington, Kew, Hammersmith Bridge, Cadogan Pier, The South Bank Centre, London Bridge, Greenwich, Woolwich, Beckton and Crossness sewage treatment works, Purfleet, West Thurrock, Gravesend, Mucking, Blythe Sands, Canvey Beach, Allhallows, Chapman Buoy, Southend, Grain Flats, Shoeburyness East and Sea Reach Number 2 Buoy. The principal meiofaunal groups present were nematodes, harpacticoid copepods and aquatic mites. Other meiofaunal groups were present at lower densities. Nematoda dominated all the assemblages examined. In total, 207 nematode taxa from 43 families were observed, although not all were present in any one survey. Total densities of nematodes ranged from 8 litre^{-1} sediment at Beckton during the second quarter of 1989 to over 153,000 litre^{-1} sediment at the Southend intertidal sampling site in the first quarter of 1990.

A total of 18 harpacticoid copepod taxa representing 12 families were observed. These were most abundant at the Greenwich intertidal site during the last quarter 1989 where 4,549 litre $^{-1}$ sediment were recorded. Although present throughout the estuary, copepods were not observed at several of the stations examined. Acari were represented by 6 taxa sparsely distributed throughout the Estuary. These comprised bdellid, oribatid, hydracarine and halacarid species. The highest densities observed were 44 litre^{-1} at the Crossness intertidal site in the 4th. quarter 1989.

The other meiofaunal groups observed included rhizopod amoebae, larger ciliated Protozoa, Kinorhyncha (*Pycnophyes* species), Gastrotricha (?*Chaetonotus* species), Tardigrada (*Macrobiotus dispar* and *Batillipes mirus*), planispiral and multilocular Foraminifera (e.g. *Elphidium* and *Braziliana* species) and several species of Turbellaria, Gnathostomulida and Ostracoda. The occurrence and distribution of representatives of several non-meiofauna groups also present in the sediment samples are also described. These include nemerteans, rotifers, annelids, molluscs, Crustacea and larval Diptera (principally Chironomidae).

The high diversity of the meiofauna reported is unique amongst British estuarine studies and appears to reflect the large range of habitats encompassed by the sampling programme. In general, meiofaunal densities and species richness conform to those described for macrofaunal species with diverse, high density assemblages occurring towards each end of the estuary. High species richness correlated well with the higher salinity sites and those with heterogeneous, coarse grained sediments. Lower meiofaunal species richness and high densities were largely associated with the finer grained or high silt/clay fraction sediments.

2. Introduction

Meiofauna are sediment-dwelling species that measure, in general, less than 1 mm in length. They are of fundamental importance in aquatic ecosystems forming food for macrofaunal invertebrates, fish and possibly certain avifauna (e.g. waders). They offer many distinct advantages in the study of prevailing environmental conditions. Unlike other animals, the less mobile meiofauna are subjected continuously to the effects and constraints of any "foreign" materials that enter their environment and this is reflected in the composition of their communities (Newell *et al.*, 1990a and b). Being nearer to the base of food webs than macrofaunal organisms and having shorter generation times, meiofauna respond more rapidly to changes in the quality and nature of their food supply. This can be used to provide early indications of improved or worsening conditions.

In addition to their sensitivity to environmental changes, meiofauna comprise exceptionally diverse groups, such as the Nematoda ("roundworms"). Combined with their high densities, this high diversity makes statistically valid sampling easier than with macrofaunal organisms and, in the case of point source discharges, greatly improves the resolution of studies aimed at detecting impact zones. This has proved to be a valuable tool for monitoring the improvements in the quality of effluents (Trett *et al.*, 1990; Newell *et al.*, 1990a and b) and has been employed by several industries and authorities as part of their environmental audit programme.

The disadvantages of using meiofauna in the assessment of prevailing environmental conditions is the requirement for expert taxonomists skilled in the identification of "difficult" groups such as the Nematoda, harpacticoid Copepoda and halacarid Acari. This has been overcome by organisations such as *Physalia* who provide routine meiofaunal services to environmental consultancies, authorities and industrial concerns throughout the world.

The aim of the survey reported here is to complement the existing Thames Estuary Benthic Programme undertaken by the National Rivers Authority (Thames Region) (see Attrill, 1990a and b). A further aim was to critically evaluate the use of meiofaunal studies in the examination of conditions in the Thames Estuary with especial attention to the pollution status and the possible effects of reduced freshwater flow resulting from the drought period. These aspects are reported elsewhere. Staff at *Physalia* were were retained through the Centre for Research in Aquatic Biology, University of London, by the National Rivers Authority, Thames Region (NRA) to examine the meiofaunal assemblages present in 4 sets of sediment samples collected over a period of one year from the Thames Estuary. This module describes the methods used and discusses the meiofaunal assemblages observed. Samples were collected from Teddington to Shoeburyness between April 1989 and March 1990 by NRA staff. Further details of the sites sampled are given in the NRA reports (Attrill, 1990a; 1990b).

3. Materials and Methods

120 - 200 ml subsamples were taken by staff at *Physalia* from formalin-fixed sediments collected by NRA from 29 sites at 22 sampling stations in the Thames Estuary (Figure 1). Initial separation was carried out using a modified Boisseau apparatus (after Macintyre and Warwick, 1984) and fractions collected at increasing water velocities onto 38, 50, 75, 100 and 150 μm sieves immersed in flowing tapwater (see Flegg and Hooper, 1970). Pooled meiofauna/silt-clay fractions for each sample were further separated using density separation techniques and meiofauna collected onto 38 μm sieves. Residual materials were examined to confirm complete elution of infauna. Harpacticoid and calanoid copepods were removed by hand using mounted needles and dissected for identification by means of 5th. limb setotaxy. Acari were also removed at this stage and mounted in polyvinyl lactophenol. After clearing (approximately 3 days at room temperature) specimens were identificed and enumerated.

Remaining fauna, principally Nematoda, was processed to glycerol using the Seinhorst method (Seinhorst, 1959) at 40°C in a vacuum oven and mounted on slides for identification and enumeration. All microscopic examination was carried out using Zeiss Nomarski and Nikon differential interference contrast microscopes (DIC). For Nematoda, the first 100 specimens encountered in a standardised "box scan" (excluding unidentified specimens) were identified and counted. The presence of other nematode species observed during subsequent counting (consequently accounting for less than 1% of the nematode population) was also recorded.

Where necessary, identification of species was confirmed by comparison with the meiofaunal reference and specimen collection maintained by taxonomists at *Physalia.* Accurate drawings and morphometric measurements were made for each unidentified species within a genus or, rarely, family to maintain continuity between surveys; essential should subsequent multivariate analyses of species assemblages be required. Data were transformed to numbers of individuals per species per litre sediment sampled enabling direct comparisons to be made between stations and surveys.

Particle size determinations were performed by dry sieving techniques as described by Buchanan (1984) using standard phi range sieves (Endecotts Ltd.) between 2 mm (phi = -1) to 63 μm (phi = +4) and a dry bed shaker.

Figure 1. Location map to show positions of 22 principal sampling stations in the Thames Estuary meiofaunal survey, April 1989 - March 1990.

In the order Monhysterida, *Sphaerolaimus gracilis* and *Desmolaimus zeelandicus* are both typical of lower salinity habitats and, as in the example above, are progressively replaced by other, closely related species towards the mouth of the estuary. Although said to be a non-selective deposit feeder (type 1B species) by some authors, *D. zeelandicus* may feed selectively on diatoms (pers. obsvn.). *S. gracilis* is a type 2B species and specimens were seen in the process of ingesting juvenile *Sabatieria* species (?*S. punctata*). Little is known of the behaviour used by this group of nematodes to capture prey and almost nothing is known of the dynamics of nematode predator-prey interactions. This emphasises the need for further study of the biology of aquatic Nematoda. In samples from the seaward end of the estuary, the more euryhaline *Sphaerolaimus balticus* was also present.

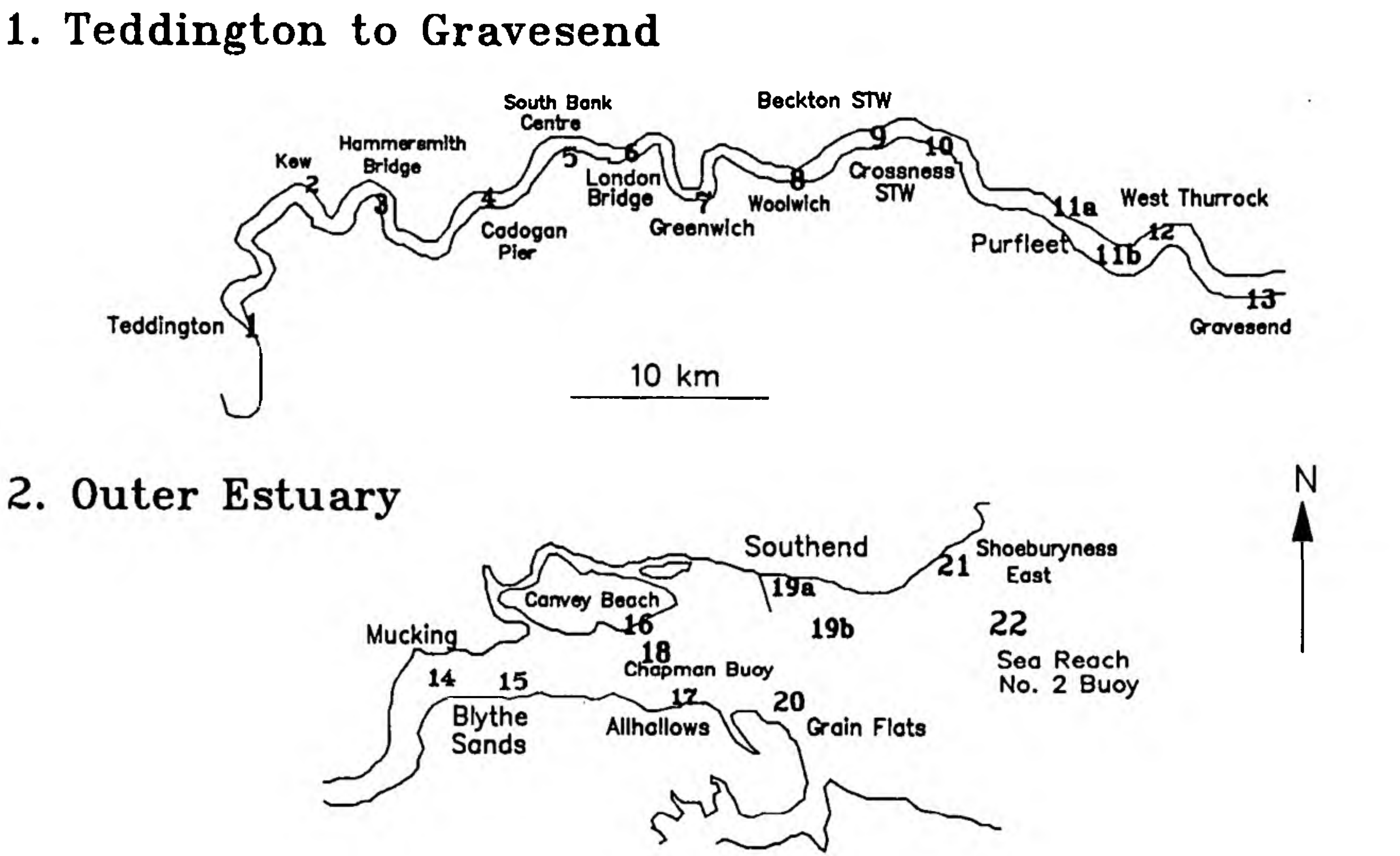
With the exception of a few almost ubiquitous species (e.g. *Daptonema setosa*), the bulk of the nematodes seen in the mid-estuary sediments are euryhaline 'marine' species at the extremes of their ranges. The distributions of these species represent realised niches as opposed to their preferred niches reflecting resource competition. The result is a typical estuarine gradation with extended species overlaps in areas of suitable sediment types (see Green, 1968).

An interesting example of species distribution is given by *Sabatieria punctata*. This type 1B species is an exceptionally common comesomatid in British estuaries where it can occur at extremely high densities (up to 25,488 litre^{-1} sediment were recorded intertidally in the Tees Estuary in 1988; Trett in Newell *et al.*, 1989b). It is also has a widespread occurrence at lower densities in full marine sublittoral habitats. In the present study, densities of *S. punctata* increased over the summer months reaching a maximum of 24,757 litre^{-1} sediment at Canvey Beach (16) between July and September (Appendix I; Section 2). Mean densities then declined with the onset of autumn but remained above the pre-survey levels recorded in the 1st. survey. Throughout, the muds at Canvey Beach retained the highest densities of *S. punctata* observed in the Thames. The distribution of the population also changed during the survey period. In the 1st. survey, *S. punctata* was confined to stations between Woolwich and Shoeburyness East with low densities occurring at each end of its range (Figure 2). In the 2nd. and 3rd. surveys, the population extended upstream to Greenwich (7) and the South Bank Centre (5), respectively (Figures 3 and 4). In the final survey, this range was extended still further, despite the decline in mean numbers, with a low density of *S. punctata* (<10 litre^{-1}) occurring at Hammersmith Bridge (3; Figure 5). This extended distribution coincided with a marked increase in densities of *S. punctata* at the subtidal site at Purfleet. These changes may have related to increased salinity in the upper reaches of the estuary and/or changes in sediment types resulting from reduced flow following the onset of drier weather.

ii. Harpacticoid Copepoda

The Thames Estuary supports a variable and diverse complement of harpacticoid Copepoda. Between April 1989 and March 1990 a total of 47 species of harpacticoid copepod were observed representing 12 families (see Appendix I; Section 1). Numerous unidentified copepodites (principally belonging to the family Diosaccidae) were also present

Figure 1.



Position of Thames Estuary Benthic Programme Sample Sites

4. Results and Discussion

I. General Observations

Samples ranged in granulometry from compacted clay muds and flocculant, high silt-clay fraction sediments to semi-clean sands. Sediment from Teddington, Kew and Cadogan Pier comprised muds with some large stones which made accurate sub-sampling difficult. The particle size distributions of sediments collected in the 4th. quarter 1989 are given in Appendix II. Sediments at either end of the estuary were predominantly coarse grained (usually sands with differing detritus contents). The middle reach sediments comprised mostly muds which were occassionally cohesive. There was some evidence for changes in the sediment types during the course of the survey, possibly as a result of changes in flow of the Thames during the drier summer months. This was most apparent at Cadogan Pier (4), Grain Flats (20) and Sea Reach No. 2 Buoy (22; see Section II below). With the exception of Kew (2), which contained a large proportion of macrophyte detritus, the organisms were separated cleanly from the sediments. Partially decomposed plant material is often of a similar density to the meiofauna and can hinder density gradient separation. However, in all cases, examination of residues showed that loss through inefficient separation was minimal. The biological material was well fixed and showed no signs of deterioration post-collection. "Oily" films were noticed in association with samples collected from Woolwich (8), Crossness (10s), Purfleet (11s) and Southend (19s).

a). Principal Meiofauna Groups

i. Nematoda

The Thames Estuary contains a rich assemblage of nematode species. In total, 207 nematode species belonging to 43 families were recorded in the sediment samples examined over the four surveys (see Appendix I; Section 1). The assemblages present at each station are discussed in detail in Section II below. The nematodes observed during the survey included species usually found in association with semi-terrestrial and freshwater habitats, brackish water species, true estuarine species and full marine species. The range of habitats encompassed in the survey means that the observed numbers of species is almost unique amongst the estuaries studied in Northern Europe (see for example, Capstick, 1959; Riemann, 1966; Warwick, 1971; Bouwman, 1983). In general, intertidal habitats yielded higher densities and diversity of nematodes than equivalent subtidal habitats (see Appendix I; Section 2). This was as expected. Similarly, with few exceptions, the high salinity sites towards the mouth of the Estuary supported larger numbers of species at higher densities than sediments collected further inland.

The Tylenchida and Dorylaimidae examined were all plant parasitic species commonly found in association with the root systems of plants. These frequently occur in freshwater sediments where the rhizosphere of marginal plants enters the littoral zone. Others are also known to feed on the tissues of freshwater euhydrophytes. In both groups, feeding is by means of a hollow stylet, the shape and size of which is of considerable taxonomic importance. These species, along with the microbivorous rhabditids, are often transported into more saline reaches of estuaries which may account for their sporadic occurrence at stations neighbouring freshwater inputs (e.g. *Rhabditis* species at Beckton sewage treatment works (9), second quarter 1989, and *Criconemoides* species at Mucking (14), second quarter 1989). With one exception, none is known to occur naturally in saline or marine conditions.

Several other freshwater species were observed. These include detritivores and diatomivorous species such as *Plectus granulosus*, *Cryptonchus* species, *Prismatolaimus ?verrucosus*, *Tobrilus gracilis*, *Tripyla affinis*, *Monhystera stagnalis* and the *Mononchoides* species as well as the predatory or omnivorous species *Ironus ignavus*, *Mononchus aquaticus* and members of the family Diplogasteridae (see Appendix I; Section 5). The above species are typical of the upper, low salinity reaches of estuaries supplied by rivers from mixed chalk and acid catchments and occur throughout the south east of England and East Anglia (Trett, pers. obsvn.). From a biological standpoint, it would be of interest to know how closely these reflect the relative abundances of these species in the freshwater reaches of the Thames immediately upstream of Teddington and at sites further inland.

Low salinity and estuarine nematode species were well represented; again the species were typical of estuaries of southern England (Warwick, 1971; see also Capstick, 1959). Amongst the Enoplida, the larger predatory species, *Adoncholaimus thalassophygas* and its less common relative, *A. fuscus*, are archetypal estuarine nematodes and are commonly found in low salinity littoral sediments. These are type 2B species (see Appendix I; Section 5) with a large buccal cavity armed with three teeth of differing sizes. Along with many other species belonging to the family Oncholaimidae, thay are probably K-strategists with populations taking several years to establish fully. *Anoplostoma viviparum* has been recorded from several estuaries in Britain (Platt and Warwick, 1983; Trett, pers. obsvn.), mostly from intertidal sites, although this might reflect the ease of sampling of these localities rather than preferred habitats. In the present survey, whilst highest densities of *A. viviparum* were recorded at intertidal sites, specimens were found in subtidal samples. *A. viviparum* is a type 1B species (see Appendix I; Section 5) and possesses a large unarmed buccal cavity. As such, it is held to be a non-selective detritivore although Thun (reported in Bouwman, 1983) suggests that they feed selectively on Protozoa.

Amongst the Chromadorida, estuarine/low salinity species include *Dichromadora geophila*. This species was largely replaced by another estuarine species in the same genus, *Dichromadora cephalata*, towards the mouth of the estuary. The latter is usually found in higher salinity habitats whereas *D. geophila* is capable of exploiting exceptionally low salinity conditions including barely brackish pools. Both are type 2A species (see Appendix I; Section 5) and are either diatomivorous or selective epigrowth feeders browsing microflora from the surfaces of sand grains. Densities of *D. geophila* were generally low (ca. 100 litre^{-1}). However, exceptional densities were occasionally observed (e.g. 28,732 litre^{-1} at the intertidal Crossness sewage treatment works sampling site (10i), 3rd. quarter 1989. The species was also uniformly distributed thoughout the upper estuary sampling sites. In contrast, densities of *D. cephalata* were more variable, ranging from 9 litre^{-1} (3rd quarter 1989; Gravesend subtidal site (13s)) to 8,932 litre^{-1} (4th. quarter 1989; Canvey Beach (16)). This is in keeping with observations made in other European estuaries (Trett pers. obsvn; see also Riemann, 1966; Bouwman, 1983; Warwick, 1971; Newell *et al.*, 1989a).

Figure 2. The percentage distribution of the population of *Sabatieria punctata* in the Thames Estuary, April - June 1989. Arrow denotes furthest upstream station at which *S. punctata* was observed.

Densities of Sabatieria punctata

Thames Estuary April–June 1989

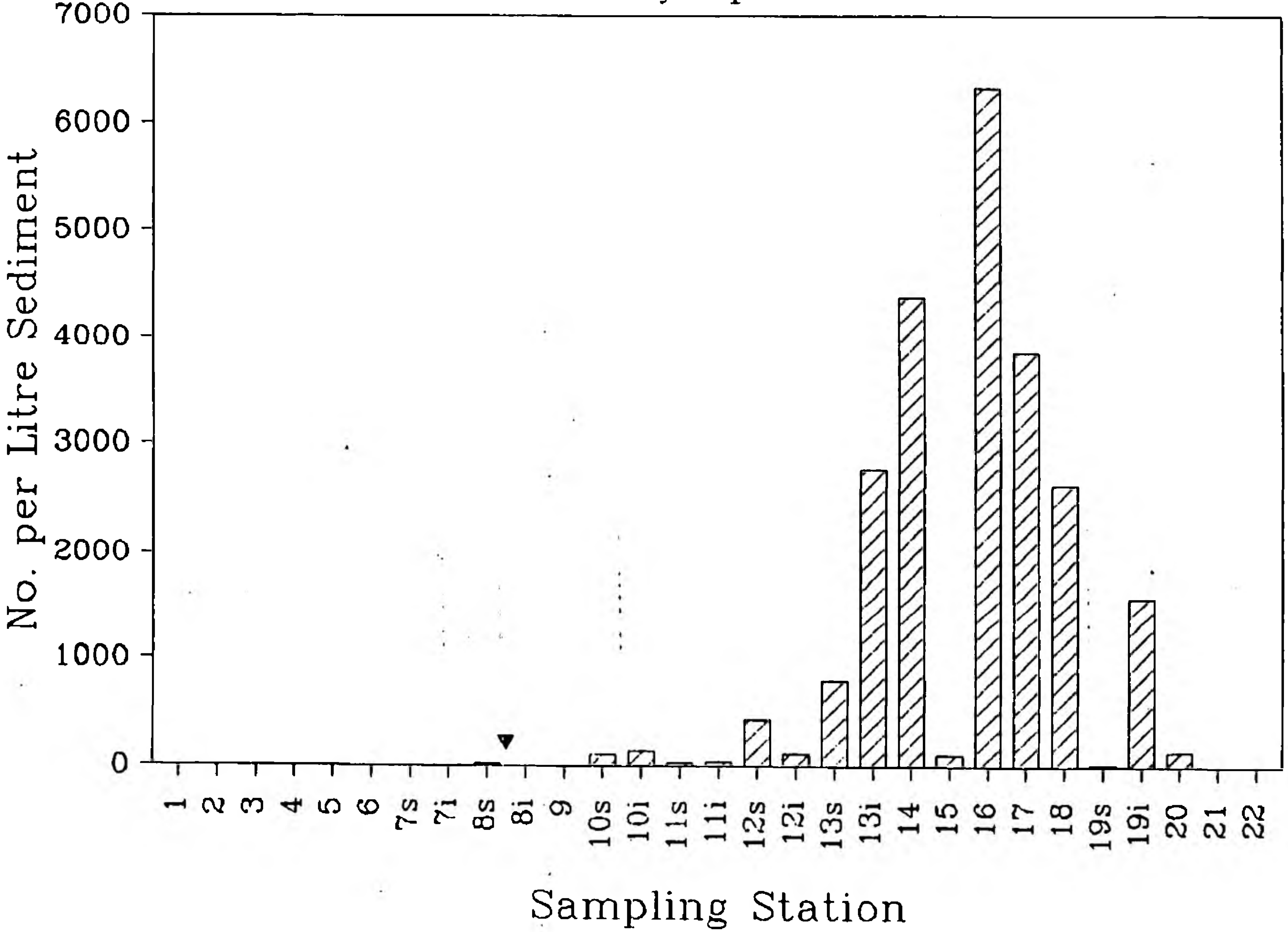


Figure 3. The percentage distribution of the population of *Sabatieria punctata* in the Thames Estuary, July - September 1989. Arrow denotes furthest upstream station at which *S. punctata* was observed.

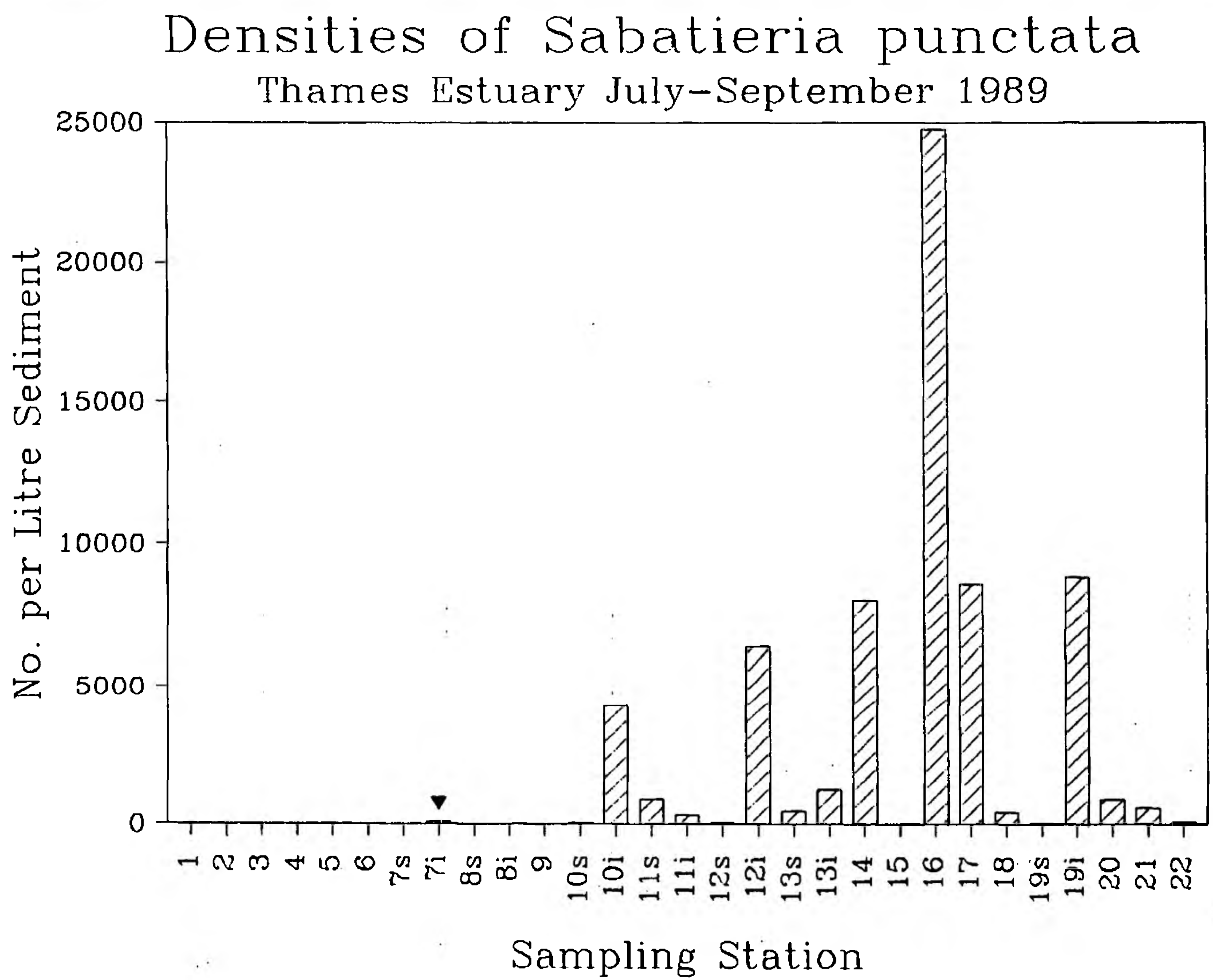

Densities of Sabatieria punctata
Thames Estuary July-September 1989
No. per Litre Sediment
25000
20000
15000
10000
5000
0
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 4. The percentage distribution of the population of *Sabatieria punctata* in the Thames Estuary, October - December 1989. Arrow denotes furthest upstream station at which *S. punctata* was observed.

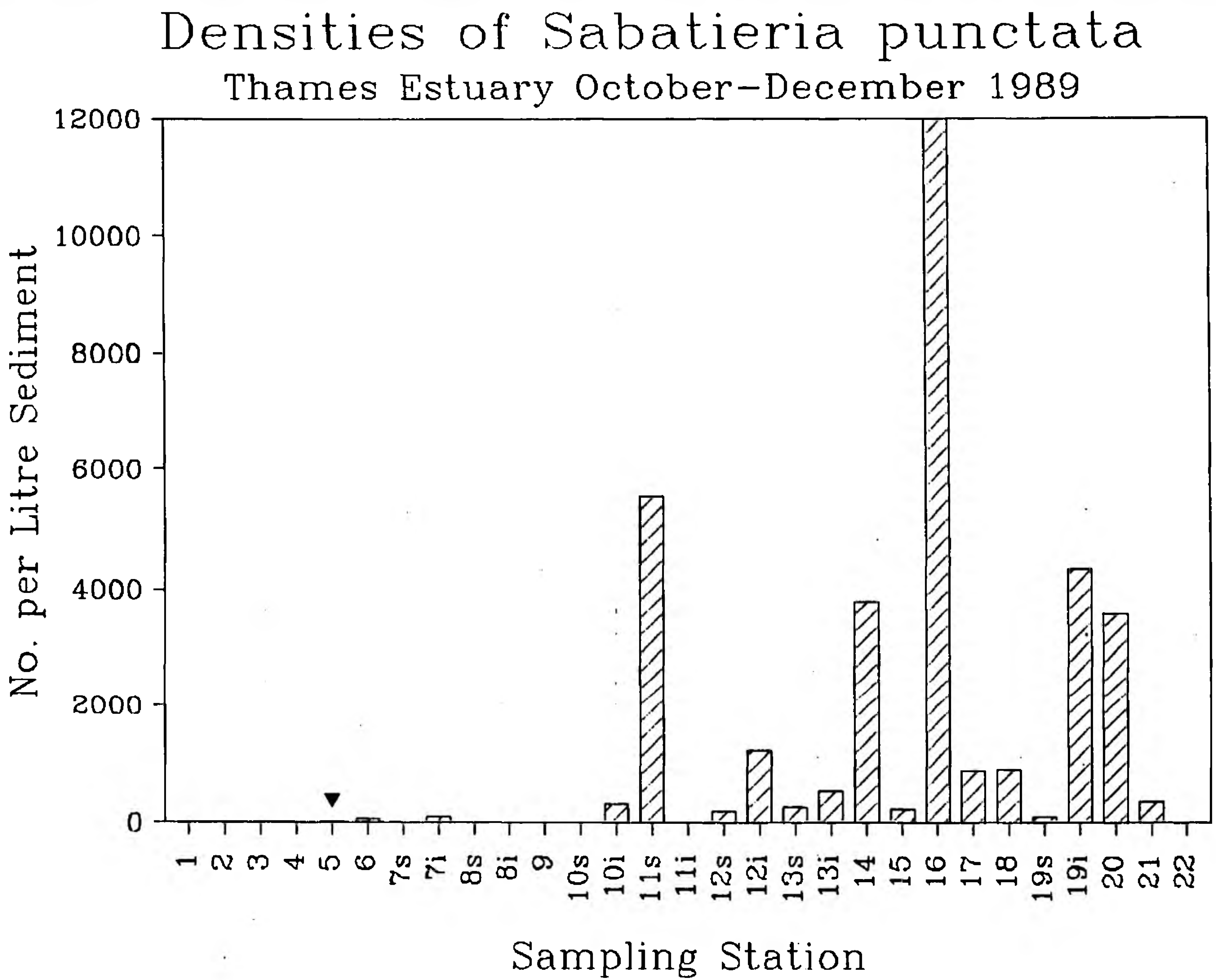
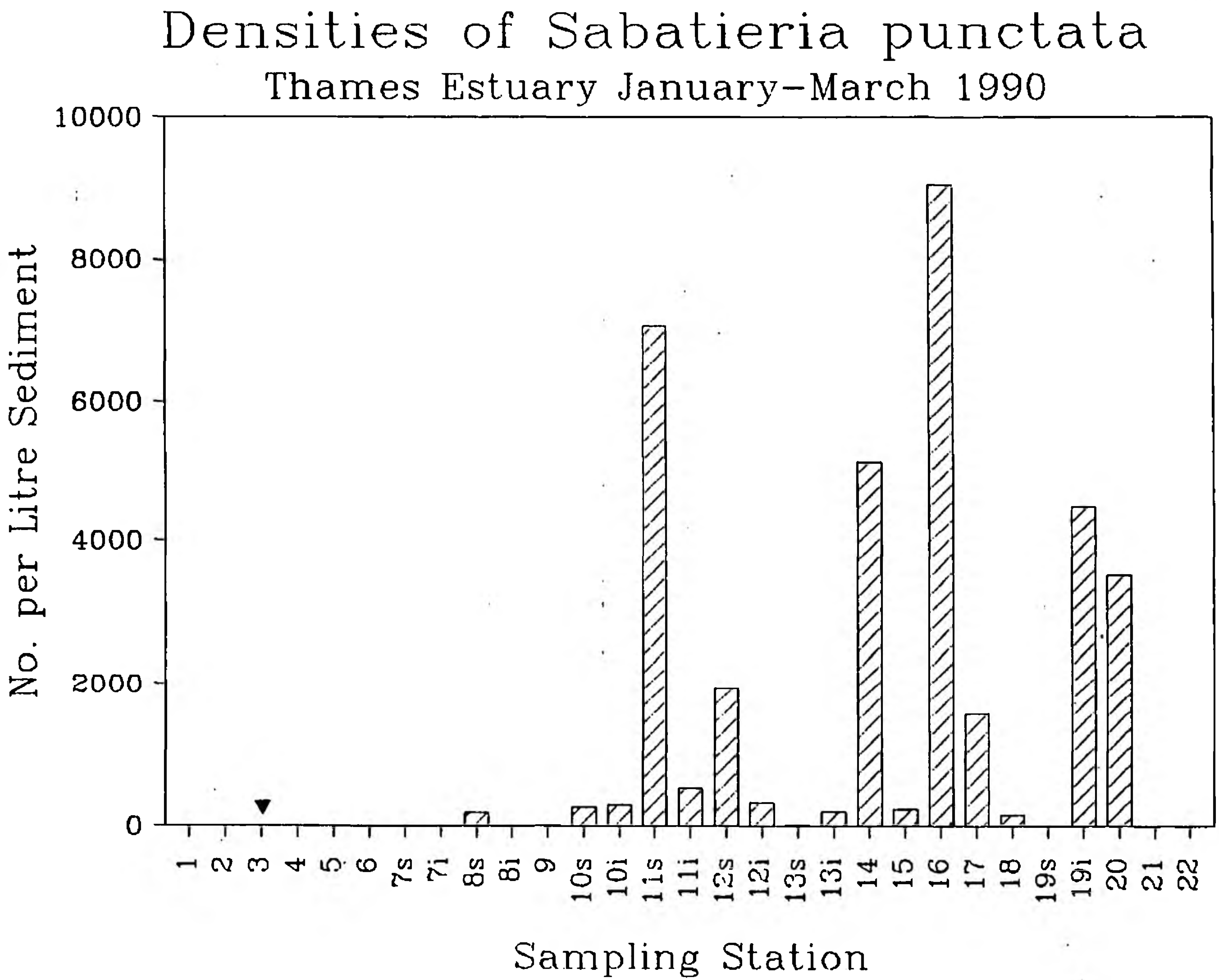

Densities of Sabatieria punctata
Thames Estuary October-December 1989
No. per Litre Sediment
0
2000
4000
6000
8000
10000
12000
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

Figure 5. The percentage distribution of the population of *Sabatieria punctata* in the Thames Estuary, January - March 1990. Arrow denotes furthest upstream station at which *S. punctata* was observed.


Densities of Sabatieria punctata
Thames Estuary January-March 1990
No. per Litre Sediment
10000
8000
6000
4000
2000
0
1
2
3
4
5
6
7s
7i
8s
8i
9
10s
10i
11s
11i
12s
12i
13s
13i
14
15
16
17
18
19s
19i
20
21
22
Sampling Station

in each of the surveys. As with the Nematoda, the high species richness probably reflects the large area encompassed by the survey and the range of salinity regimes to which the sites sampled are subjected. The assemblages present at each station are considered in Section II below.

Apart from their distribution, comparatively little is known of the biology of the harpacticoid species found in the Thames samples. Several are known to be freshwater species accounting for their dominance at the Teddington end of the Estuary in the first survey (2nd. quarter 1989; see Appendix I; Section 2). For example, *Epactophanes richardi* is usually found in freshwater and semi-terrestrial habitats such as *Sphagnum* bogs or permanently wet leaf litter along banks of rivers. Similarly, *Bryocamptus ?praegeri*, *Canthocamptus* species, *Elaphoidella gracilis* and *Moraria* species are all usually associated with freshwater habitats such as lakes or slower flowing rivers. It is of interest to note that few freshwater species were found in the 2nd., 3rd. and 4th. surveys (see III below). Most of these species are epibenthic and feed in the upper layers of the sediment. They are probably detritivores but this is not known for all the species named above. In nearly all cases they are highly mobile and, in the case of lake and still water species, may undertake short dispersal swims up into the water column at night.

The same may be true of the diosaccid harpacticoids which are mostly marine and estuarine species although there are some notable exceptions. *Schizopera* species, including *S. clandestina*, prefer brackish waters and some species have been reported from freshwater localities (Lang, 1948). Earlier studies of the Thames revealed *Schizopera compacta* in and amongst fine red-brown algae and in the byssal holdfasts of *Mytilus edulis* (Feil, pers. obsvn.). *Stenhelia palustris* is a common epibenthic diosaccid of estuaries (Green, 1968) and has characteristic nauplius larvae which were observed at low densities in many of the samples examined. *S. palustris* is known to occur in muddy intertidal sites where there may be considerable variations in temperature and salinity. We have found that this species often builds small temporary tubes, up to 4 mm long, into the sediment. This suggests that it might feed in a similar manner to certain species of *Corophium* that also construct burrows, namely a combination of filter and deposit feeding (Hughes, pers. comm.).

Diosaccids and canthocamptids have well developed, protruding swimming limbs. In contrast the body shape of ectinosomatids is streamline. The antennae are reduced and the limbs are directed posteriorly and held against the body. This appears to facilitate burrowing. In the present survey their distribution demonstrates their preference for higher salinity estuarine sediments and correlates with coarser grained sediment types. Of the Ectinosomatidae, *Halectinosoma* species are commonly found in subtidal marine sediments. The furthest into the estuary that *Halectinosoma* species penetrated was the subtidal sampling site at Gravesend (13s) in the 1st. quarter 1990 (*H. curticorne*). This probably represents the extreme end of its salinity tolerance range. Densities of this species increased towards the mouth of the estuary and were accompanied by the appearance of other ectinosomatid species such as *Ectinosoma melaniceps*.

In the Ameiridae and Laophontidae, the limbs are reduced and the species are almost vermiform. Members of these families are much less mobile than the other harpacticoid species and adopt a truly interstitial existence. In *Leptomesochra macintoshi* the reduction in limbs is more pronounced than in *Laophonte ?denticornis*. The interstitial species are more sensitive to environmental conditions than epibenthic species and their distribution within an estuary usually reflects this fact. It is of note that the two species were largely restricted to the coarser grained sediments at the mouth of the estuary (see Southend (19s), Shoeburyness East (21) and Sea Reach No. 2 Buoy (22)).

iii. Acari

The total acarine community of the Thames Estuary observed over the 4 surveys was found to comprise 6 taxa from 4 families (Appendix I; Section 1). The different assemblages of Acari at each station are considered in Section II below. Of the species recorded, an oribatid species was the most commonly observed, occurring at 16 of the 29 stations sampled over the 12 month period sampled (Appendix I; Section 2). Oribatid mites are commonly present in sediment samples from estuarine and nearshore marine habitats. They prefer terrestrial rather than aquatic habitats and probably originate from decaying organic material along the strandline. Accordingly their distribution within a survey area such as the estuary may be of little direct biological significance. However, their densities do appear to vary in relation to the amounts of macrophyte or macroalgal detritus that is present. The single bdellid species is not thought to be an aquatic species (Green, pers. comm.) and has probably arisen from leaf litter in the Thames catchment. In contrast the cryptostigmatid mites observed are all true aquatic species. The hydracarine found at Teddington (1), 1st. quarter 1989, is a true freshwater species and is indicative of clean, unpolluted conditions. Halacaridae can occur in freshwater, but the species observed are marine species that will happily tolerate reduced salinities. *Copidognathus rhodostigma* is a common species from around the British coast. It has been recorded in samples down to a depth of 60 m but occurs in highest densities in algae just below the low water springtide levels. Personal observations (Trett and Feil) suggest that it is also common in the byssal attachments of *Mytilus edulis* and amongst attached weed on piers in the outer Thames Estuary.

Copidognathus dentatus is an interesting species. Until recently its known distribution was the Adriatic coast of Yugoslavia only. Specimens were then found in a meiofaunal survey of the Humber Estuary, off Grimsby, and at Westgate-on-Sea on the North Kent coast (Green and McQuitty, 1987). It is usually found in the lower intertidal zone and shallow subtidal sediments amongst stones and algae. In the present surveys it was found at low densities at Blythe Sands (15), Canvey Beach (16), Chapman Buoy (18), Southend subtidal (19s) and Sea Reach No. 2 Buoy (22). From the biological point of view, it would be of interest to know something of the macrofauna recorded at these stations.

Remaining unidentified species comprised mostly halacarid nymphs which might well belong to *C. rhodostigma* or *C. dentatus*. The densities of halacarids in the middle reaches of the Estuary are smaller than those reported in other estuaries. Trett (in Newell *et al.*, 1989a), for example, reported 6 acarine species at densities of up to 109 $litre^{-1}$ sediment in the Humber Estuary.

b. Other Meiofaunal Groups

Qualitative data on the occurrence of other groups of meiofauna observed in the Thames sediment samples are summarised in Appendix I; Section 3, Tables 1 to 8 and considered at each sampling station in Section II below. The tests of rhizopod amoebae (predominantly *Centropyxis* species) were very abundant at stations from Teddington (1) to Cadogan Pier (4). Other records seaward of the pier relate to observations of single tests. Measuring up to 400 μm in length, the amoebae prefer freshwater and are intolerant of polluted conditions. Marine ciliate species were observed in comparatively large numbers at 3 stations at the mouth of the estuary at densities up to 500 litre^{-1} sediment (4th. quarter, 1989). In common with the Rhizopoda, these do not tolerate polluted conditions. The distribution of tests of Foraminifera reflects their preference for higher salinity waters with high densities of planispiral *Elphidium* species and multilocular *Braziliana* species present at stations in the outer Estuary but relatively few specimens occurring upstream of West Thurrock. Single specimens of the large, unilocular marine genus *Lagena* were occasionally found at sampling stations near the mouth of the estuary.

Tardigrada were represented by three species. *Macrobiotus dispar* and *Echiniscus* species were present at stations between Teddington (1) and Woolwich (8). These are predominantly freshwater species that often occur in fresh-brackish water sediment samples. Stations between Canvey Beach (16) and Sea Reach No. 2 Buoy (22) possessed a 'primitive' marine species, *Batillipes mirus*. Each of these species of tardigrade is commonly found in British estuaries in southern England (Morgan and King, 1976) and *B. mirus* may be distributed widely throughout British coastal waters (Forster and Trett, pers. obsvn.).

Kinorhyncha and Gastrotricha have been recorded in European estuaries but are usually restricted to clean, unpolluted sites and the higher salinity sediments. In the present surveys, both kinorhynchs and gastrotrichs were observed, represented by a *Pycnophyes* species and a *Chaetonotus* species, respectively. However, these were present at the mouth of the estuary (e.g. Grain Flats (20), Shoeburyness East (21) and Sea Reach No. 2 Buoy (22)). In contrast, Turbellaria were recorded at several stations in the estuary and, as many of these are stenohaline it is likely that several species are present. Taxonomy of this group is particulary difficult and requires fresh, anaethetised specimens of sexually mature adults. The same applies to the closely related Gnathostomulida. However, these were much rarer and were observed at Shoeburyness East (21) in the 2nd quarter 1989 and Sea Reach No. 2 Buoy (22) in the 1st. quarter 1990 only.

c. Non-meiofaunal Groups

Qualitative observations made on the presence/absence of non-meiofaunal groups present in the sediment samples examined are presented in Appendix I; Section 4, Tables 1 to 8. Groups present at individual stations are described in Section II below. Diatoms and their empty frustules were almost ubiquitous in the Thames Estuary sediments. Towards Teddington, these were predominantly freshwater pennate species which were replaced by increasing densities of marine and estuarine centric species (*Trigonium* and *Coscinodiscus* species). *Nitzschia* species were also present in many of the higher salinity sediments (stations to the east of West Thurrock). In sediments from many of the upper estuarine sampling stations, loricae of rotifers were present (mostly *Keratella* species). Many of these may have been transported to the higher salinity sites from the upper reaches of the Thames Tideway and from the catchment although some specimens of *Brachionus* species were seen. The latter are tolerant of higher salinity conditions and can become abundant in estuarine systems (Green pers. comm.). The chironomid larvae observed were not identified to species. These were found in samples from Teddington (1) and Kew (2) only during the 2nd. quarter 1989 but were more widespread in subsequent surveys, extending as far as London Bridge (5) in the 1st. quarter, 1990. At Teddington and Kew the numbers of larvae were high with densities of up to 200 litre^{-1} ocurring in the 3rd. quarter 1989. Cladocerans showed a similar distribution to the chironomids with *Bosmina* and *Daphnia* species present at low densities at both Teddington (1) and Kew (2). Unidentified chydorid cladocerans were also commonly observed in the sediments from these stations.

The distribution of oligochaete annelid juveniles was much as expected. Nadiid and tubificid species were abundant towards Teddington. These became increasingly rare towards the mouth of the Estuary. However, the distribution of polychaete neochaete larvae was much wider than expected and extended almost throughout the estuary in the 2nd. quarter 1989 and the 1st. quarter 1990. The neochaete larvae resembled those of spionids and, to the seaward end, nereid species. *Polydora* species are known to occur in large numbers in the Estuary, usually in mud tubes around the bases of epilithic hydroids and bryozoans (Hughes, pers. comm.; observations made on epifauna on rocks collected with a Baird dredge). It is possible that the neochaetes and newly metamorphosed individuals at the westerly end of the estuary belong to the freshwater polychaete genus *Manayunkia* although British records of this are uncertain.

Comparatively few newly settled mollusc larvae were observed in any of the surveys. Low densities of littorinid gastropod egg capsules were observed at Canvey Beach (16), Allhallows (17) and Southend (19i) in the 2nd quarter 1989. Whether these had arisen from local gastropod populations is uncertain. A survey of Thames shores undertaken in 1987 (Feil and Newell pers. comm.) failed to find littorinids for use in silver determinations between Dartford and Cliffe Creek. Low densities of newly settled bivalve larvae were also observed in sediments downstream of Gravesend. These are thought to belong to tellinid species.

The calanoid copepod, *Eurytemora affinis* is not a benthic species and is usually a member of the zooplankton present in the water column. It is a typical estuarine species and commonly present in considerable numbers in plankton samples taken from middle reaches of the Thames by CRAB staff. Care has to be taken to distinguish this species from *Eurytemora velox* which occurs in the lower salinity waters of the London docks but can enter the estuary during operation of locks (e.g. at St. Katherine's Dock (Green and Hutchinson, pers. comm.)). Despite its widespread occurrence within the estuary, its presence at Teddington (1) and Shoeburyness East (21) is somewhat extreme and may have resulted from tidal or avian transportation.

II. Meiofaunal Summaries

This section provides a more detailed description of the fauna present at each sampling site reported in Appendix I; Section 2 (q.v.) with additional comments on seasonal variation.

Station 1, Teddington

The muddy sediment between the coarse stones at this station supported a mixed community of predominantly freshwater meiofaunal species, typical of those that we have observed in surveys of freshwater ecosystems in lower course rivers in southern England. The complement of nematode species present varied in composition between the surveys and, although a cumulative total of 37 species was observed, a maximum of 26 species was observed in any one survey (4th. survey). The lowest number of nematode species were recorded in the 3rd. survey 1989 (7 species). Plant-parasitic members of the Tylenchida and Dorylaimida were commonly observed at this site although their relative abundance declined in the samples collected after the 1st. survey. These are a common component of lake and riverine meiofaunal assemblages and probably feed on the root systems of marginal plants. The 1B:2A feeding-type ratios indicate that detritivorous species were relatively more important at this site in the latter half of the year than the selective epigrowth and diatomivorous species. This results from a decrease in type 2A species rather than an increase in type 1B species and might reflect a change in the diatom populations or a change in the quality or nature of bacterial and algal epigrowth communities.

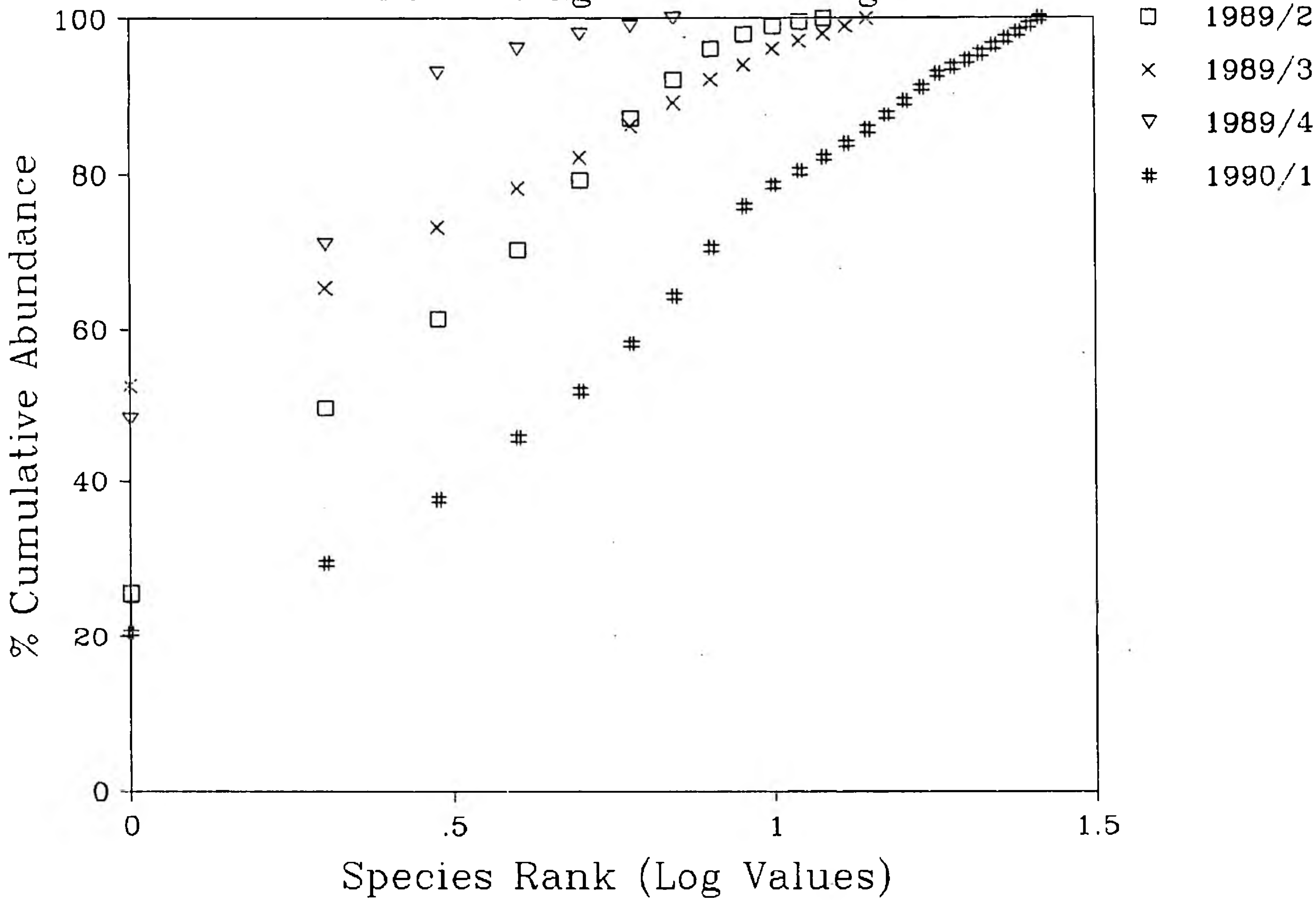
Dominance-diversity characteristics of the nematode assemblages at this site are illustrated in Figure 7. Between April and June, *Tobrilus gracilis* was the dominant species accounting for just less than 26% of the individuals in an assemblage of 12 species. In the following 2 surveys the dominance of *T. gracilis* increased to approximately 50% and was highest in the 3rd. survey (53%). In the final survey species richness had risen from 7 in the previous quarter to 26 taxa with a concomitant decline in dominance as *Paracyatholaimus intermedius*, a low salinity type 2A cyatholaimid, superseded *T. gracilis* as the dominant species.

The most diverse harpacticoid copepod assemblage was observed during the 1st. survey (April - June 1989). This assemblage comprised 8 species most of which are associated with freshwater habitats. Harpacticoids were not observed in the 2nd. survey and few individuals only were present in the remaining surveys. This significant change in the harpacticoid community may have resulted from changes in the flow rates upstream of the lock owing to drier weather and/or changes in the ambient salinity. Acarina were observed only in the 1st. quarter 1990 and included an oribatid and bdellid species.

In each of the surveys, other invertebrate species observed in the meiofaunal samples from this station were typical of low salinity or freshwater conditions. Densities of chironomid larvae were highest in the late summer and winter samples and lowest in the spring. This most probably relates to the emergence of adults in spring and progressive larval recruitment through the summer months.

Figure 7. The dominance:diversity characteristics of the nematode assemblages observed at the Teddington sampling station between April 1989 and March 1990.

k-Dominance Curves for Nematode Assemblages at Teddington



Station 2, Kew

Meiofauna at Kew was similar in many respects to that observed at Teddington. *Tobrilus gracilis* was a key component of the nematode assemblages which, again, comprised freshwater nematodes including several plant-parasitic tylenchid and dorylaimid species. Variability in composition of the nematode assemblages was also high and of a total of 37 species observed throughout the year, 18 was the maximum number observed in any one survey (4th. survey). The number of species and the densities observed, however, were more uniform than at Teddington. Dominance-diversity plots (Figure 8) also showed that dominance in the 2nd. survey exceeded that recorded in any of the other surveys (ca. 80%; *T. gracilis*). This correlated with the lowest number of species observed (11 taxa). Feeding type ratios at this site indicated a balance in favour of non-selective detritivores.

Fewer harpacticoid species were observed at Kew than at Teddington and none was observed in the October-December samples. The species that were present included freshwater groups and an epibenthic estuarine species as well as diosaccid copepodites. As at Teddington, Acarina were observed only in the January - March samples and comprised oribatid and bdellid species.

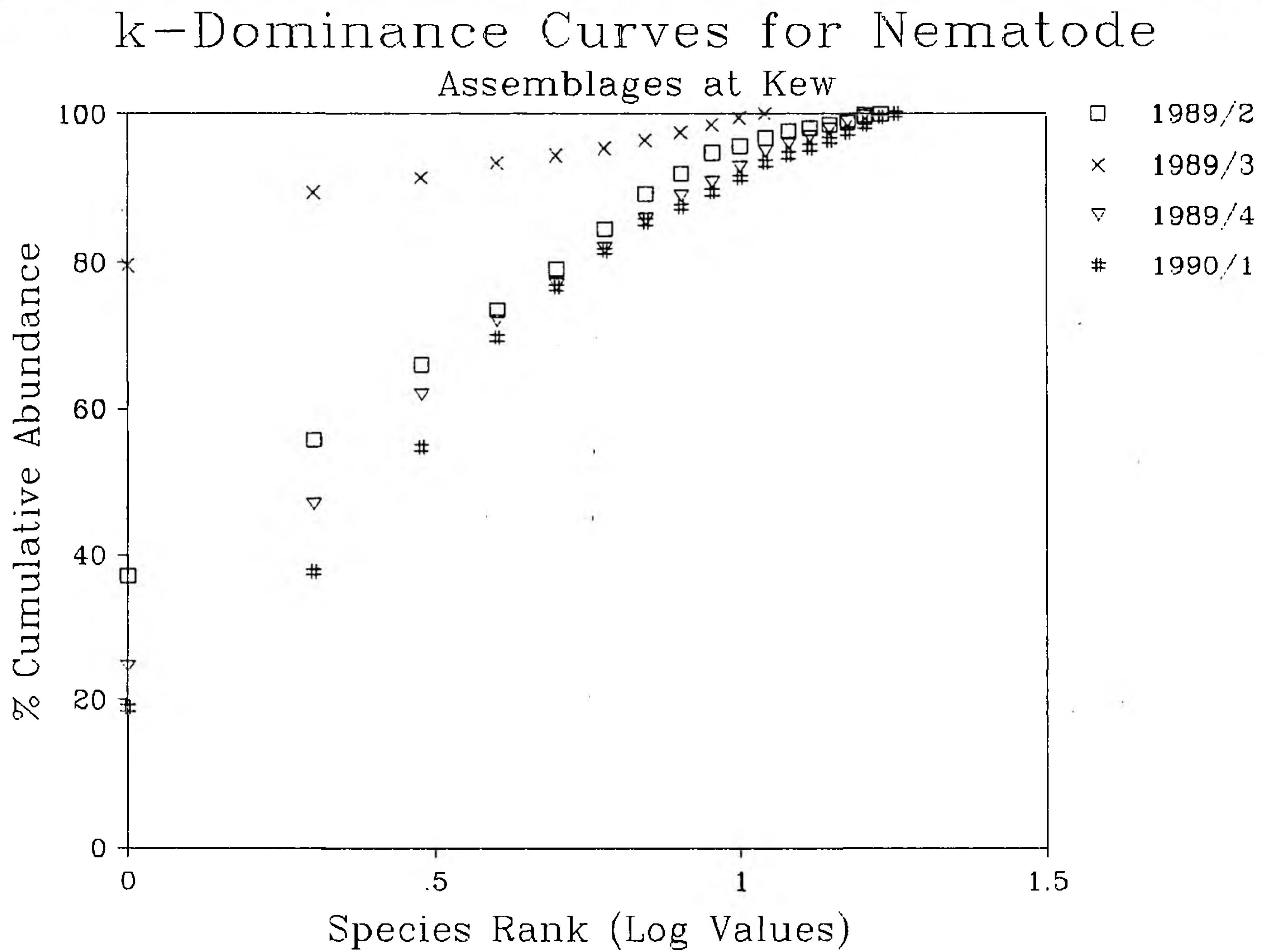
Ostracod, tardigrade and turbellarian species along with the other invertebrates present in the samples were all in keeping with a low salinity-freshwater locality

Station 3, Hammersmith Bridge

A total of 44 nematode species were observed at this site. These included several estuarine and low salinity species such as *Oncholaimus campylocercoides*, *Dichromadora geophila*, *Axonolaimus paraspinosus* and a *Metachromadora* species. Hammersmith Bridge also marked the most easterly record of the common estuarine species *Sabatieria punctata* which was observed as a single specimen in the January - March 1990 samples. Several freshwater species persisted at this station including certain plant-parasitic species (e.g. Dorylaimid species 1, *Hirschmanniella* species and *Criconemoides* species) and several rhabditids (e.g. *Mononchoides striatus*, *Butlerius butleri* and the *Rhabditis* and rhabditid species). Again the feeding type ratios indicated a predominance of non-selective deposit feeders but the lower ratios throughout the year confirmed that the relative densities of diatomivorous and epigrowth feeding species were higher than at either Teddington or Kew. Inspection of the species lists shows these type 2A species to be principally chromadorids and cyathoIaimids more commonly found in coarse grained, low to moderately low salinity sediments.

Very few harpacticoid copepods were observed at this station. Indeed, 9 *Attheyella* species litre^{-1} were the only recrod (4th. survey). The genus *Attheyella* is more usually associated with the margins of lakes and rivers and, in estuaries, is usually restricted to the upper reaches. We have also observed this species in a survey of the upper tidal reaches of the Medway (Feil and Trett, pers. obsvn.). Amongst the other invertebrate groups

Figure 8. The dominance:diversity characteristics of the nematode assemblages observed at the Kew sampling station between April 1989 and March 1990.



k-Dominance Curves for Nematode
Assemblages at Kew
% Cumulative Abundance
Species Rank (Log Values)
100
80
60
40
20
0
0
.5
1
1.5
1989/2
1989/3
1989/4
1990/1

present in the samples examined, oligochaetes and rotifers were found throughout the year. Chironomid larvae were abundant in each of the surveys except the 1st. survey (April - June) when none was observed. The frustules of marine centric diatoms were present amongst those of freshwater pennate species indicating the proximity of the upper estuary limit of transportation of finer particulate material.

Station 4, Cadogan Pier

The 47 species of nematode observed at this site during the year April 1989 - March 1990 were a mixture of fresher water and true estuarine species. There was some evidence of colonisation by lower estuary and marine species such as *Innocuonema* species and *Tripyloides gracilis* during the middle surveys (July - December). This correlated with the observation of muddier sediments at Cadogan Pier and may have related to reduced flow during these periods (see also Stations 20 and 22). In the April 1989 and January 1990 surveys the sediment contained noticeable sand fractions. The 1B:2A feeding type ratio was highest in the second survey (July - September 1989) largely as a result of the *Daptonema* species (*D. furcata*), a non-selective detritivore, that became dominant (ca. 65%) in the finer sediments. This is another species that would be expected to occur in higher salinity conditions and its presence here probably reflects a realised as opposed to a preferred niche.

Harpacticoid species were observed in the final survey only and even here were restricted to a single species of *Microarthridion* at low density (46 $litre^{-1}$). This genus comprises small epibenthic species that appear to be "completely euryhaline" (Gurney in Lang, 1948). Acari were not observed.

The most diverse assemblage of other invertebrate phyla present in the Cadogan Pier samples was observed in the final survey. Oligochaetes were the only invertebrate group to be observed in each of the 4 surveys as were the diatoms amongst the algae.

Station 5, South Bank Centre

This station was characterised essentially by sandy sediments and sandy sediment infauna. As at Cadogan Pier, the mid-survey samples (July - December 1989) contained higher silt-clay fractions than in either the first or last samples. In general, sandy sediment nematode assemblages would be expected to be richer in species than those present in fine sediments. However, a total of 27 species only was observed in the 4 surveys, all at comparatively low densities (range: 102 to 354 $litre^{-1}$). The relatively high densities of cyatholaimid and/or chromadorid species and low abundances of non-selective detritivores accounted for the low feeding type ratios in the 1st. and 3rd. surveys. However, selective epigrowth (epipsammic) and diatomivorous species (type 2A) were not observed in the 2nd. or final surveys, undermining comparison of the trophic assemblages.

The trend for reduction in fresh and brackish water species with increasing distance down the estuary continued to be observed and relative densities of true estuarine were higher than at any of the preceding sampling stations. Single individuals of *Ptycholaimellus ponticus*, *Odontophora setosa* and *Chromadora macrolaima* were observed at this site in the 3rd. survey marking the most westerly occurrence of these essentially outer estuarine, type 2A species.

Harpacticoid copepods were not observed in any of the samples from the South Bank Centre sampling station. Acari were limited to observations of single individuals of an oribatid species (1st. survey) and *Copidognathus dentatus* (final survey). It is of interest to note that the South Bank Centre may represent one of the lowest salinity sites at which *C. dentatus* has ever been recorded. This species usually inhabits much higher salinity sites either in the outer estuary or in coastal waters.

Turbellaria (indet.) were present in each sample taken from this site. Other groups, however, were comparatively poorly represented.

Station 6, London Bridge

In contrast to the South Bank Centre sampling site, the London Bridge site yielded a high nematode species count (cumulative total of 46 species). Total numbers of nematodes observed litre^{-1} sediment were, with the exception of the 1st. survey, high with a maximum of 6,640 litre^{-1} in the July - September 1989 sample. The species recorded here are commonly found in muddy substrates that contain at least some coarse-grained material in a low to moderate salinity environment. The freshwater catchment and low salinity upper reaches of the estuary were indicated by the presence of species such as *Plectus granulosus*, *Criconema* species, Dorylaimid species 2, *Tobrilus gracilis* and *Mononchoides striatus*. The marine influence is indicated by the presence of trace *Oxystomina asetosa*, *Deontolaimus* species, *Paracanthonchus heterodontus*, and, possibly, *Axonolaimus paraspinosus*. The remaining species are all commonly observed in European mid- to upper estuarine samples. As in the Cadogan Pier samples, the 1B:2A feeding type ratio was highest in the second survey again as a direct result of increased densities of xyalid species (*Daptonema* species).

The harpacticoids were represented by a single specimen of a species of the freshwater genus *Bryocamptus*. These are commonly found in more acid waters associated with decaying leaflitter in woodland streams, *Sphagnum* bogs or, occasionally, subterranean streams. As such, it is likely that this species was transported to the London Bridge site from the Thames catchment. Specimens were also recorded at Teddington and Kew in the 3rd. and 4th. surveys, respectively.

Acari were not observed in any of the London Bridge samples. Other fauna included specimens of the calanoid copepod, *Eurytemora affinis*; this is a common species in the plankton of the Thames Estuary (Green pers. comm.) and frequently occurs as aberrant specimens in meiofaunal samples from European estuaries (Trett, Feil and Forster, pers.

obsvn.). It occurs in brackish waters only, unlike its close relative *Eurytemora velox* which can inhabit fresh and brackish water; *E. velox* occurs widely in the lower salinity Dockland waters and is an occasional inhabitant of the Thames Estuary zooplankton. Rotifers observed at London Bridge included a species of *Brachionus* which is again usually planktonic. Some species of this herbivorous rotifer are able to exploit low salinity waters and may be a characteristic component of certain estuaries in southern England.

Station 7, Greenwich

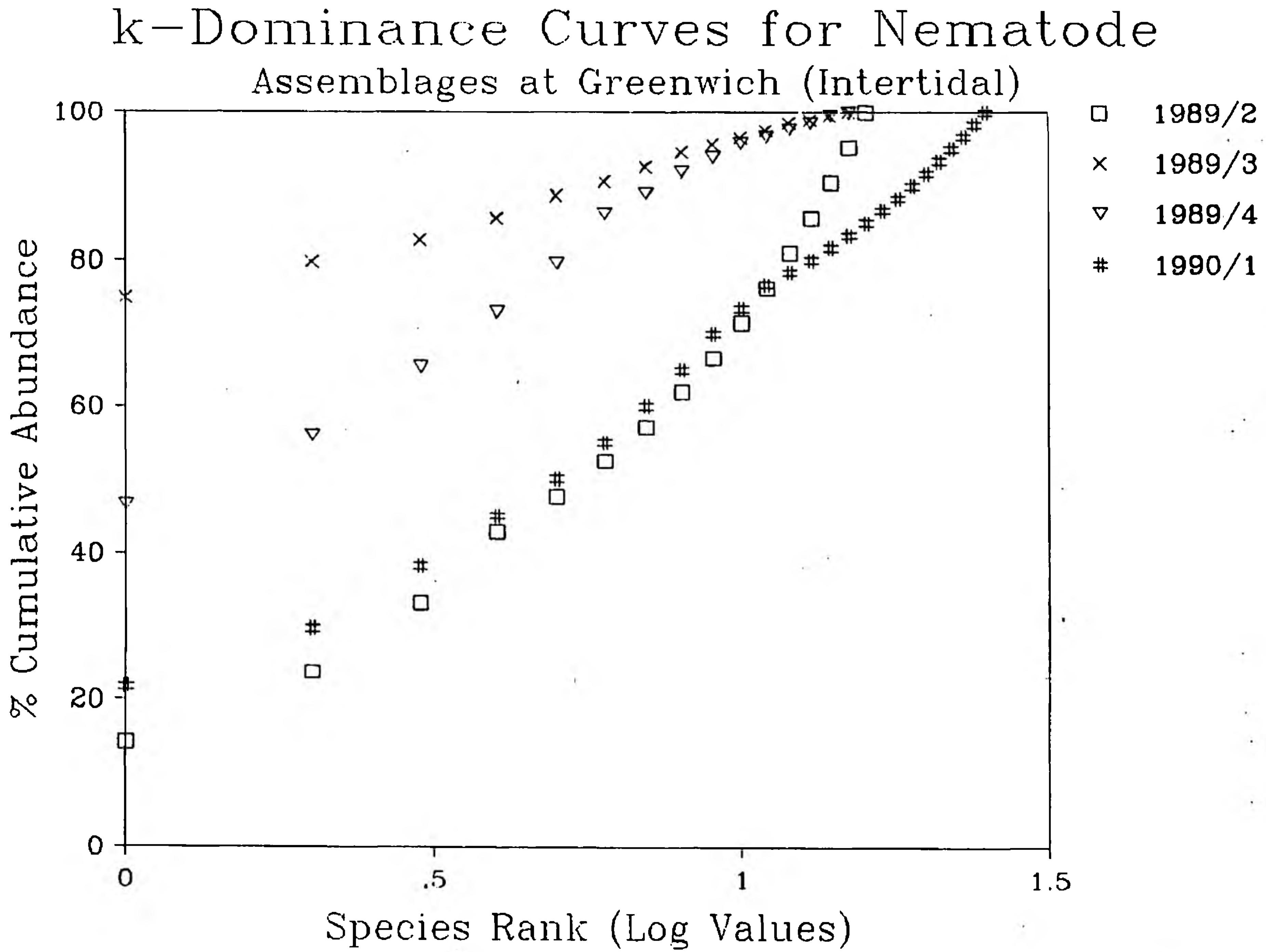
Subtidal and intertidal sampling sites were established at Greenwich, although the subtidal site was not assessed during the 1st. survey. In all cases, larger numbers of meiofaunal species were observed at the intertidal rather than the subtidal site; the cumulative species totals for nematodes being 48 and 29 species, respectively and, for harpacticoid copepods, 5 and 1 species, respectively. An oribatid species was recorded in the 1st. and final surveys of the intertidal site only. Similar differences between the inter- and subtidal meiofaunal assemblages have been noted in surveys of the Yare, Bure and Waveney (East Anglia; Trett pers. obsvn.) and studies of the Elbe (Germany; Riemann, 1966) and Ems Estuary (Netherlands/Germany; Bouwman, 1983). Factors that might be responsible for these differences include greater heterogeneity of the littoral habitat, elevated primary production, especially of benthic diatoms, increased oxygenation of sediments and mechanical disturbance by wave action.

Of the 29 species observed in the subtidal samples; 8 species only were not observed in the intertidal zone. With the exception of *Paroigrolaimellus bernensis* and a plectid species, which are common in low salinity or freshwater habitats, those unique to the subtidal site were either marine or outer estuary species. Densities of nematodes in the intertidal site were not always higher than the subtidal populations. However, intertidal nematode densities did rise to between 5 and 7 times those of the subtidal site in the mid-survey samples (July - December 1989).

Sufficient species were present at the intertidal site to enable dominance-diversity characteristics to be examined graphically (see Figure 9). Dominance was highest during the 2nd. survey (July - September 1989) when *Daptonema setosa* accounted for 76% of the nematode population. The dominance of this species declined to approximately 49% in the 4th. survey (October - December 1989) and 22% in the final survey (January - March 1990). This is in keeping with the biology *D. setosa* which is a euryhaline r-selected opportunist with a high biotic potential. Whilst it is usually considered to be a non-selective deposit feeder, feeding on decaying organic material, several specimens in the Thames were observed with intact pennate diatoms in their intestines. Several other nematode species appear to infill as the dominance of *D. setosa* declines and species richness increased from 15 taxa between July and December to 25 taxa between January and March.

The richest assemblage of harpacticoids at Greenwich was observed at the intertidal site in the 3rd. survey when 4 taxa were recorded at a total density of 4,549 $litre^{-1}$. This coincided with the occurrence of the only harpacticoid specimen at the subtidal site

Figure 9. The dominance:diversity characteristics of the nematode assemblages observed at the Greenwich intertidal sampling station between April 1989 and March 1990.



k-Dominance Curves for Nematode
Assemblages at Greenwich (Intertidal)
% Cumulative Abundance
Species Rank (Log Values)
100
80
60
40
20
0
0
.5
1
1.5
1989/2
1989/3
1989/4
1990/1

(*Microarthridion* species - also present in the intertidal samples). The high density of harpacticoids supported by the intertidal sediments at this time of year might relate to the high primary productivity of the Greenwich mudflats (Hughes pers. comm.).

With the exception of the 1st. intertidal sample (April - June), juvenile oligochaetes were observed in all the samples examined from Greenwich (subtidal and intertidal). Newly metamorphosed gastropod larvae (probably hydrobiid species) were present in the intertidal samples between October 1989 and March 1990 and the subtidal sample for October - December. In *Hydrobia* and *Potamopyrgus* species, breeding in the East of England usually commences between May and June. Egg maturation may take up to 3 weeks and the veligers may remain in the plankton for up to 1 month which suggests that peak recruitment might be in mid- to late summer. Meiofaunal sampling in the Thames may have missed this peak as the juveniles develop rapidly once settled.

Station 8, Woolwich

The subtidal and intertidal meiofaunal communities at Woolwich are very different from each other. As at Greenwich, the total number of meiofaunal species observed at the subtidal site was lower than at the intertidal. However, this was solely due to the large number of nematode species encountered during the 1st. survey (23 species; see Appendix I; Section 2). In subsequent surveys higher numbers of species were observed at the subtidal site. The reason for this is unknown. Sediment descriptions suggest that the sediment types remained similar with compacted muds occurring sublittorally and fine soft muds in the littoral zone. *Sabatieria* species were present in each of the subtidal samples (*S. punctata* was the only species observed at this site in the 1st. survey). Apart from a single *S. punctata* in the intertidal sample from the 1st. survey, none was observed in any of the later samples. This would seem to suggest that the intertidal and subtidal sites experience unusually different environmental conditions and might merit closer investigation.

Daptonema setosa populations dominated the intertidal nematode assemblages in the first 3 surveys (April - December 1989). In common with the Greenwich intertidal site, the densities of *D. setosa* rose markedly between the April and July sampling programmes. However, peak densities did not occur until the 3rd. survey (6,574 $litre^{-1}$). This was reflected in the elevated 1B:2A feeding type ratios of the 2nd. and 3rd. surveys. In contrast, in the subtidal assemblages, *S. punctata*, *Adoncholaimus thalassophygas* and *Dichromadora geophila* were more important components of the meiofauna than *D. setosa* which was present at low densities only in the 3rd. and 4th. surveys.

Harpacticoid species were present in each of the samples from the intertidal site and comprised marine and estuarine species. However, adult harpacticoid copepods were not observed in the subtidal samples. Copepodites (indet.) were present in the samples collected in the 1st. and 3rd. surveys. Of the Acari, oribatid species were found at low densities in some of the samples at both sites.

Comparatively few other invertebrate groups were observed in the subtidal samples.

Sections of perisarc and detached hydranths of thecate hydroids were found in the July - September sample indicating the proximity of more stable substrata. Our own observations on the benthos of this reach imply that these might derive from epifaunal colonies on large cobblestones. Hydranths were also present in the April - June sample from the intertidal site.

Station 9, Beckton

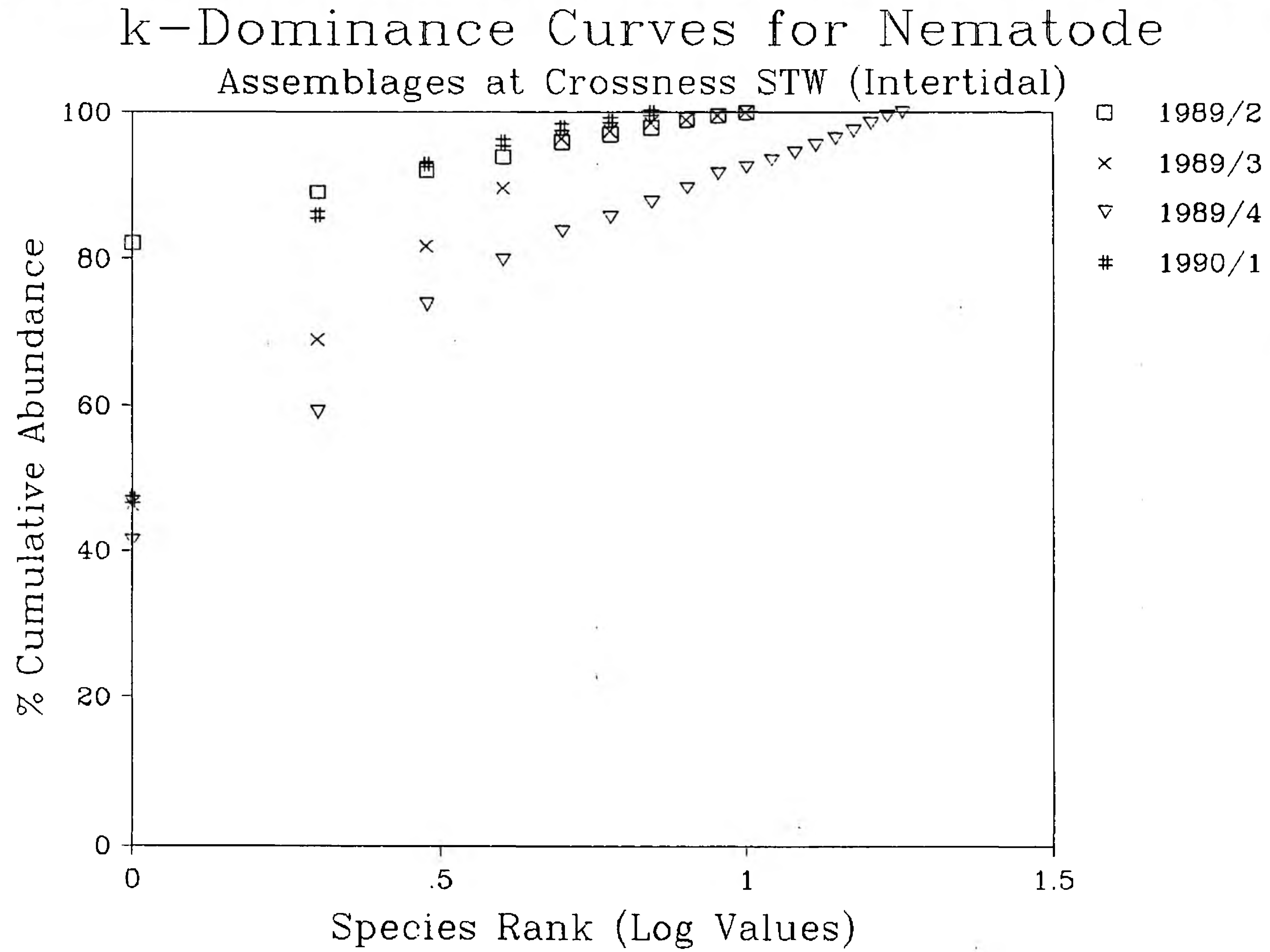
The observed meiofaunal assemblages at Beckton included a reduced number of nematode and harpacticoid species. The cumulative totals for these groups were 14 and 1 species, respectively. Amongst the nematodes, several fresh and brackish water species were present. Many of these were microbivorous. The remaining nematodes comprised euryhaline, non-selective detritivores, such as *S. punctata* and *D. setosa*, and selective deposit feeders/microbivores, such as the leptolaimids, *Leptolaimus papilliger* and *Leptolaimoides* species. The diatomivorous species, *Ptycholaimellus ponticus* was also present in the muddy Beckton sediments collected between October and December along with low densities of the predatory marine species *Enoplolaimus vulgaris*. The latter 2 species are generally found in higher salinity habitats. The cletodid harpacticoid copepod species observed as a single specimen in the January - March samples may have been an aberrant record; it resembled closely species more usually found in well oxygenated sandy sediments. Similarly, the Acari were also represented by a solitary specimen of an oribatid species present in the July-September survey.

Densities of other faunal groups were low and comprised mostly single individuals. Tests of marine Foraminifera were present in the first 3 surveys at densities of up to 200 litre^{-1} (mostly planispiral *Elphidium*-type species - possibly *E. striato-punctata*). However, it is likely that these were transported to the site from more saline reaches as they are relatively intolerant of reduced salinities likely to be encountered near the Beckton sewage treatment works.

Station 10, Crossness

The subtidal meiofauna at Crossness comprised a species-poor assemblage dominated by the euryhaline nematode species, *Sabatieria punctata* (1st., 2nd. and 4th. surveys) and the predator *Adoncholaimus thalassophygas* (3rd. survey). Where type 2A nematodes were present, their relative importance was outweighed by non-selective detritivore species. This was reflected in the 1B:2A ratios (>1.00). Throughout, the species present were essentially marine although some lower salinity species persisted in the January - March survey. These included *Ironus ignavus*, a predatory freshwater ironid, and a diplogasterid species - a fresh/brackish water species belonging to a family that includes predators as well as microbivorous nematodes. This station also marked the upstream limit of *Richtersia inaequalis*, a species that thrives in organically rich sediments but is more commonly associated with higher salinity conditions. A single specimen of *R. inaequalis* was observed in the January - March survey. This species became an important component of the

Figure 10. The dominance:diversity characteristics of the nematode assemblages observed at the Crossness intertidal sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at Crossness STW (Intertidal)
% Cumulative Abundance
0
20
40
60
80
100
Species Rank (Log Values)
0
.5
1
1.5
1989/2
1989/3
1989/4
1990/1

meiofauna at stations nearer the mouth of the estuary (see Stations 19 and 22). As noted elsewhere, the total number of species observed at the subtidal site was lower than at the intertidal (18 species as compared to 25 species).

Total meiofaunal densities were also higher in the intertidal sediments reaching nearly 62,000 individuals litre^{-1} sediment between July and September. The latter was due principally to the high densities of 3 nematode species, namely *Dichromadora geophila*, *Anoplostoma viviparum* and *Daptonema setosa*. *D. geophila* is a comparatively large type 2A chromadorid species that is common in low salinity habitats in Britain and parts of Europe where it may feed on diatoms. *A. viviparum* is also common in low salinity waters but is suggested to feed on Protozoa (Von Thun in Bouwman, 1983). *D. setosa*, in the Thames at least, is probably diatomivorous. The latter species predominated in the intertidal sample, representing approximately 83% of the nematode population in the April - June survey (Figure 10). Dominance was lower in all other intertidal samples examined.

The harpacticoid population in the subtidal samples was restricted to a relatively few unidentified copepodites that were observed in the first survey. The intertidal site offered a slightly higher diversity including copepodites and the diosaccids *Stenhelia giesbrechti* and *Paramphiascella* species. None was observed in the last survey. The harpacticoid complement and their densities were lower than might usually have been found at this level in other estuarine systems such as the Tees or Humber. Acari were observed in the intertidal samples only and were restricted to the oribatid species and *Copidognathus rhodostigma* found in the first 2 surveys.

Other faunal groups included low densities of newly settled bivalve molluscs in the subtidal sample (<25 litre^{-1}; January - March). The identity of these could not be determined and their ability to survive in these sediments was not known. In the intertidal samples from the 1st. survey, free amphipod embryos were noted (probably *Corophium* species). These would normally be retained by the adult in the marsupium until they were fully developed and capable of a free-existence. Whilst they might have become dislodged during sample preparation, there is some suggestion that *Corophium volutator* may release its embryos into the mud that forms its burrows which it then ventilates (Feil, pers. obsvn.; Hughes, pers. comm.). Ostracod species at densities of up to 75 litre^{-1} were also observed in the 1st. survey of the intertidal site.

Station 11, Purfleet

This station was characterised by variable densities of estuarine meiofauna. Species richness was again comparatively low with a cumulative total of 29 principal meiofauna species in the intertidal and 28 in the subtidal samples. In the subtidal samples, the nematodes *Daptonema setosa* and *Sabatieria punctata* were the only species observed in each of the surveys. Both species exhibited peak densities in the January - March survey (707 and 7069 individuals litre^{-1}, respectively). Maximum total nematode densities, however, were observed in the preceding survey (9,770 litre^{-1}, October - December) which correlated with the highest species richness (17 species). In the intertidal samples, nematode densities were much lower and ranged from 33 litre^{-1} (October - December), when 2 species only were observed, to 3,000 litre^{-1} (July - September). The peak density again correlated with the highest species richness (15 species).

The trophic groups represented in the nematode assemblages were strongly biased towards the non-selective detritivores (type 1B species). However, in the Thames, some of these species may well specialise, ingesting whole benthic diatoms for example (*D. setosa* and *Desmolaimus zeelandicus*).

The numbers of harpacticoid species were greatest at the subtidal site with a total of 6 taxa being recorded during the survey period. Most of these were present in the January-March survey (4 species) and were all epibenthic estuarine species. As with the nematodes, the variability was high and none was observed in the subtidal samples in the 2nd. survey. Three harpacticoid species observed in the intertidal samples - *Tachidius discipes* and 2 *Stenhelia* species. The latter are common estuarine species that can tolerate a broad range of salinities (0 to 30 ppt) and temperatures from below zero to 30 °C. As such, it is ideally suited to the extreme conditions that can occur in the littoral habitat. It was also the most abundant species in the sublittoral samples at this station.

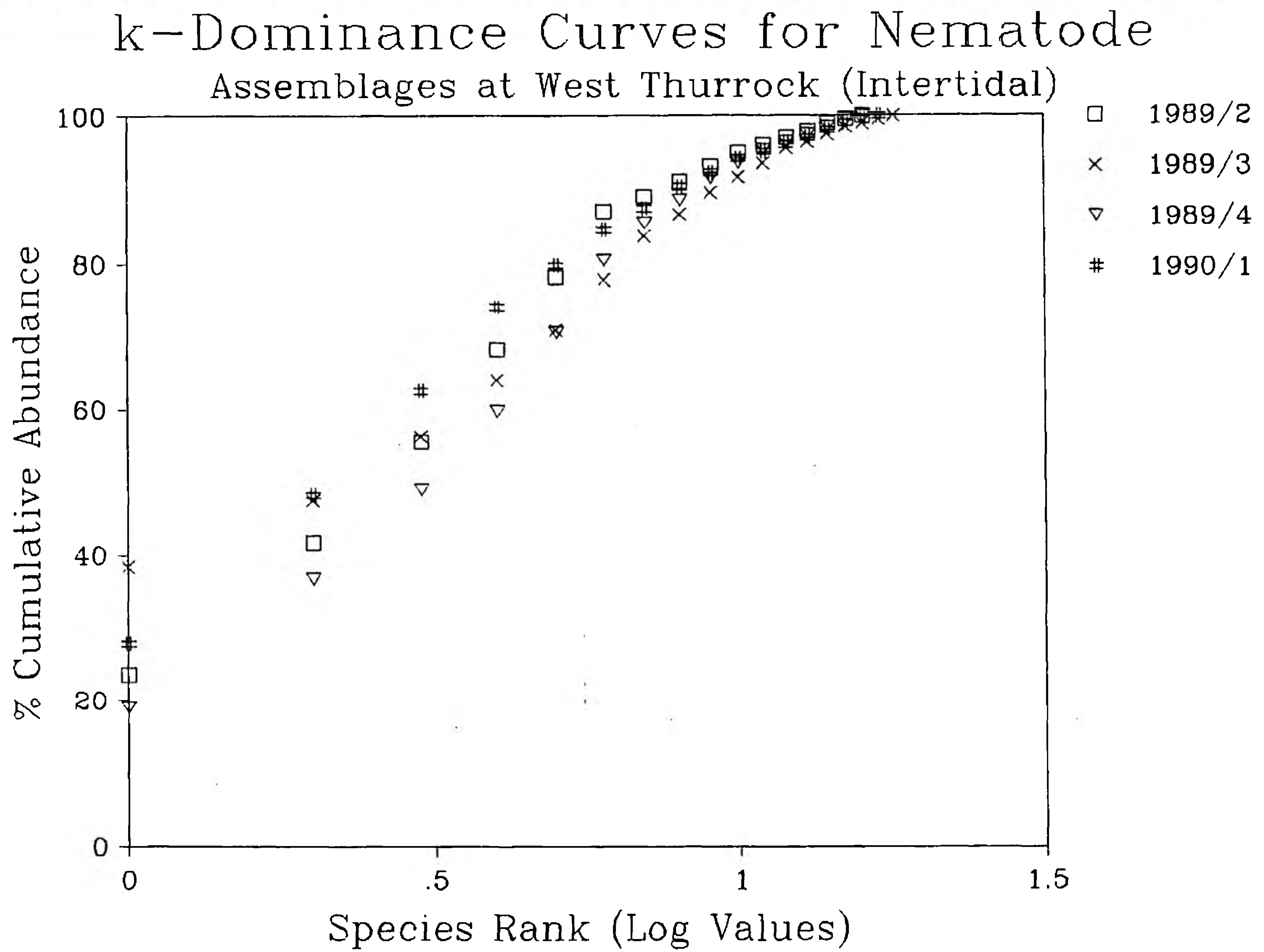
The Acari were sparsely distributed in the samples examined with *Copidognathus rhodostigma* occurring in the intertidal and sublittoral samples in April - June only and a record of single sublittoral oribatid in the January - March survey. Other invertebrate groups were also sparse; immature oligochaetes and crustacean nauplii accounted for the majority of other organisms observed in the sediments at this station. Amongst the algae, diatoms and their frustules were widespread and abundant.

Station 12, West Thurrock

The intertidal nematode population at West Thurrock was indicative of a comparatively healthy estuarine mud ecosystem. The feeding type ratios at this site were lower than might be expected for a moderate salinity mud but probably related to the high densities of type 2A species that exploit the surface blooms of benthic diatoms that occur during low tides. The intertidal population appeared to be more stable than those described further upstream with a higher degree of correspondence between the species complements. Six species were present in all 4 surveys and species richness varied little between the samples (16 to 18 species observed per survey). The dominance-diversity curves (Figure 11) exhibit a high degree of congruence with dominance varying between approximately 19 and 39% only. Further, the minimum faunal similarity (presence:absence) between any two sequential samples was approximately 48% (October - December and January - March surveys); the highest similarity of species complements was between the July - September survey and that in October - December assemblages (65%).

Nematode densities in the intertidal samples did not fall below 1,700 litre^{-1} sediment and were highest in the July - September samples (17,210 litre^{-1}). This peak was principally due to the densities of *S. punctata*. However, the populations of 11 other species also

Figure 11. The dominance:diversity characteristics of the nematode assemblages observed at the West Thurrock intertidal sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at West Thurrock (Intertidal)
% Cumulative Abundance
Species Rank (Log Values)
0
20
40
60
80
100
0
.5
1
1.5
1989/2
1989/3
1989/4
1990/1

attained their highest observed densities in this sample. In the subtidal samples, the nematode populations were more variable in composition. Of a cumulative total of 20 species (as compared to 36 in the intertidal samples), 1 species only was present in all 4 samples (*S. punctata*) and 4 species only were present in 2 or more samples. The sample from the 2nd. survey appears to be anomalous as it comprised 38 *S. punctata* litre^{-1} only. The reason for this is unknown but is believed to be reflected in the macrofaunal assemblage as well (Attrill, pers. comm.).

A similar dichotomy existed between the harpacticoid populations of the inter- and subtidal sites. In total, 8 taxa were recorded in the intertidal samples at densities of up to 270 harpacticoids litre^{-1} (July - September). Apart from diosaccid copepodites present in the 1st. survey, a single species only (*Amphiascus* species 2) was recorded in the subtidal samples in the final survey, and then at low density.

The other invertebrate phyla assemblages were characterised by the occasional occurrence of amphipod embryos (probably *Corophium* species) and newly settled gastropod larvae. A single tardigrade, *Batillipes* species (probably *B. mirus*) was observed at the subtidal site between October and December. This marks the furthest upstream site at which this marine species was observed.

Station 13, Gravesend

The marked increase in meiofaunal species richness at the subtidal and intertidal sampling sites at Gravesend as compared to upstream stations indicates, amongst other things, the increased influence of full strength seawater. Fifty-one nematode taxa were recorded at the intertidal site and included many true marine species. The presence of some coarse grained material observed amongst the fine, oxidised mud undoubtedly promoted this diversity, enabling selective epigrowth feeders to colonise the sediments. This said, the trophic balance was always in favour of non-selective detritivores (see 1B:2A ratios, Appendix 1; Section 5). Highest nematode densities occurred in October - December (14,286 litre^{-1}) and declined to their lowest observed value (2,199 litre^{-1}) in the final survey.

The subtidal nematode assemblage was less diverse and comprised a total of 29 species. With the exception of 4 species, all those present at this site were observed in the intertidal zone. *S. punctata* and *D. setosa* were the dominant species. Maximum densities of these species occurred in the 1st. survey between April and June and coincided with the maximum total nematode density (3,141 litre^{-1}). In each of the surveys non-selective detritivores predominated although all the other feeding types were well represented.

Harpacticoid copepods were abundant and diverse in the intertidal samples with densities ranging from 54 litre^{-1} to 2,144 litre^{-1}. The 8 taxa observed were all epibenthic and, in the July - September survey, included the freshwater *Bryocamptus* species found in the upstream samples. A similar species complement was found in the subtidal samples (6 epibenthic species) but these were largely restricted to the final survey. None was observed in the July - September survey which correlated with the lowest densities of harpacticoids observed in the littoral samples. Acari were poorly represented at Gravesend and a single specimen of *Copidognathus rhodostigma* was the only record (intertidal site; April - June).

Marine ostracods were a common component of the Gravesend fauna at densities of up to 120 $litre^{-1}$ occurring in 5 of the 8 samples from this station. In common with other sites such as West Thurrock, the 1st. survey also yielded several free amphipod embryos which might indicate the close proximity of *Corophium* beds. Newly settled bivalves were present in 3 of the 4 intertidal samples and 1 of the subtidal samples.

Station 14, Mucking

The reduced meiofaunal species complement at Mucking may relate to the proximity of the Creek and a localised zone of reduced salinity. However, with the exception of the plant-parasite *Criconemoides* species that was observed in the 1st. survey, there is little faunal evidence for the influence of fresh or low salinity water. Thirty-two nematode species were observed in total. Linhomoeid species 1 and *S. punctata* were the only species to occur in all the samples and were co-dominant (alternately dominant and sub-dominant). The family Linhomoeidae includes numerous estuarine and higher salinity species that are common in muddier substrata. The large, unarmed buccal cavities of many linhomoeid species (including Linhomoeid species 1) has lead them to be classified as non-selective detritivores (type 1B species). However, our own observations suggest that some may be highly specialised diatomivorous species capable of ingesting whole pennate and centric diatoms.

The high densities of Linhomoeid species 1 and *S. punctata* are reflected directly in the high total nematode densities and the elevated feeding type ratios (q.v.). Total nematode densities were uniformly high throughout the year and showed little seasonal variation, although a slight peak was observed in the 2nd. survey. This is unusual and might indicate a change over from herbivorous species to those capable of exploiting allochthonous organic material or the bacteria that it might support.

Six taxa of harpacticoid copepods observed in the Mucking samples. Of these *Halectinosoma curticorne* generally occurs in high salinity sites although it can tolerate reduced salinities. It is interesting to note that it was found in the 3rd. survey only at low density. This might relate to an earlier period of reduced freshwater flow from the upstream Thames catchment and the Creek.

Acari did not form a significant component of the meiofauna at Mucking and were represented by low densities of an oribatid species in the 2nd. and 3rd. surveys. Other invertebrates present in the samples confirmed the influence of marine communities, especially in the 3rd. survey when juvenile nemerteans were also observed.

Station 15, Blythe Sands

In comparison with upstream stations, increased densities of representatives of the nematode family Desmodoridae were apparent in the sandy muds present at Blythe Sands. This family contains predominantly marine species that specialise in feeding on marine diatoms and the epigrowth that develops on sand particles. The 47 nematode species observed during the 4 surveys are all characteristic of coarser sediments in outer estuaries of European river systems. *S. punctata* was the only species common to all surveys at this site. A faunal similarity analysis (Jaccard presence:absence index) shows the species complements present in the 1st. and 4th. surveys to be most similar (41.9%) and those described in the 1st. and 2nd. surveys to be the least similar (15.7%). Similarities between the 2nd. and 3rd. surveys and the 3rd. and 4th. are 21% and 24%, respectively. This implies a cyclical loss and recruitment of species during the year.

Highest nematode densities were observed in the April - June survey and the lowest in the July - September samples. This appears unlikely to have been a natural phenomenon and correlated with the appearance of abnormally high densities of detritus in the July - September Blythe Sands sample. The origin of this material was not known but it supported several microbivorous (type 1A) species many of which were unique to this quarter's sample. These included Leptolaimid species 1, *Leptolaimus* species 1 and *Monhystera filicaudata*. These species were more characteristic of stations upstream of Blythe Sands.

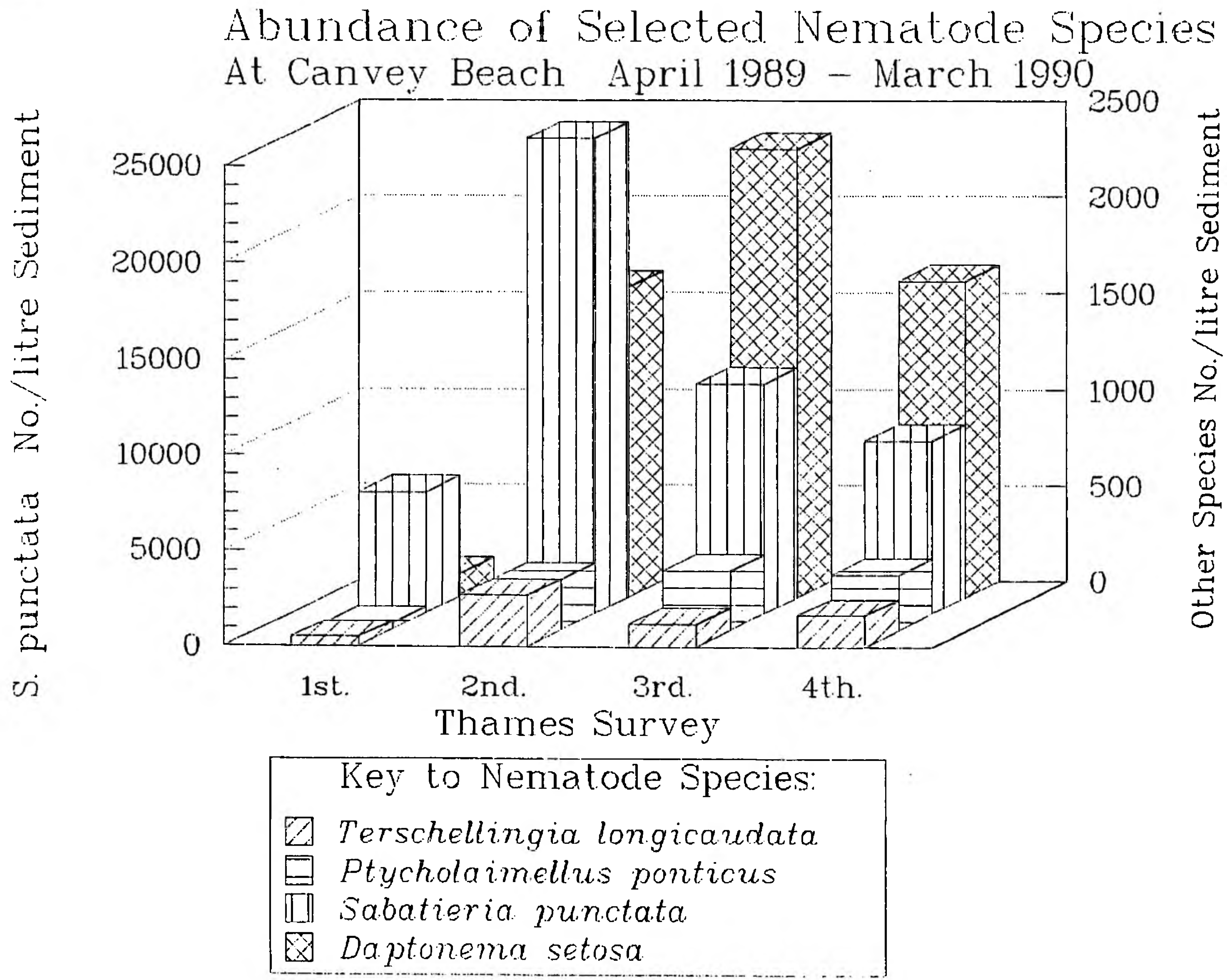
As with the nematodes, the densities of harpacticoid copepods were highest in the 1st. survey (3,320 litre^{-1}) and lowest in the 2nd. survey when none was observed. The numbers of individuals then increased to 108 litre^{-1} in the 4th. survey. The ectinosomatid species present dominated the assemblages and, in the case of *Ectinosoma melaniceps* in the 1st. survey, accounted for 99.5% of harpacticoids present. Species of the genus *Phyllothalestris* are generally associated with marine habitats and the occurrence of a species in the Blythe sample in the January - March survey may represent the inland extreme of its distribution.

Acarine assemblages comprised oribatid species present in the 2nd. and 3rd. surveys and *C. dentatus* in the 3rd. survey. Other groups included several spionid polychaete larvae (neochaetes) in the April - June and July - September samples. Marine and outer estuarine ostracods were observed in all the samples examined.

Station 16, Canvey Beach

A typical, species-rich, high salinity meiofaunal assemblage was present in the muds at Canvey Beach. The 4 assemblages of nematodes described contained a total of 64 species at densities of between 13,483 litre^{-1} (1st. survey) and 55,433 litre^{-1} (2nd. survey). Species discovery curves suggest that over 100 species might be present at this site. Seven species were present in all the samples examined and included *S. punctata* which was dominant in each case at between 22% and 53% (4th. and 1st. surveys, respectively). This suggests that the sediment may be detritus-rich. Although the majority of species were marine or estuarine, some freshwater species were observed. These included the plant-parasite, *Macroposthonia* species, more commonly found in agricultural soils and drainage ditches.

Figure 12. Histograms showing the seasonal abundance of *Terschellingia ,longicaudata*, *Sabatieria punctata*, *Daptonema setosa* and *Ptycholaimellus ponticus* at the Canvey Beach sampling station, Thames Estuary, April 1989 - March 1990. Note different density scale for populations of *S. punctata*.


Abundance of Selected Nematode Species
At Canvey Beach April 1989 – March 1990
S. punctata No./litre Sediment
Other Species No./litre Sediment
0
5000
10000
15000
20000
25000
0
500
1000
1500
2000
2500
1st.
2nd.
3rd.
4th.
Thames Survey
Key to Nematode Species:
Terschellingia longicaudata
Ptycholaimellus ponticus
Sabatieria punctata
Daptonema setosa

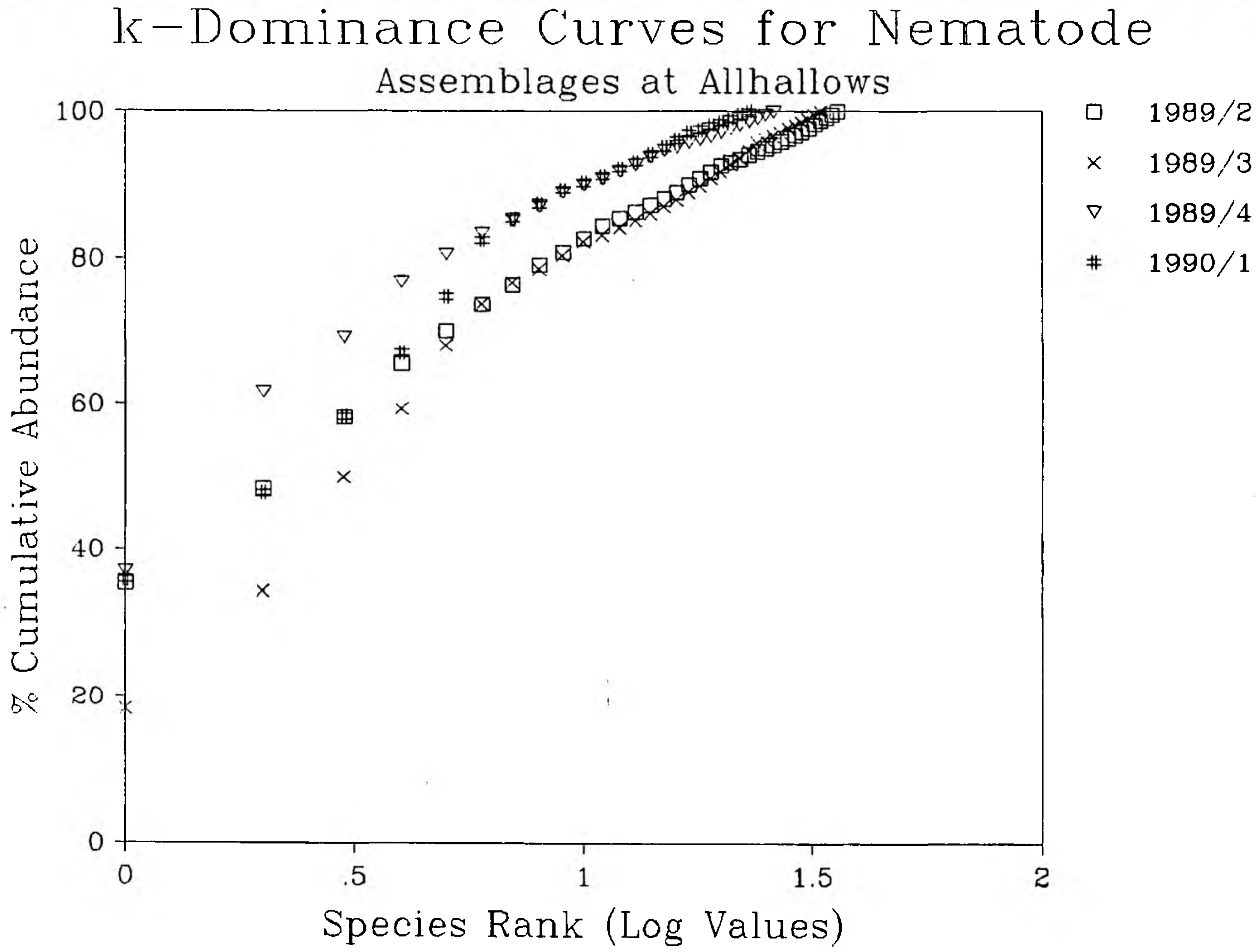
However, the relatively high densities of oxystominids, desmoscolecids and monoposthiids, amongst others, confirm the marine nature of this site.

The data for this sampling station illustrate the ecological strategies of several different species. *S. punctata* and *Terschellingia longicaudata* have maximal densities in the samples collected between July and September (Figure 12). As a non-selective detritivore, *S. punctata* is able to exploit the detritus and associated bacteria directly and its populations are rarely substrate-limited in the early part of the year. Consequently, densities of *S. punctata* increase steadily from spring onwards in response to the higher water temperatures. The autumn decline may reflect a reduction in suitable organic material and bacteria and/or competitive stress exerted by populations of other non-selective deposit feeders. *T. longicaudata* is a type 1A species and feeds selectively on deposits, thriving on the rich bacterial flora present in muddier sediments. Its numbers also increase in the early summer in response to elevated water temperatures. In contrast, *Ptycholaimellus ponticus* and *D. setosa* are dependent to a greater or lesser extent on diatoms as food and their populations peak in the final quarter of the year (October - December) after a steady period of increase over the summer months. Growth of their populations relies on spring and summer blooms of benthic and, possibly, planktonic diatoms and is probably held in check until these have occurred. Of the 4 species compared, *S. punctata* and *D. setosa* both exhibit the highest intrinsic rates of natural increase once suitable conditions arise. This opportunistic behaviour combined with their euryhaline physiology makes them characteristic elements of the meiofaunal assemblages of many of the stations examined in the Thames Estuary.

The assemblage of harpacticoid copepods observed at Canvey Beach was amongst the most diverse found in the Thames survey area. Twenty-one species were recorded during the course of the survey. All were of estuarine or marine origin and were predominantly epibenthic species feeding in the upper or surface layers of sediment on detrital material or, possibly, diatoms. Maximal total densities coincided with those of the nematodes in the 2nd. survey. However, 2 species only were observed in the July - September samples. These were *Amphiascus angusticeps* and *Cletodes limicola*. The latter species accounted for 2,687 of the total 2,731 individuals litre^{-1} observed. This contrasted with the January - March sample, in which the harpacticoid population comprised 11 species at a total density of 1,388 litre^{-1}. Intermediate numbers of species were present at lower densities in the 1st. and 3rd. surveys. The reasons for these marked changes in the harpacticoid assemblage are unknown.

Acari observed at Canvey Beach included *C. rhodostigma*, *C. dentatus* and an oribatid species. All were present at low densities and none was observed in the 3rd. and 4th. surveys. The low numbers and species of Acari in the Thames Estuary in general remains unexplained. Polychaetes, oligochaetes, ostracods, molluscs, turbellarians and crustacean nauplii were all well represented in the Canvey Beach samples. Comparatively high densities of Foraminifera again emphasised the high prevailing salinity at this site.

Figure 13. The dominance:diversity characteristics of the nematode assemblages observed at the Allhallows sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at Allhallows
% Cumulative Abundance
Species Rank (Log Values)
100
80
60
40
20
0
0
.5
1
1.5
2
1989/2
1989/3
1989/4
1990/1

Station 17, Allhallows

As at Canvey Beach, the nematodes present in the muddy sediments at Allhallows were almost exclusively marine and estuarine species. The assemblages observed in each survey were similar in composition suggesting that the habitat and prevailing conditions were stable during the period sampled. Of the 60 nematode species recorded, 7 were present in all 4 surveys and 13 species in 3 or more surveys. The 1B:2A feeding type ratios were all less than 1.00, emphasising the relative importance of diatomivorous species at this site. These were mostly chromadorid species although several cyatholaimids were also observed. Dominance-diversity characteristics of the Allhallows nematode assemblages are illustrated in Figure 13. The high degree of congruence of the k-dominance curves again indicates stability of environmental conditions. Dominance alternated between *Metachromadora scotlandica*, a large, epigrowth feeding (?) desmodorid (1st. and 3rd. surveys) and the diatomivore, *Ptycholaimellus ponticus* (2nd. and 4th. surveys). Peak nematode densities occurred in the July - September period, as at Canvey Beach, although almost equally high densities were recorded in the April- June and January - March surveys.

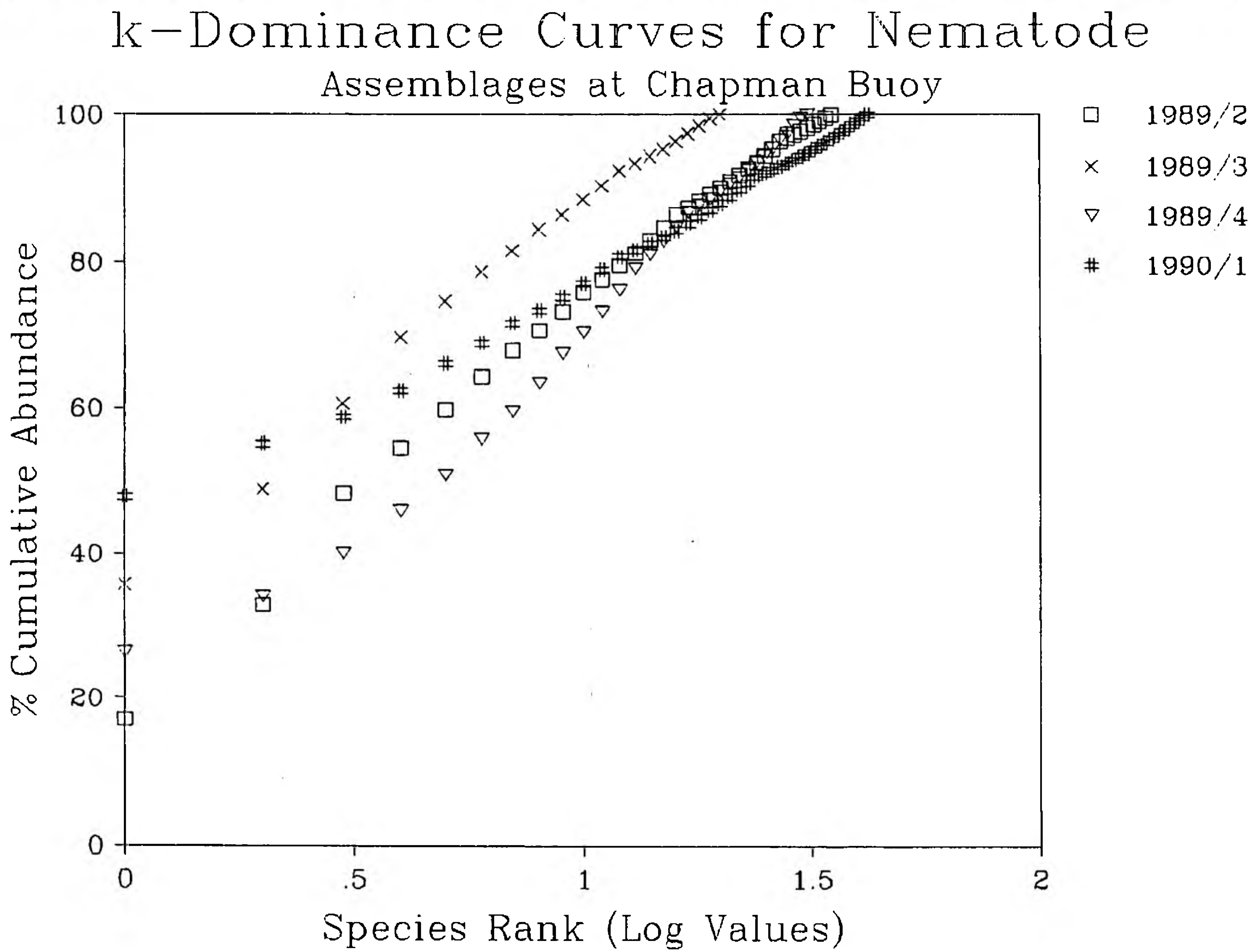
Several species of marine and estuarine harpacticoid copepods were observed with a total of 13 taxa recorded in the 4 surveys. These included a low density of *Tisbe* species (100 $litre^{-1}$) recorded in the 2nd. survey. Members of this genus are usually found in marine habitats although they may occur sporadically in estuaries. It is possible that some species of *Tisbe* feed on decaying macroalgae amongst which they are often found. The densities of harpacticoids correlated directly with those of the Nematoda throughout the year with a maximum density in the 2nd. survey and a minimum in the 3rd. Amongst the aquatic mites, the halacarid *Copidognathus rhodostigma* was the only species to be observed at Allhallows; this was present at a density of 40 $litre^{-1}$ in the 1st. survey (April - June).

A range of other invertebrate taxa were present in the Allhallows sediments, all essentially of marine origin. Kinorhyncha are a comparatively minor phylum and are generally sensitive to reduced to reduced salinities. As such they are largely restricted to coastal waters. A single specimen of a *Pycnophyes* species was observed at Allhallows during the first survey and several specimens during the 3rd. survey along with individuals belonging to the genus *Echinoderes*. This was the furthest that kinorhynchs were observed to penetrate into the Thames Estuary.

Station 18, Chapman Buoy

The total of 98 principal meiofaunal taxa (nematodes, harpacticoids and mites) observed at this mid-channel station was the highest observed during the year at any Thames sampling station. Examination of the granulometry reveals the heterogeneity of the Chapman Buoy sediments (Appendix II) which may well have accounted for this. Nematode and harpacticoid densities were highest between April and June and lowest between July and September rising again during the last 2 surveys. The lowest numbers of species of both these groups were observed during the 2nd. and 3rd. surveys. The reason for the decline in densities and species richness over the period July to December 1989 is not known.

Figure 14. The dominance:diversity characteristics of the nematode assemblages observed at the Chapman Buoy sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at Chapman Buoy
100
80
60
40
20
0
% Cumulative Abundance
0
.5
1
1.5
2
Species Rank (Log Values)
1989/2
1989/3
1989/4
1990/1

Amongst the nematodes, dominance in the 2nd. and 3rd. survey assemblages is intermediate between those of the 1st. and final surveys (Figure 14). This might indicate that several factors are operating as a single tolerant/opportunist species or small group of species does not flourish at these times. Dominance is greatest in the final survey when *Daptonema normandica* accounts for nearly 50% of the individuals present in the population.

Feeding type ratios reflected the muddy nature of the sediment (obscured in the granulometric studies by the high proportion of coarse material (principally wood and shell fragments)). In all cases the 1B:2A ratio was greater than 1.00 as non-selective detritivores predominated. This was least pronounced in the 2nd. survey.

The harpacticoid assemblages were unique to each survey with the majority of the 18 taxa observed occurring in the January - March sample (13 taxa). This high diversity of harpacticoid species coincided with the highest number of species recorded in the nematode samples (42 species). Acari were not seen in the October - December survey. However, the 2 species of *Copidognathus* and an oribatid species were represented in the other samples.

High densities of many other marine groups were noted at Chapman Buoy. The presence of ctenostome bryozoans and detached thecate and athecate hydroids indicated the proximity of semi-permanent or permanent substrata. Small epibenthic and interstitial marine amphipods were especially common in the January - March samples at densities of up to 300 $litre^{-1}$ sediment.

Station 19, Southend

Exceptionally high densities of nematodes were recorded in the intertidal samples from Southend. The sandy muds at this site supported between 85,700 and 153,00 nematodes $litre^{-1}$ and exhibited a steady increase in densities from the beginning to the end of the survey period. In contrast, the sandier sediments at the Southend subtidal sampling site yielded between 2,911 and 10,471 nematodes $litre^{-1}$. Dominance ranges also varied between the 2 sites. In the intertidal nematode assemblages dominance was comparatively low (<31%; Figure 15) and varied little between the surveys (minimum 19%). Dominance was higher in the subtidal samples (Figure 16) ranging from approximately 26% to 44%.

The subtidal assemblages were characterised throughout the year by *Richtersia inaequalis* which dominated in each survey. This selachinematid species is often abundant in sediments that contain elevated levels of organic material where the ambient salinity is sufficiently high. High densities of *R. inaequalis* have been recorded by Trett *et al.* (1990) in the Irish Sea in a study of the Fylde Coast sewage outfalls, including that at Blackpool. In the present study, the 1B:2A ratios were all greater than 1.00 except in the final survey where large numbers of juvenile cyatholaimids were observed (type 2A species grouped under the taxon "Cyatholaimid species 2"). Sandy sediments are more usually characterised by low 1B:2A ratios as high densities of non-selective detritivores rarely occur and

Figure 15. The dominance:diversity characteristics of the nematode assemblages observed at the Southend intertidal sampling station between April 1989 and March 1990.

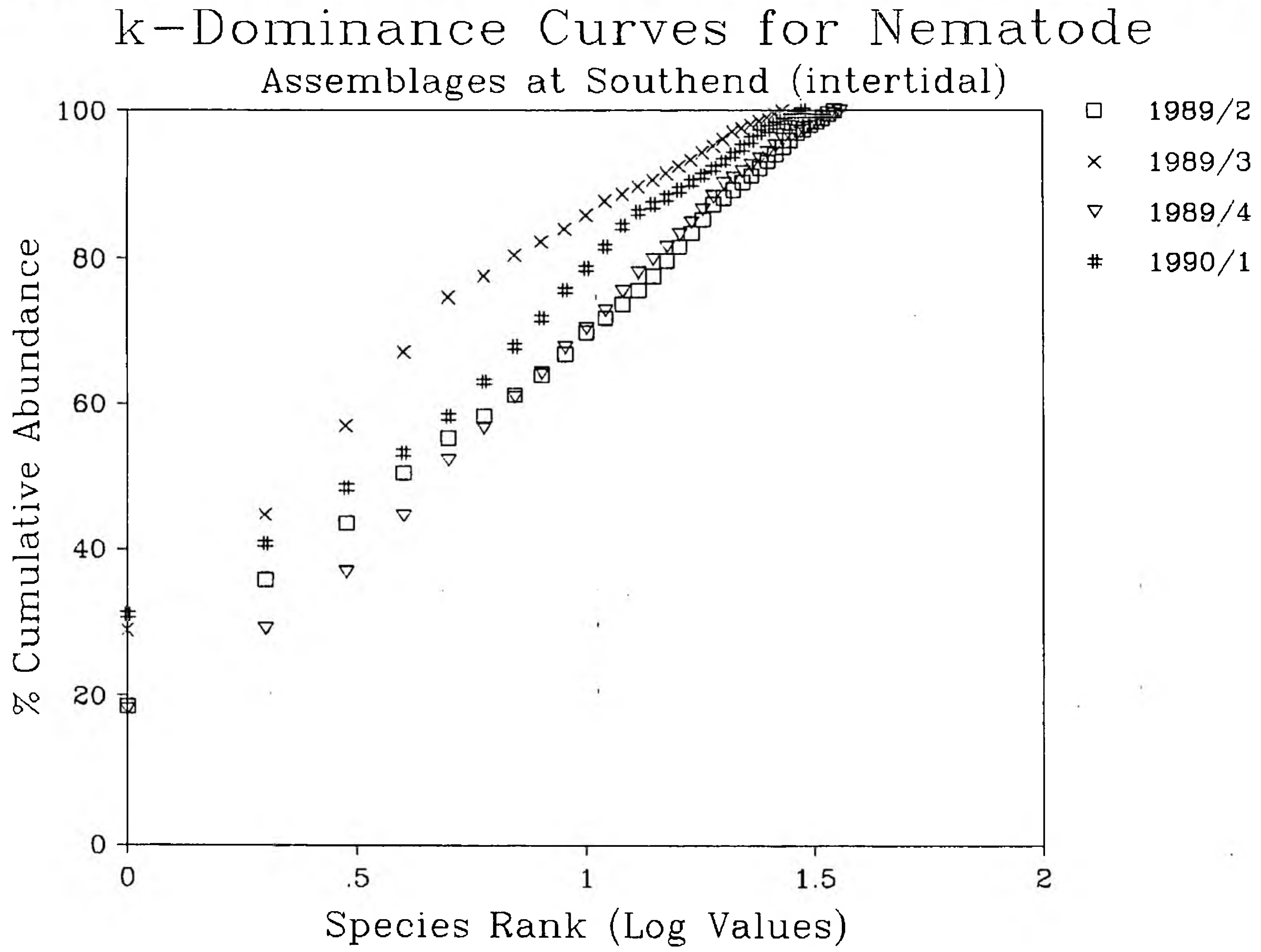
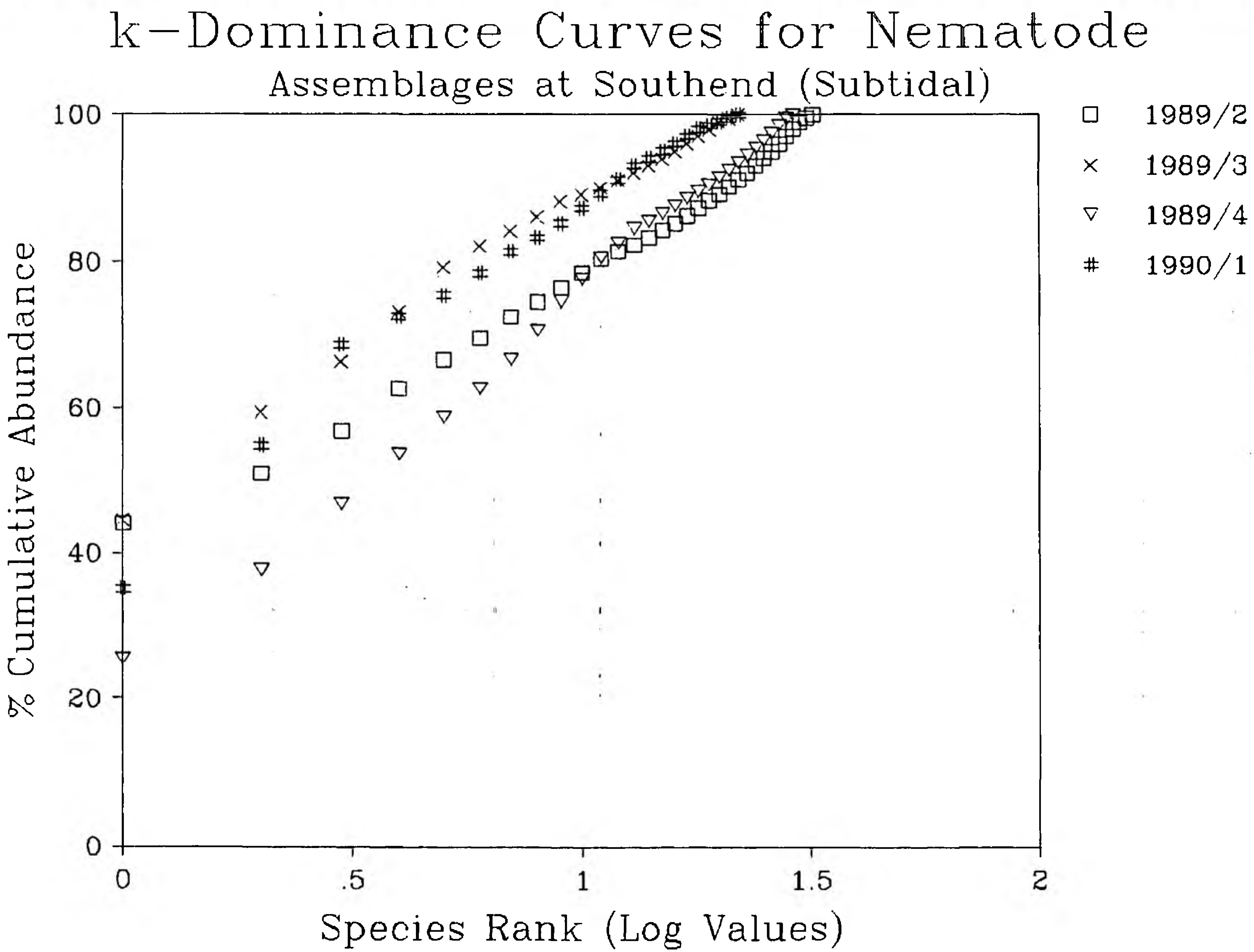

k-Dominance Curves for Nematode
Assemblages at Southend (intertidal)
% Cumulative Abundance
Species Rank (Log Values)
100
80
60
40
20
0
0
.5
1
1.5
2
1989/2
1989/3
1989/4
1990/1

Figure 16. The dominance:diversity characteristics of the nematode assemblages observed at the Southend subtidal sampling station between April 1989 and March 1990.



k-Dominance Curves for Nematode
Assemblages at Southend (Subtidal)
% Cumulative Abundance
Species Rank (Log Values)
0
20
40
60
80
100
0
.5
1
1.5
2
1989/2
1989/3
1989/4
1990/1

epipsammic and diatomivorous species are favoured.

Although similar to one another in species composition (minimum faunal similarity between consecutive surveys 42%), each of the intertidal assemblages was dominated by a different species. All were type 2A species and contributed strongly to the low 1B:2A ratios. In this context, the family Desmodoridae was well represented, numerically, in each of the intertidal samples. Eight species occurred in all 4 intertidal surveys including *Sabatieria punctata*, although this 1B species did not account for more than 10% of any of the nematode populations. As in the subtidal samples, *R. inaequalis* was also present in each survey but at this site represented less than 1% of the nematodes present.

Thirteen harpacticoid taxa were identified in the 4 surveys of the intertidal site at Southend. These were predominantly epibenthic species, many belonging to the family Diosaccidae. The high densities recorded in the April - June survey declined throughout the year from 3,154 to 258 litre^{-1} in the 4th. survey. Fewer species were found in the subtidal samples (total 6 taxa) and their densities were lower, ranging from 18 litre^{-1} (January - March) to 281 litre^{-1} (October - December).

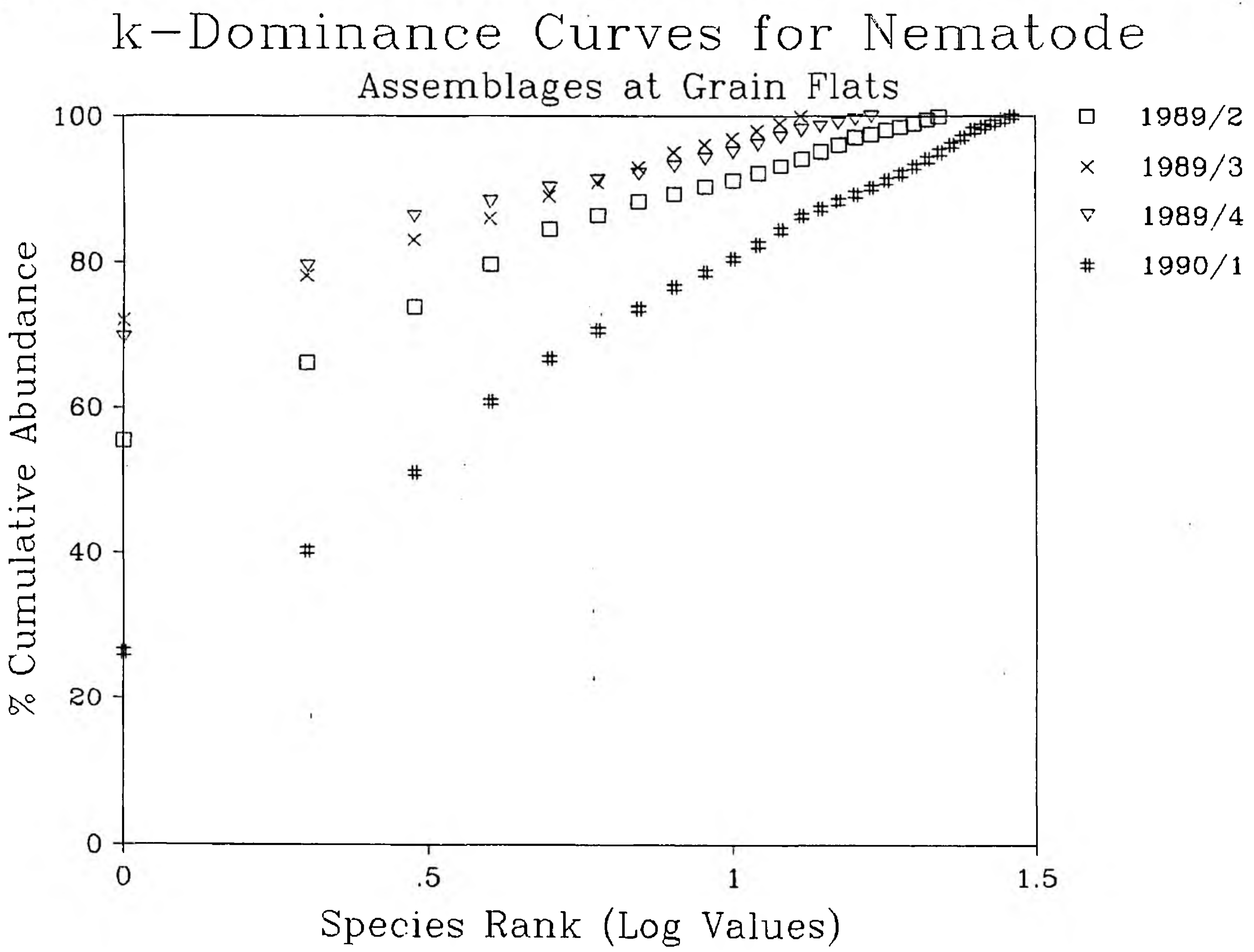
Low densities of oribatid species were noted in 3 of the 4 intertidal samples which might have related to mite populations present in decaying intertidal material. The only acarine observed in the subtidal samples was a single individual of *Copidognathus dentatus* in the final survey.

In general the intertidal assemblages of other invertebrate groups were more diverse than those observed in the subtidal samples. The marine tardigrade *Batillipes mirus* was recorded at both the inter- and subtidal sites at low densities (8 - 16 litre^{-1}) although it was not present in all samples. Turbellaria, however, were ubiquitous. The distribution of ostracods is noteworthy in that they occurred at moderate densities (50 - 125 litre^{-1}) in all the intertidal samples that were examined but were not seen in any of the subtidal samples.

Station 20, Grain Flats

The meiofaunal assemblages at the Grain Flats sampling site are almost indistinguishable from those of sites around the southern coast of England and the southern shores of the North Sea coast of Europe. However, the lower total number of nematode species observed (55 species over the 4 surveys) at Grain Flats was lower than at more inland stations under the influence of full strength seawater. This might have reflected a change in sediment type. In the 1st. survey the sediment conformed to a fine sand that contained some silty material (mostly frustules of centric marine diatoms). During the 2nd. and 3rd. survey the sediment type changed progressively through a muddy sand to a mud with a low sand content. In the final survey the sediment returned to a muddy fine sand. As expected, the highest numbers of nematode species were associated with the coarser grained sediments in the 1st. and 4th. surveys (22 and 29 species, respectively) whilst the muddier sediments of the 2nd. and 3rd. surveys were less species rich (13 and 17 species,

Figure 17. The dominance:diversity characteristics of the nematode assemblages observed at the Grain Flats sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at Grain Flats
% Cumulative Abundance
100
80
60
40
20
0
0
.5
1
1.5
Species Rank (Log Values)
1989/2
1989/3
1989/4
1990/1

respectively). The same pattern was also noted amongst the harpacticoid copepods although fewer species were observed (see below). The muddier conditions appear to correlate with periods of reduced flow of the Thames and Medway and may form part of an annual cycle.

The changes in species numbers may not be fully explained by the altered granulometry. Although muddy soft substrates support lower numbers of meiofaunal species than coarser grained sediments, they usually support higher total densities of individuals, especially in the marine environment. In the present study, the higher silt or silt/clay fraction sediments yielded 1,278 nematodes litre^{-1} (2nd. survey) and 5,246 nematodes litre^{-1} (3rd. survey). The sands of the 1st. and final surveys maintained 15,409 and 14,179 individuals litre^{-1}, respectively. This cannot be explained on existing data, especially as the densities of the nematode populations would be expected to increase over the summer months. The change in sediment type also correlated with a marked increase in dominance (Figure 17) with *S. punctata* accounting for over 70% of the nematode population during the 2nd. and 3rd. surveys.

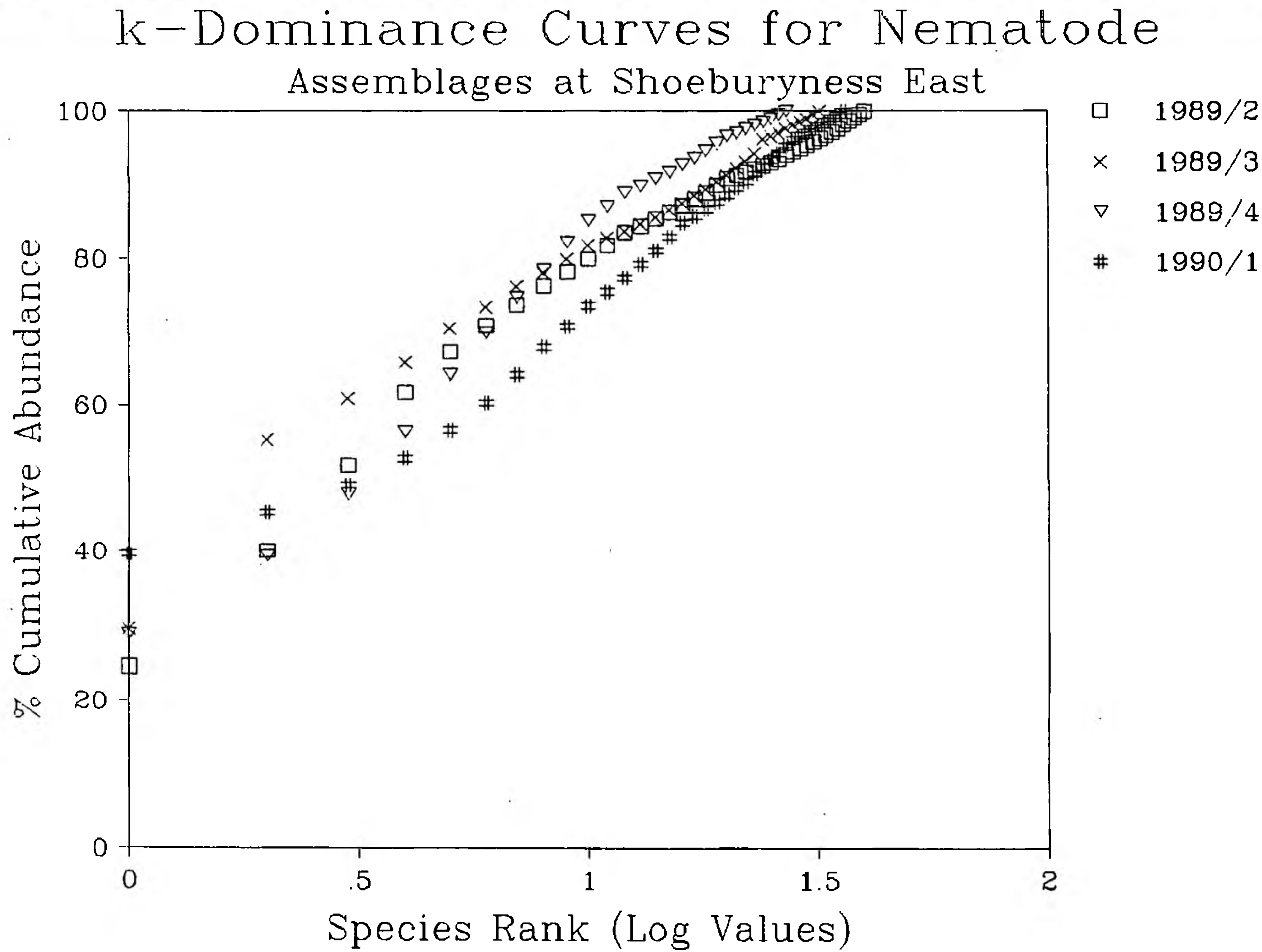
Given its near marine location, the harpacticoid copepod assemblage of Grain Flats was depauperate with only 3 species being identified over the year (cf. 18 taxa at Stations 18 and 21). Acari were not observed in any of the samples examined. Densities and diversity of other invertebrate taxa (mostly marine species) were also lowest in the July - December surveys. The 1st. and 4th. surveys produced comparatively high densities of meiofaunal kinorhynchs, ostracods, turbellarians and tardigrades and several other, transitional meiofaunal groups such as poylchaetes and bryozoans.

Station 21, Shoeburyness East

This site was second only to Chapman Buoy (Station 18) in the species richness of the principal meiofaunal groups that it supported. A total of 90 taxa (nematodes, harpacticoids and mites) was noted. The species composition of the meiofaunal assemblages was comparatively stable throughout the year, with percentage faunal similarities (presence:absence) of 38%, 44% and 51% between consecutive surveys and 47% between the 1st. and 4th. surveys. This stability is also reflected in the dominance-diversity characteristics of the Shoeburyness East nematode assemblages (Figure 18) where dominance varied between 27% and 39% only. The dominant species were all members of the Microlaimidae - type 2A species characteristic of coarser grained sediments. The feeding type ratios were accordingly lower than 1.00 throughout the year although several non-selective detritivore species, such as *S. punctata* and species of *Daptonema*, *Theristus* and *Ascolaimus*, were present at low densities. Total nematode densities were high for a fine sand and ranged from 37,108 litre^{-1} (October - December) to 125,012 litre^{-1} (January - March).

With the exception of *Bryocamptus* species, which is a freshwater species, the harpacticoids were all of marine or outer estuarine origin and typical of British waters. The *Arenostella* species noted in the 3rd. survey (October - December) is a small, vermiform species with reduced limbs which adopts a true interstitial existence. Species of this and

Figure 18. The dominance:diversity characteristics of the nematode assemblages observed at the Shoeburyness sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at Shoeburyness East
% Cumulative Abundance
Species Rank (Log Values)
0
20
40
60
80
100
0
.5
1
1.5
2
1989/2
1989/3
1989/4
1990/1

related genera are common in clean, well oxygenated sands and exceptionally high densities (> 1,000 $litre^{-1}$) have been recorded in pollution surveys off the North Sea coast of France (Feil, pers. obsvn.).

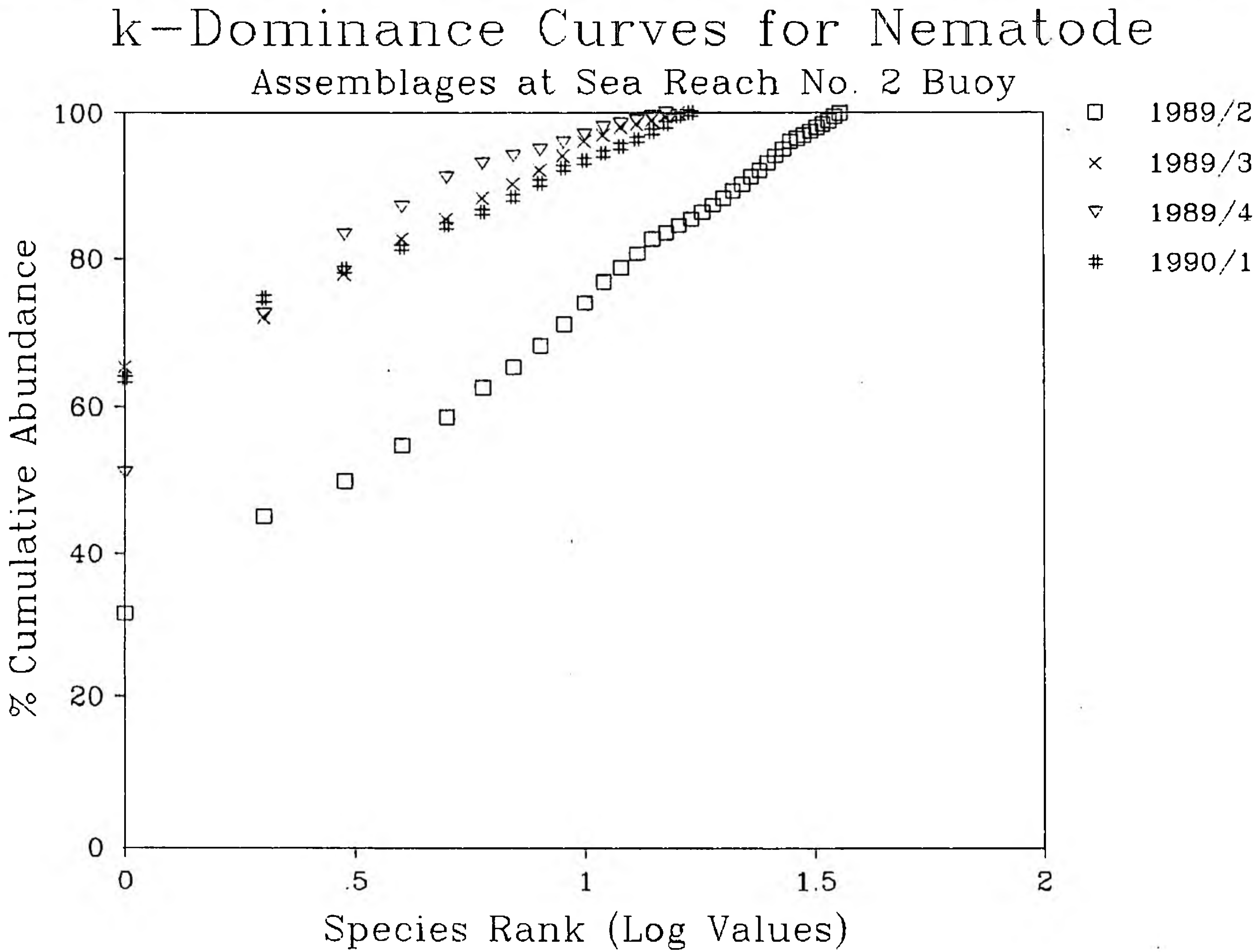
Acarine species were not well represented at the Shoeburyness East site and a single unidentified halacarid mite was noted in the 2nd. survey only. In temperate waters, densities of halacarid mites are not often high in coarser sediments unless macro- or filamentous algae are also present. This occasionally occurs were fish farm effluent is discharged to coastal waters (Trett and Forster, pers. obsvn.). Other invertebrate phyla were abundant and included interstitial marine ciliates, larvae of littorinid gastropod molluscs and one of the few records of Gnathostomulida in this part of England. All groups were in keeping with a clean, marine sand habitat.

Station 22, Sea Reach No. 2 Buoy.

Potentially the most marine of the Tideway habitats surveyed, Sea Reach No. 2 Buoy yielded a variable assemblage of meiofaunal species. As at the Grain Flats site (Station 20) this may again have related to a partial change that was noted in sediment type; fine sands present in the 1st. survey were replaced by a muddier sand in subsequent surveys. Fifty-seven nematode taxa were recorded, 36 in the 1st. survey and between 15 and 17 in the following surveys. That this decline in species richness was related in part to substrate type may be indicated by the nematode feeding type ratio. This became greater than 1.00 in the samples examined from July 1989 onwards, indicating a greater relative importance of the non-specialist deposit feeding species as opposed to the highly specialist epipsammic and diatomivorous species. Unlike the Grain Flats nematode assemblages, the densities recorded were uniformly high throughout the year. Dominance also increased after the 1st. survey and remained high during the rest of the survey period (Figure 19). As at the Southend subtidal site, the dominant species in each of the surveys was *Richtersia inaequalis* which accounted for between 33 and 65% of the nematodes observed. As stated earlier (see Station 19), this probably indicates elevated levels of organic material in the sediments at this station.

Given its location, comparatively few harpacticoid copepod species were observed at Sea Reach No. 2 Buoy (total 8 taxa). Those present included the larger epibenthic, detritivorous species. Acari were observed at low densities in all the samples except that collected in July - September. Other invertebrate phyla were represented by several species at low densities in the 1st. survey and fewer species in subsequent surveys. Gastrotrichs were notable records at this site although very few were seen.

Figure 19. The dominance:diversity characteristics of the nematode assemblages observed at the Sea Reach No. 2 Buoy sampling station between April 1989 and March 1990.


k-Dominance Curves for Nematode
Assemblages at Sea Reach No. 2 Buoy
% Cumulative Abundance
Species Rank (Log Values)
0
20
40
60
80
100
0
.5
1
1.5
2
1989/2
1989/3
1989/4
1990/1

5. Acknowledgements

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7. APPENDIX

Thames Estuary Survey

Sections 1 to 5

Meiofaunal Species Lists and Faunal Results Tables

Section 1

CUMULATIVE MEIOFAUNAL SPECIES LIST

THAMES ESTUARY

April 1989 - March 1990

COPEPODA

Copepoda: Harpacticoida

A. Ameiridae:

Leptomesochra macintoshi

B. Canthocamptidae:

Attheyella species
Bryocamptus (*Limnocamptus*) species (?*echinatus*)
Canthocamptus species
Elaphoidella gracilis
Epactophanes richardi
Moraria species

C. Canuellidae:

Canuella perplexa

D. Cletodidae:

Cletodes longicaudatus
Cletodid species
Enhydrosoma propinquum

E. Diosaccidae:

Amphiascella species
Amphiascoides species
Amphiascus angusticeps
Amphiascus species 1
Amphiascus species 2
Amphiascus species 3
Amphiascus varians
Bulbamphiascus species
Diosaccid copepodites
Paramphiascella species
Pseudomesochra species (?*latifurea*)
Schizopera clandestina
Stenhelia aemula
Stenhelia giesbrechti
Stenhelia palustris
Stenhelia species
Typhlamphiascus species

F. Ectinosomatidae:

Arenostella species
Ectinosoma melaniceps
Ectinosoma species
Halectinosoma curticorne
Halectinosoma herdmani
Halophytophilus species
Pseudobradyia brevicornis

G. Harpacticidae:

Harpacticella species

H. Laophontidae:

Laophonte species (?*denticornis*)
Onychocamptus species (?*bengalensis*)

I. Longipediidae:

Longipedia coronata
Longipedia species

J. Tachidiidae:

Microarthridion species
Tachidius discipes
Tachidius species

K. Thalestridae:

Idomene forficata
Phyllothalestris species

L. Tisbidae:

Tisbe species

M. Unascribed specimens:

Unidentified copepodites

NEMATODA

i. Adenophorea: Araeolaimida

A. Plectidae:

Plectid species (?*Paraplectonema*)
Plectus granulosus

ii. Adenophorea: Enoplida

A. Alaimidae:

Alaimus species

B. Anoplostomatidae:

Anoplostoma viviparum
Chaetonema riemanni

C. Anticominidae:

Anticoma acuminata

D. Cryptonchidae:

Cryptonchus species

E. Enchelidiidae:

Belbolla teisseiri
Calyptronema maxweberi
Chaetonema riemanni
Eurystomina species

F. Enoplidae:

Enoplus brevis
Enoplus communis

G. Ironidae:

Ironus ignavus

H. Leptosomatidae:

Pseudocella coecum

I. Oncholaimidae:

Adoncholaimus fuscus
Adoncholaimus thalassophygas
Oncholaimellus calvadosicus
Oncholaimid species 1
Oncholaimid species 2 (?*Viscosia*)
Oncholaimus brachycercus
Oncholaimus campylocercoides
Oncholaimus oxyuris
Oncholaimus skawensis
Viscosia cobbi
Viscosia elegans
Viscosia glabra
Viscosia species
Viscosia viscosa

J. Oxystominidae:

Halalaimus capitulatus
Halalaimus isaitshikovi
Halalaimus longicaudatus
Nemanema cylindraticaudatum
Oxystomina asetosa
Oxystomina elongata
Thalassoalaimus tardus

K. Prismatolaimidae:

Prismatolaimus species (?*verrucosus*)
Prismatolaimus stenurus

L. Thoracostomopsidae:

Enoploides brunettii
Enoplolaimus vulgaris
Mesacanthion diplechma

M. Tripyloididae:

Bathylaimus capacosus
Tobrilus gracilis
Tobrilus species
Tripyla affinis
Tripyloides marinus
Tripyloides species

iii. Adenophorea: Chromadorida

A. Aegialoalaimidae:

Aegialoalaimid species (?*Aegialoalaimus*)

B. Ceramonematidae:

Dasynemella species
Ceramonematid species

C. Chromadoridae:

Chromadora macrolaima
Chromadorella species
Chromadorid species
Chromadorina viridis
Chromadorita leuckarti
Chromadorita species
Chromadorita tentabunda
Dichromadora cephalata
Dichromadora geophila
Dichromadora species (?*cucullata*)
Euchromadora vulgaris
Hypodontolaimus balticus
Hypodontolaimus inaequalis
Innocuonema species
Neochromadora poecilosoma
Neochromadora tricophora
Prochromadora species (?*orleji*)
Prochromadorella attenuata
Prochromadorella ditlevseni
Ptycholaimellus ponticus
Punctodora species
Spilophorella candida
Spilophorella paradoxa

D. Comesomatidae:

Comesomatid species
Sabatieria breviseta
Sabatieria celtica
Sabatieria longisetosa
Sabatieria punctata
Setosabatieria species (?*hilarula*)

E. Cyatholaimidae:

Cyatholaimid species 1 (?*Cyatholaimus*)
Cyatholaimid species 2
Cyatholaimus species (?*gracilis*)
Marylynnia species
Paracanthonchus caecus
Paracanthonchus heterodontus
Paracanthonchus longus
Paracanthonchus species
Paracyatholaimus intermedius
Paralongicyatholaimus species
Pomponema species
Praeacanthonchus opheliae
Praeacanthonchus species

F. Desmodoridae:

Desmodora communis
Desmodora species
Desmodorid species 1 (?*Chromaspirina*)
Desmodorid species 2
Metachromadora remanei
Metachromadora scotlandica
Metachromadora species
Metachromadora suecica
Molgolaimus cuanensis
Onyx perfectus
Pseudonchus species
Sigmophoranema rufum
Spirinia parasitifera

G. Desmoscolecidae:

Desmoscolex falcatus
Pareudesmoscolex species
Quadricoma species

H. Leptolaimidae:

Antomicron elegans
Camacolaimus barbatus
Camacolaimus tardus
Chronogaster species
Deontolaimus species
Leptolaimid species
Leptolaimoides species
Leptolaimus papilliger
Leptolaimus species 1 (?*ampullaceus*)
Leptolaimus species 2 (?*limicolus*)

Leptolaimus species 3
Onchium conicaudatus
Stephanolaimus jayassrei
Stephanolaimus species (?*spartinae*)

I. Microlaimidae:

Calomicrolaimus honestus
Microlaimus conothelis
Microlaimus globiceps
Microlaimus marinus
Microlaimus robustidens

J. Monoposthiidae:

Monoposthia costata
Monoposthia mirabilis

K. Selachinematidae:

Gammanema rapax
Halichoanolaimus robustus
Richtersia inaequalis

iv. Adenophorea: Monhysterida

A. Axonolaimidae:

Ascolaimus elongatus
Axonolaimus paraspinosus
Axonolaimus species
Odontophora setosa
Odontophora villoti

B. Coninckiidae:

Coninckia species

C. Diplopeltidae:

Campylaimus species (?*inaequalis*)
Diplopeltid species (?*Diplopeltula*)

D. Linhomoeidae:

Desmolaimus zeelandicus
Eleutherolaimus species
Linhomoeid species 1 (?*Terschellingia*)
Linhomoeid species 2

Linhomoeid species 3
Linhomoeus species 1
Linhomoeus species 2
Terschellingia longicaudatus

E. Monhysteridae:

Diplolaimella ocellata
Monhystera filicaudata
Monhystera disjuncta
Monhystera species
Monhystera stagnalis
Monhystera vulgaris
Monhysterid species 1
Monhysterid species 2

F. Sphaerolaimidae:

Parasphaerolaimus species (??*paradoxa*)
Sphaerolaimus balticus
Sphaerolaimus gracilis

G. Xyalidae:

Daptonema furcata
Daptonema normandica
Daptonema setosa
Daptonema tenuispiculum
Daptonema species 1
Daptonema species 2
Linhystera speices
Paramonhystera species
Theristus acer
Theristus species 1
Theristus species 2
Theristus species 3
Xyalid species 1
Xyalid species 2

v. Adenophorea: Trefusida

A. Trefusiidae:

Halanonchus species
Rhabdocoma riemanni
Trefusia longicaudata
Trefusia zostericola
Trefusiid species

vi. Adenophorea: Dorylaimida

A. Dorylaimidae:

Dorylaimid species 1 (?*Dorylaimus*)
Dorylaimid species 2
Dorylaimid species 3
Labronema species

B. Mononchidae:

Iotonchus species
Mononchus aquaticus

vii. Secernentea: Rhabditida

A. Cephalobidae:

Acrobeles species
Cephalobus species

B. Diplogasteridae:

Butlerius butleri
Diplogaster species
Diplogasterid species
Paroigolaimella bernensis

C. Panagrolaimidae:

Panagrolaimus species

D. Rhabditidae:

Diploscapter coronata
Mononchoides species
Mononchoides striatus
Panagrellus species
Rhabditid species 1
Rhabditid species 2
Rhabditis species

viii. Secernentea: Tylenchida

A. Criconematidae:

Criconema species
Criconemoides species
Macroposthonia species

B. Heteroderidae:

Heteroderid species (?*Globodera*)

C. Hoplolaimidae:

Hirschmanniella species

D. Tylenchidae:

Tylenchid species 1
Tylenchid species 2
Tylenchid species 3

ix. Unascribed Species

Miscellaneous unidentified specimens

ACARINA

i. Prostigmata

A. Bdellidae:

Bdellid species

B. Oribatidae:

Oribatid species

ii. Cryptostigmata

A. Hydracarina:

Hydracarine species

B. Halacaridae:

Copidognathus dentatus
Copidognathus rhodostigma
Unidentified species

Section 2

QUARTERLY MEIOFAUNAL RESULTS LISTS

April 1989 - March 1990

Station TW1	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Diplogaster sp.	376			
Tobrilus gracilis	1953	7850	2300	85
Monhystera stagnalis	901	1926	1054	36
Labronema sp.	676			
Dichromadora geophila	1803			
Chromadorella sp.	300			
Chromadorina viridis	676		144	24
Hirschmanniella sp.	150			24
Tripyla affinis	75	741		
Dorylaimid sp. 1	+	148	48	24
Monhystera vulgaris		1185		
Paroigrolaimellus bernensis		592	383	
Mononchoides sp.		444		
Tobrilus sp.		592		12
Mononchus aquaticus		296		85
Tylenchid sp. 1		148		24
Dorylaimid sp. 2		148		24
Ironus ignavus		296		12
Paracanthonchus sp.		148	48	
Paracyatholaimus intermedius				278
Tylenchid sp. 2				24
Daptonema normandica				109
Chromadorid sp. 1				12
Plectus granulosus				85
Criconema sp.				24
Chromadorita leuckarti				121
Monhystera filicaudata				109
Heteroderid sp.				12
Rhabditid sp. 1				12
Daptonema setosa				12
Cephalobus sp.				73
Iotonchus sp.				24
Dorylaimid sp. 3				12
Panagrolaimus sp				12
Indet.	1502	889	383	206
1B:2A	1.03	57.00	12.00	0.69
N	8402	15847	5127	1560
S	12	14	7	26

continued ...

Station TW1 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Pseudomesochra sp.	242			
Diosaccid copepodites	88			
Idomene forficata	66			
Tachidius sp.	44			
Laophonte sp.	22			
Canthocamptus sp.	159			
Moraria sp.	22			
Elaphoidella gracilis	67			
Bryocamptus sp.			8	
Onychocamptus sp.			92	
Attheyella sp.				30
N	573	0	100	30
S	8	0	2	1
Acari				
Bdellid sp.				10
Oribatid sp.				10
N	0	0	0	20
S	0	0	0	2

Station TW2	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Tobrilus gracilis	1249	2448	284	601
Diplogaster sp.	187			
Paracanthonchus sp.	156			
Monhysterid sp. 1	344		417	
Tripyla affinis	187		19	+
Mononchoides striatus	94			63
Monhystera stagnalis	250	306	19	158
Ironus ignavus	94	31	19	32
Xyalid sp. 1	625			
Dorylaimid sp. 1	31			63
Plectus granulosus	31	31		63
Chromadorina viridis	31	+		
Dichromadora geophila	+	61		32
Mononchus aquaticus	+	31		
Viscosia sp.	+			
Rhabditid sp.	+		19	63
Chromadorella sp.	+			
Tobrilus sp.		61		32
Heteroderid sp.		31		32
Punctodora sp.		31		
Mononchoides sp.		31		
Leptolaimus sp. 1			57	
Diplolaimella ocellata			38	
Paroigrolaimellus bernensis			95	221
Theristus sp. 1			38	
Butlerius butleri			95	475
Diplogasterid sp.			76	
Theristus sp. 2			19	
Daptonema normandica			474	601
Microlaimus globiceps			38	
Diploscapter coronata			19	
Daptonema setosa				538
Hirschmanniella sp.				32
Monhysterid sp. 2				127
Monhystera filicaudata				32
Indet.	248	153	303	791
1B:2A	11.50	20.25	6.14	21.67
N	3527	3215	2200	3956
S	17	11	16	18

continued ...

Station TW2 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Schizopera clandestina	8			
Idomene forficata	8			
Copepodites		17		
Bryocamptus sp.				73
N	16	17	0	73
S	2	1	0	1
Acari				
Bdellid sp.				27
Oribatid sp.				9
N	0	0	0	36
S	0	0	0	2

Station TW3	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema sp. 2	36			
Xyalid sp. 2	36			
Monhysterid sp. 1	9			
Daptonema sp. 1	18	12		
Ascolaimus elongatus	18		10	
Paracanthonchus sp.	18	12	10	
Microlaimus globiceps	9		20	
Monhystera stagnalis	45		100	
Chromadorina viridis	18			
Rhabditis sp. 1	9			
Desmodora communis	18			
Dorylaimid sp. 1	9		10	
Metachromadora sp.	9			
Chromadorella sp.	9			
Trefusiid sp.	63			
Onchium conicaudatus		12		
Monhystera vulgaris		12		
Oncholimus campylocercoides		12		
Diplogasterid sp.			10	
Daptonema setosa			350	173
Axonolaimus paraspinosus			10	
Odontophora villoti			10	
Butlerius butleri			50	
Leptolaimus sp. 1			20	
Daptonema furcata			10	
Anoplostoma viviparum			10	
Mononchus aquaticus			10	
Rhabditid sp. 1			10	
Theristus sp 1			10	
Dichromadora geophila			20	9
Mononchoides striatus			40	9
Chromadorita leukarti				9
Plectus granulatus				9
Sabatieria punctata				9
Tobrilus sp.				9
Hirschmanniella sp.				9

continued ...

Station TW3 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Monhystera filicaudata				18
Tobrilus gracilis				9
Chromadorid sp. 1				9
Monhysterid sp. 2				9
Viscosia sp.				9
Criconemoides sp.				9
Paracyatholaimus intermedius				9
Daptonema normandica				18
Indet.	63	0	40	55
1B:2A	1.44	1.00	3.08	5.00
N	333	72	720	381
S	15	6	18	16
Copepoda				
Attheyella sp.				9
N	0	0	0	9
S	0	0	0	1
Acari				
Hydracarine sp.	9	12		
Oribatid sp.			10	
N	9	12	10	0
S	1	1	1	0

Station TW4	Q U A R T E R			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Monhystera stagnalis	475		53	178
Monhystera filicaudata	850	150		200
Mononchoides striatus	25			44
Monhystera vulgaris	125	365		
Mononchus aquaticus	25	43		22
Dorylaimid sp. 1	125	21		
Tobrilus gracilis	125			445
Diploscapter coronata	25			
Plectus granulosus	25			
Paracanthonchus sp.	75		53	
Daptonema furcata	25	1397	214	
Rhabditid sp. 1	25	21		
Daptonema normandica	100	21		89
Tripyla affinis	25			
Anoplostoma viviparum		21	80	
Diplolaimella ocellata		21	187	22
Paroigrolaimellus bernensis		21		89
Chromadorina viridis		21		22
Butlerius butleri		+		
Daptonema setosa			1148	467
Diplogasterid sp.			160	
Monhysterid sp. 1			160	
Innocuonema sp			27	
Tripyloides gracilis			53	44
Theristus sp. 1			53	133
Chromadora macrolaima			80	
Leptolaimus sp. 1			107	
Axonolaimus paraspinosus			27	
Adoncholaimus thalassophygas			53	22
Leptolaimus papilliger			27	
Ascolaimus elongatus			133	
Dichromadora geophila			27	89
Desmolaimus zeelandicus			27	
Sphaerolaimus gracilis			+	
Tobrilus sp.				44
Rhabditis sp. 1				89

continued ...

Station TW4 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Tylenchid sp. 1				44
Monhysterid sp. 2				44
Paracyatholaimus intermedius				44
Dorylaimid sp. 3				22
Plectid sp.				22
Halalaimus isaitshikovi				22
Microlaimus globiceps				22
Indet.	50	21	27	422
1B:2A	3.00	34.50	3.59	6.00
N	2050	2166	2696	2641
S	14	13	20	23
Copepoda				
Microarthridion sp.				46
N	0	0	0	46
S	0	0	0	1

Acari None observed

Station TW5	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Xyalid sp. 1	44	13		
Monhystera stagnalis	22			9
Daptonema sp. 1	11			
Paracanthonchus sp.	33		10	
Plectus granulosus	22			
Mononchoides striatus	11			
Theristus sp. 2	22			
Butlerius butleri	11			
Daptonema furcata		50	10	
Anticoma acuminata		13		
Tripyloides gracilis		13		
Axonolaimus paraspinosus			31	
Sabatieria punctata			31	9
Daptonema setosa			94	291
Innocuonema sp.			10	
Diplolaimella ocellata			10	
Ptycholaimellus ponticus			10	
Chromadora macrolaima			10	
Chromadorita sp.			52	
Dichromadora geophila			42	
Odontophora setosa			10	
Adoncholaimus thalassophygas			10	
Diplogasterid sp.			10	
Viscosia sp.				9
Chronogaster sp.				9
Indet.	11	0	10	27
1B:2A	3.00	x2A	1.07	x2A
N	187	102	350	354
S	8	5	14	5
Copepoda None observed				
Acari				
Oribatid sp.	11			
Copidognathus dentatus				10
N	11	0	0	10
S	1	0	0	1

Station TW6	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Microlaimus robustidens	9			
Monhystera filicaudata	43	1136		364
Prochromadora sp.	52			
Xyalid sp. 1	17			
Cyatholaimid sp. 1	26			
Plectus granulosus	9			
Daptonema setosa	17		154	1405
Diplolaimella ocellata	26	120	19	52
Monhystera disjuncta	9			
Theristus sp. 2	26			
Tobrilus gracilis	9			
Daptonema furcata		538		
Dichromadora geophila		359	346	260
Daptonema normandica		3827	788	104
Deontolaimus sp.		60		
Dorylaimid sp. 2		60		
Paracanthonchus heterodontus		120	58	
Axonolaimus paraspinosus		60		
Monhystera vulgaris		60		
Trefusiid sp.		60		
Chromadorina viridis		60		
Halalaimus isaithshikovi		60		260
Mononchus aquaticus		+		
Tobrilus gracilis		+		
Leptolaimus papilliger		+	19	52
Oxystomina asetosa		+		
Tripyloides sp.		+		156
Anoplostoma viviparum			77	
Adoncholaimus thalassophygass			38	52
Sabatieria punctata				58
Diplogasterid sp.			269	
Leptolaimus sp. 1			58	
Monhysterid sp. 1			19	
Sphaerolaimus gracilis			19	
Ascolaimus elongatus			19	
Rhabditis sp. 1				52

continued ...

Station TW6 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Paracyatholaimus intermedius				1509
Microlaimus globiceps				364
Chromadorita leukarti				104
Mononchoides striatus				104
Monhystera stagnalis				104
Criconema sp.				52
Panagrolaimus sp.				52
Plectid sp.				52
Tylenchid sp. 3				+
Indet.	43	120	115	468
1B:2A	0.88	8.22	1.66	0.78
N	286	6640	2056	5670
S	11	19	14	20
Copepoda				
Bryocamptus sp.	42			
N	42	0	0	0
S	1	0	0	0
Acari None observed				

Station TW7s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema furcata		486		10
Rhabditis sp.		29		
Monhystera filicaudata		29		
Adoncholaimus thalassophygas		14	33	40
Theristus acer		14		
Paracanthonchus caecus		14		
Daptonema setosa		14	11	80
Mononchoides striatus		14		
Microlaimus robustidens		14		
Daptonema sp. 1			11	
Diplolaimella ocellata			22	140
Sabatieria punctata			11	
Ascolaimus elongatus			22	
Chromadorita sp.			67	
Leptolaimus papilliger			33	20
Dichromadora geophila			11	10
Axonolaimus paraspinosus			11	
Paracanthonchus heterodontus			11	10
Anoplostoma viviparum			11	10
Ptycholaimellus ponticus				10
Paracyatholaimus intermedius				130
Paroigrolaimellus bernensis				60
Halalaimus isaitshikovi				30
Hypodontolaimus balticus				10
Microlaimus globiceps				20
Monhystera disjuncta				40
Plectid sp.				10
Daptonema normandica				10
Indet.	-	14	0	100
1B:2A	-	12.00	0.88	0.95
N	-	656	254	750
S	-	10	12	18

continued ...

Station TW7s continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Microarthridion sp.			11	
N	0	0	11	0
S	0	0	1	0

Acari None observed

Station TW7i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Diploscapter coronata	17			
Butlerius butleri	8			
Monhystera disjuncta	17			8
Oncholaimellus calvadosicus	8		13	
Rhabditis sp.	17			8
Plectus granulosus	25			
Tylenchid sp. 1	8			
Diplogasterid sp.	8		40	8
Heteroderid sp.	8			
Dichromadora geophila	8		13	42
Axonolaimus paraspinosus	8			
Tylenchid sp.	8			
Metachromadora suecica	8			
Xyalid sp. 1	8			
Monhystera filicaudata	8	216		17
Cryptonchus sp.	8			
Diplolaimella ocellata		130	13	42
Paracanthonchus heterodontus		86	93	
Daptonema setosa		3285	652	108
Theristus acer		43		
Sabatieria punctata		86	106	8
Anoplostoma viviparum		86	133	33
Leptolaimus papilliger		130	93	25
Microlaimus globiceps		130		8
Viscosia elegans		43		
Tripyloides sp.		43		8
Dichromadora cephalata		43		
Prochromadorella attenuata		+		
Adoncholaimus thalassophygas		+	133	8
Sphaerolaimus gracilis			13	
Monhystera sp. 2			40	
Antomicron elegans			13	
Microlaimus marinus			27	
Halalaimus isaitshikovi			+	
Leptolaimid sp. 1				8
Tripyla affinis				8

continued ...

Station TW7i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Daptonema normandica				25
Paracyatholaimus intermedius				17
Tylenchid sp. 3				8
Tobrilus gracilis				25
Mononchoides striatus				8
Viscosia sp.				25
Neochromadora poecilosoma				8
Monhysterid sp. 2				25
Panagrellus sp.				8
Chromadorita leukarti				8
Indet.	42	0	13	42
1B:2A	4.00	13.50	5.23	2.25
N	214	4321	1409	538
S	16	14	15	25
Copepoda				
Stenhelia giesbrechti	44			
Microarthridion sp.			3068	
Harpacticella sp.			741	
Stenhelia palustris			423	
Copepodites			317	
N	44	0	4549	0
S	1	0	4	0
Acari				
Oribatid sp.	16			8
N	16	0	0	0
S	1	0	0	0

Station TW8s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Sabatieria punctata	25	14		191
Dichromadora geophila		800	29	
Adoncholaimus thalassophygas		43	43	9
Daptonema furcata		143		
Theristus acer		14		
Leptolaimus papilliger		14	29	
Monhystera disjuncta		14		
Daptonema normandica		14	14	
Anoplostoma viviparum		29		9
Daptonema setosa			29	18
Sabatieria breviseta			14	
Oncholaimuellus calvadosicus			29	
Monhysterid sp. 1			14	
Diplolaimella ocellata			43	
Acrobeles sp.			14	
Monhystera filicaudata			29	
Hypodontolaimus inaequalis				9
Indet.	0	0	0	0
1B:2A	x2A	0.27	2.00	24.00
N	25	1085	287	236
S	1	9	11	5
Copepoda				
Copepodites			29	
N	0	0	29	0
S	0	0	1	0
Acari				
Oribatid sp.		22		
N	0	22	0	0
S	0	1	0	0

Station TW8i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Dichromadora geophila	152	128	212	
Diplolaimella ocellata	32			
Monhystera filicaudata	72			
Tylenchid sp. 3	8			
Monhysterid sp. 2	32			
Sabatieria punctata	8			
Monoposthia mirabilis	8			
Microlaimus robustidens	8			
Mononchoides sp.	24			
Daptonema setosa	312	3978	6574	8
Chromadorella sp	8			
Oncholaimid sp. 2	16			
Cyatholaimid sp. 1	16			
Chromadorina viridis	16			
Desmoscolex falcatus	8			
Microlaimus globiceps	8			
Chromadorita sp.	16			
Criconema sp.	8			
Anoplostoma viviparum	8	26	+	
Daptonema sp. 1	8			
Plectus granulosus	8			
Theristus sp. 2	8			
Axonolaimus paraspinosus	8			
Paracanthonchus heterodontus		43	71	
Theristus acer		43		
Adoncholaimus thalassophygass		+	+	
Prochromadorella attenuata		+		
Leptolaimus papilliger			141	
Diplogasterid sp.			71	
Daptonema furcata				17
Richtersia inaequalis				8
Daptonema normandica				8
Indet.	32	0	0	8
1B:2A	1.55	24.00	18.60	x2A
N	824	4278	7069	49
S	23	7	7	4

continued ...

Station TW8i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Pseudomesochra latifurea	8			
Stenhelia palustris	24		29	
Stenhelia giesbrechti		32		
Microarthridion sp.			86	17
Copepodites			14	
N	32	32	129	17
S	2	1	3	1
Acari				
Oribatid sp.	16	22		
N	16	22	0	0
S	1	1	0	0

Station TW9	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Rhabditis sp. 1	8		25	
Daptonema furcata		20		
Monhysterid sp. 1		10		
Mononchoides striatus		10		
Butlerius butleri			63	
Ptycholaimellus ponticus			50	
Anoplostoma viviparum			13	55
Leptolaimus papilliger			13	
Leptolaimoides sp.			13	
Monhystera sp. 1			13	
Enoplolaimus vulgaris			13	
Daptonema setosa				82
Sabatieria punctata				27
Paroigrolaimus sp.				+
Indet.	0	0	50	18
1B:2A	x1B/x2A	2.00	0.25	x2A
N	8	40	253	191
S	1	3	8	4
Copepoda				
Cletodid sp.				9
N	0	0	0	9
S	0	0	0	i
Acari				
Oribatid sp.		10		
N	0	10	0	0
S	0	1	0	0

Station TW10s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema setosa	400			11
Sabatieria punctata	112	63	10	267
Daptonema furcata		100		
Dichromadora geophila		38		11
Leptolaimus papilliger		13		
Oncholaimid sp. 2		13		
Paracanthonchus heterodontus		13		
Monhystera filicaudata		13		
Daptonema sp. 1		13		
Adoncholaimus thalassophygas			19	11
Monhystera disjuncta				11
Richtersia inaequalis				11
Anoplostoma viviparum				78
Camacolaimus barbatus				11
Diplolaimella ocellata				22
Hypodontolaimus balticus				11
Ironus ignavus				11
Diplogasterid sp.				11
Indet.	8	13	0	11
1B:2A	x2A	3.50	x2A	8.25
N	520	279	29	477
S	2	8	2	12
Copepoda				
Copepodites	16			
N	16	0	0	0
S	1	0	0	0

Acari None observed

Station TW10i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Diploscapter coronata	48			
Xyalid sp. 1	48			
Daptonema setosa	3992	7947	749	1650
Sabatieria punctata	144	4279	321	296
Adoncholaimus thalassphygas	96	4891	36	42
Dichromadora geophila	96	28732	71	42
Anoplostoma viviparum	337	14061	267	1988
Microlaimus robustidens	48			
Mononchoides sp.	+	611		
Oncholaimid sp. 2	+			
Daptonema normandica		4891	18	
Adoncholaimus fuscus		+		
Sabatieria breviseta		+	18	
Hypodontolaimus balticus		+		127
Diplogasterid sp.			36	
Hypodontolaimus inaequalis			107	
Sphaerolaimus balticus			18	
Leptolaimus papilliger			36	
Viscosia cobbi			36	
Mononchoides striatus			18	85
Butlerius butleri			18	
Theristus sp. 1			18	
Praeacanthonchus sp.			18	
Ptycholaimellus ponticus			18	
Prochromadorella attenuata			+	
Indet.	0	611	53	42
1B:2A	31.67	0.92	5.33	15.50
N	4809	61743	1856	4272
S	10	10	18	7
Copepoda				
Copepodites	10			
Stenhelia giesbrechti		12		
Paramphiascella sp.			9	
N	10	12	9	0
S	1	1	1	0

Station TW10i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Acari				
Oribatid sp.	10	44		
Copidognathus rhodostigma	10			
N	20	44	0	0
S	2	1	0	0

Station TW11s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Calytronema maxweberi	8		376	
Daptonema setosa	40	71	658	707
Sabatieria punctata	32	900	5542	7069
Sphaerolaimus gracilis	8		94	
Ptycholaimellus ponticus	8		+	
Microlaimus conothelis		14		
Richtersia inaequalis		14		
Sabatieria breviseta			94	
Daptonema furcata			1784	
Leptolaimus papilliger			188	
Monhystera disjuncta			94	
Monhystera filicaudata			282	
Dichromadora cephalata			94	
Monhysterid sp. 1			188	
Sphaerolaimus balticus			94	+
Antomicron elegans			94	
Daptonema sp. 1			+	
Camacolaimus tardus			+	
Oncholaimus brachycercus			+	
Terchellingia longicaudata				79
Indet.	0	14	188	0
1B:2A	10.00	69.00	88.00	x2A
N	96	1013	9770	7855
S	5	4	17	4
Copepoda				
Copepodites	8			
Paramphiascella sp.			42	
Amphiascus sp. 2				45
Harpacticella sp.				164
Microarthridion sp.				64
Tachidius discipes				409
N	8	0	42	682
S	1	0	1	4

Station TW11s continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Acari				
Copidognathus rhodostigma	8			
Oribatid sp.				9
N	8	0	0	9
S	1	0	0	1

Station TW11i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema setosa	1063	1830	11	
Sabatieria punctata	48	330		533
Diplolaimella ocellata	12			
Daptonema sp. 1	12			
Metachromadora suecica	12	30		
Leptolaimus papilliger	12	30		
Dichromadora geophila	12	150		
Anoplostoma viviparum	12	30		
Monhystera filicaudata	12			25
Daptonema normandica	+	300		
Daptonema furcata		30		
Monhysterid sp.		30		
Spilophorella paradoxa		90		8
Antomicron elegans		30		
Hypodontolaimus balticus		30		
Spirinia parasitifera		30		
Calomicrolaimus honestus		30		
Spilophorella candida			22	
Paraoigrolaimellus bernensis				8
Desmolaimus zeelandicus				8
Mononchoides sp.				42
Ptycholaimellus ponticus				17
Richtersia inaequalis				8
Viscosia cobbi				8
Indet.	0	0	0	25
1B:2A	47.00	7.73	0.50	9.50
N	1207	3000	33	757
S	10	15	2	10
Copepoda				
Stenhelia palustris	24	11		
Stenhelia giesbrechti		11		
Tachidius discipes				17
N	24	22	0	17
S	1	2	0	1

Station TW11i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Acari				
Copidognathus rhodostigma	8			
N	8	0	0	0
S	1	0	0	0

Station TW12s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Theristus acer	12			
Sabatieria punctata	447	38	200	1938
Sphaerolaimus gracilis	162			
Sabatieria breviseta	25			
Oncholaimid sp. 1	25			
Tripyloides sp.	87			
Anticoma acuminata	12			
Leptolaimus papilliger	236			42
Axonolaimus paraspinosus	12			
Dichromadora cephalata	112			
Paracanthonchus heterodontus	50			
Monhystera sp.	12			
Daptonema setosa	25		13	42
Diplolaimella ocellata	12			
Monhystera filicaudata	12		13	
Enoplus brevis	+			
Daptonema sp. 1			100	
Theristus sp. 3			13	
Leptolaimus sp. 2			13	21
Ptycholaimellus ponticus				21
Desmolaimus zeelandicus				21
Indet.	37	0	0	0
1B:2A	4.31	x2A	x2A	96.00
N	1278	38	352	2085
S	16	1	6	1
Copepoda				
Copepodites	8			
Amphiascus sp. 2				8
N	8	0	0	8
S	1	0	0	1
Acari None observed				

Station TW12i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema tenuispiculum	1120			
Anoplostoma viviparum	124			
Leptolaimus papilliger	560	1475	1165	192
Cyatholaimus sp.	809			
Ptycholaimellus ponticus	1493	983	647	80
Dichromadora geophila	62	1475	194	
Spilophorella paradoxa	871	1311		465
Axonolaimus paraspinosus	622	1147	324	32
Spaerolaimus gracilis	62	164		
Sabatieria punctata	124	6392	1229	337
Desmolaimus zeelandicus	124	492	712	48
Sabatieria celtica	62			
Diplolaimella ocellata	62			
Sphaerolaimus balticus	124		65	
Calyptronema maxweberi	+	+	129	48
Antomicron elegans	+		+	
Praeacnthonchus sp.		492	194	
Dichromadora cephalata		328	776	16
Metachromadora suecica		164		
Sabatieria breviseta		328	65	
Daptonema sp. 2		1147		
Molgolaimus cuanensis		328		
Hypodontolaimus balticus		164		
Parasphaerolaimus paradoxa		+	712	
Chromadora macrolaima		+		
Spilophorella candida			65	
Daptonema sp. 1			129	
Halalaimus isaitshikovi			65	16
Daptonema setosa				242
Praeacanthonchus opheliae				32
Metachromadora remanei				16
Neochromadora poecilosoma				96
Monhystera filicaudata				16
Diploscapter coronata				16
Richtersia inaequalis				+

continued ...

Station TW12i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Adoncholaimus thalassophygas				+
Indet.	435	820	129	48
1B:2A	0.71	2.14	1.14	0.91
N	6654	17210	6600	1700
S	16	18	16	17
Copepoda				
Pseudomesochra latifurea	40			
Stenhelia palustris	64	10		
Copepodites	40			
Bryocamptus sp.		10		
Stenhelia giesbrechti		180		
Amphiascus angusticpes		70		
Tachidius discipes			25	
Amphiascus sp. 2				8
N	144	270	25	8
S	3	4	1	1
Acari				
Oribatid sp.		30		
N	0	30	0	0
S	0	1	0	0

Station TW13s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Sabatieria punctata	799	482	278	25
Daptonema setosa	1598	18		125
Leptolaimus papilliger	148	27	41	8
Halalaimus isaitshikovi	30			8
Oncholaimid sp. 1	30			
Richtersia inaequalis	30			17
Anoplostoma viviparum	30			
Terschellingia longicaudatus	30	18		
Monhystera filicaudata	89			
Sabatieria celtica	30			
Desmolaimus zeelandicus	30		10	
Linhomoeid sp. 1	59		31	
Antomicron elegans	30	9		
Dichromadora cephallata	30	9		
Camacolaimus barbatus	+			8
Sphaerolaimus balticus	+		10	
Adoncholaimus thalassophygas	+			
Calyptronema maxweberi	+	45		
Ptycholaimellus ponticus		18		17
Sphaerolaimus gracilis		36	10	
Leptolaimus sp. 1		9		
Sabatieria breviseta		9		
Paracanthonchus heterodontus		9		
Parasphaerolaimus paradoxa		9		
Spirinia parasitifera			10	
Desmodora communis			10	8
Leptolaimus sp. 2				8
Monhystera disjuncta				8
Metachromadora scotlandica				17
Indet.	178	9	10	33
1B:2A	85.00	15.25	30.00	3.33
N	3141	725	410	282
S	18	14	8	11

continued ...

Station TW13s continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Schizopera clandestina	48			
Tachidius discipes			10	25
Amphiascus sp. 2				25
Harpacticella sp.				83
Halectinosoma curticorne				8
Stenhelia palustris				33
N	48	0	10	174
S	1	0	1	5
Acari None observed				

Station TW13i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema tenuispiculum	1477			
Sabatieria punctata	2769	1271	544	209
Leptolaimus papilliger	369	741	272	63
Desmolaimus zeelandicus	738	635	272	42
Sphaerolaimus gracilis	646	106	136	42
Daptonema setosa	831		188	
Molgolaimus cuanensis	92			
Axonolaimus paraspinosus	462	1800		167
Dichromadora cephalata	369	212	3946	63
Monhystera sp. 1	185			
Calomicrolaimus parhonestus	92			
Oncholaimellus calvadosicus	92			
Linhomoeus sp. 1	185			
Anoplostoma viviparum	92			
Monhystera filicaudata	92			
Tripyloides sp.	92			
Sphaerolaimus balticus	277			
Calyptronema maxweberi	92	212	+	63
Sabatieria breviseta	92			
Prochromadora sp.	92			
Metachromadora suecica	92	+		
Antomicron elegans	+			
Cyatholaimus gracilis	+			
Ascolaimus elongatus	+			
Halalaimus isaitshikovi	+			
Paracanthonchus heterodontus	+			42
Parasphaerolaimus paradoxa	+	424		
Spirinia parasitifera	+			
Richtersia inaequalis	+			+
Dichromadora geophila		529		
Daptonema sp. 1		4024		774
Adoncholaimus thalassophygas		106		
Chromadora macrolaima		212		
Praeacanthonchus sp.		318	1225	
Viscosia elegans		+		
Terschellingia longicaudata		+		
Daptonema sp. 2			5443	

continued ...

Station TW13i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Linhomoeid sp. 1			680	
Viscosia viscosa			680	
Daptonema furcata			136	
Chromadorita tentabunda			136	
Microlaimus marinus			136	
Ptycholaimellus ponticus			136	
Leptolaimus sp. 2			+	
Desmodora communis			+	
Daptonema normandica				109
Diplolaimella ocellata				63
Praeacanthonchus opheliae				126
Viscosia cobbi				21
Metachromadora scotlandica				+
Indet.	554	635	544	126
1B:2A	10.00	8.89	1.78	4.87
N	9782	11225	14286	2199
S	29	16	13	19
Copepoda				
Pseudomesochra latifurea	496			
Schizopera clandestina	328			
Stenhelia palustris	992	18		118
Copepodites	328		56	
Bryocamptus sp.		36		
Tachidius discipes			78	300
Harpacticella sp.				109
Amphiascoides sp.				73
N	2144	54	134	600
S	4	2	2	4
Acari				
Copidognathus rhodostigma	8			
N	8	0	0	0
S	1	0	0	0

Station TW14	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Sphaerolaimus gracilis	107			
Metachromadora suecica	213	+		103
Linhomoeid sp. 1	5016	3460	6636	3608
Sabatieria punctata	4375	8073	3792	5155
Daptonema normandica	427			
Sabatieria celtica	107			
Chromadora macrolaima	107			
Cyatholaimid sp. 1	107			
Desmolaimus zeelandicus	107			
Ptycholaimellus ponticus	107			
Microlaimus conothelis	+			
Richtersia inaequalis	+			103
Monhystera sp.	+			
Ascolaimus elongatus	+			+
Eleutherolaimus sp.	+			
Criconemoides sp.	+			
Molgolaimus cuanensis		897		
Parasphaerolaimus paradoxa		128		
Daptonema setosa		128		515
Leptolaimus sp. 1		128		
Daptonema furcata		+		
Daptonema sp. 2		+		
Paracanthonchus heterodontus		+		+
Viscosia viscosa			105	
Spirinia parasitifera			+	
Sabatieria breviseta			+	
Leptolaimus sp. 3			+	
Daptonema sp. 1			+	103
Viscosia cobbi				515
Sphaerolaimus balticus				103
Terschellingia longicaudatus				103
Indet.	213	256	0	0
1B:2A	19.00	9.29	x2A	58.00
N	10886	13070	10533	10308
S	16	10	71	11

continued ...

Station TW14 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Stenhelia giesbrechti		20		
Schizopera sp.		10		
Stenhelia palustris		60		
Halectinosoma curticorne			17	
Cletodid sp.				18
Tachidius sp.				18
N	0	90	17	36
S	0	3	1	2
Acari				
Oribatid sp.		30	33	
N	0	30	33	0
S	0	1	1	0

Station TW15	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema setosa	114		25	15
Eleutherolaimus sp.	3430			
Desmodorid sp. 1	1372			59
Richtersia inaequalis	1829		13	117
Microlaimus robustus	343			
Oncholaimid sp. 2	915			
Daptonema furcata	572			
Daptonema normandica	800			396
Sphaerolaimus gracilis	114			
Enoploides brunettii	114			15
Oncholaimellus calvadosicus	572			
Odontophora villoti	114			
Sigmophoranema rufum	114			
Rhabdocoma riemani	114			
Ascolaimus elongatus	343			147
Sabatieria punctata	114	33	239	235
Chromadorita tentabunda	457			15
Metachromadora suecica	+	11		
Monoposthia mirabilis	+		13	44
Camacolaimus barbatus	+	33		
Ptycholaimellus ponticus		11		
Odontophora setosa		22		
Daptonema sp. 1		11	880	
Leptolaimus sp. 1		11		
Monhystera filicaudata		11		
Spirinia parasitifera		11		
Calyptronema maxweberi		22		15
Monhysterid sp. 2		44		15
Adoncholaimus thalassophygas		11		
Microalimus conothelis		11		15
Leptolaimus papilliger		11		15
Onchium conicaudatum		11	13	
Daptonema sp. 2		11		
Viscosia glabra		11		
Linhomoeid sp. 1			13	29
Desmodora communis			38	15
Viscosia viscosa			13	

continued ...

Station TW15 continued	Q U A R T E R			
Species	1989/2	1989/3	1989/4	1990/1
Linhomoeus sp. 1			13	
Eleutherolaimus sp.				15
Viscosia cobbi				191
Calaomicrolaimus honestus				29
Halalaimus isaitshikovi				15
Monhystera sp.				15
Setosabatieria hilarula				44
Diplopeltid sp. 1				15
Sphaerolaimus balticus				+
Indet.	1143	22	13	73
1B:2A	7.60	0.71	23.50	0.11
N	12574	319	1273	1544
S	20	18	10	23
Copepoda				
Ectinosoma melaniceps	3305			
Copepodites	15			
Halectinosoma curticorne			9	50
Phyllothalestris sp.				25
Pseudobradyia brevicornis				33
N	3320	0	9	108
S	2	0	1	3
Acari				
Oribatid sp.		11	9	
Copidognathus dentatus			26	
N	0	11	35	0
S	0	1	2	0

Station TW16	QUARTER			
Species	1989/2	1982/3	1989/4	1990/1
Nematoda				
Sabatieria celtica	239	+	+	1645
Leptolaimus papilliger	119		+	411
Daptonema normandica	1910			1234
Sabatieria punctata	6325	24757	12039	9050
Microlaimus robustidens	477			
Tripyloides sp.	239			
Paracanthonchus heterodontus	716	+		
Oncholaimid sp. 2	119			
Daptonema furcata	358		388	3702
Leptolaimus sp. 1	239	538		
Chromadora macrolaima	239	8611		6170
Ptycholaimellus ponticus	358	2691	3107	2880
Richtersia inaequalis	119	538	+	+
Halalaimus isaitshikovi	119			+
Eleutherolaimus sp.	119	1076	+	+
Xyalid sp. 2	119			
Metachromadora suecica	119	+	+	
Terschellingia longicaudatus	477	2691	1165	1645
Eurystomina sp.	239			
Daptonema setosa	119	1615	2330	1645
Linhomoeid sp. 1	119		1165	1234
Spirinia parasitifera	119			411
Macroposthonia sp.	+			
Linhomoeid sp. 2	+			411
Setosabatieria hilarula	+		388	411
Spilophorella paradoxa	+			
Oncholaimus oxyuris	+			
Oncholaimellus calvadosicus	+	+		
Monoposthia costata	+		775	+
Monoposthia mirabilis	+		+	
Theristus sp. 3	+			
Dichromadora cephalata		2691	8932	1234
Dichromadora sp.		1076		
Daptonema sp. 2		2153		
Microlaimus marinus		538	+	
Molgolaimus cuanensis		1615		
Chromadorina viridis		538		

continued ...

Station TW16 continued	QUARTER			
Species	1989/2	1982/3	1989/4	1990/1
Sabatieria breviseta		538		
Pareudesmoscolex sp.		1076		411
Paracanthonchus sp.		538		
Microlaimus conothelis		538		
Sigmophoranema rufum		+		
Trefusia longicaudata		+		
Metachromadora sp.		+		
Calyptronema maxweberi		+		
Ascolaimus elongatus		+	+	411
Chromadorita sp.		+		
Oxystomina asetosa		+	388	
Sphaerolaimus gracilis		+		
Daptonema sp. 1			3107	2468
Cyatholaimid sp. 1			775	
Aegialoalaimid sp. 1			775	411
Paracanthonchus caecus			1942	2057
Tripyloides sp.			775	411
Desmodora communis			388	
Chromadorita tentabunda			388	
Sphaerolaimus balticus			+	
Leptolaimus sp. 2				411
Sabatieria longisetosa				823
Metachromadora remanei				411
Calomicrolaimus honestus				823
Desmolaimus zeelandicus				411
Viscosia viscosa				+
Indet.	477	1615	1165	1645
1B:2A	4.59	1.63	1.12	1.64
N	13483	55433	39992	42776
S	31	30	27	31
Copepoda				
Epactophanes richardi	25			
Pseudomesochra latifurea	8			
Amphiascus angusticeps	292	44	453	
Schizopera clandestina	33			
Ectinosoma melaniceps	8			27

continued ...

Station TW16 continued	QUARTER			
Species	1989/2	1982/3	1989/4	1990/1
Copepodites	158			
Cletodes limicola		2687		
Stenhelia palustris			133	9
Cletodes longicaudatus			53	
Longipedia coronata			120	
Stenhelia sp.			67	
Paramphiascella sp.			40	
Canuella perplexa				27
Pseudobradyia brevicornis				18
Amphiascus varians				18
Microarthridion sp.				18
Enhydrosoma propinquum				167
Stenhelia aemula				27
Tachidius discipes				289
Amphiascus sp. 2				773
Amphiascus sp. 3				55
N	524	2731	866	1388
S	6	2	6	11
Acari				
Oribatid sp.	8	22		
Copidognathus rhodostigma	8			
Copidognathus dentatus		22		
N	16	44	0	0
S	2	2	0	0

Station TW17	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Dichromadora cephalata	5313		596	
Oncholaimellus calvadosicus	483	1074		
Daptonema tenuispiculum	1932	537		525
Metachromadora scotlandica	18838	9133	11615	4725
Monoposthia costata	966			
Ptycholaimellus ponticus	6762	10207	7743	19425
Richtersia inaequalis	183			525
Daptonema furcata	2415	5372	2383	4200
Ascolaimus elongatus	1449			
Chromadorita tentabunda	1449	537		+
Sabatieria celtica	966	537		
Antomicron elegans	483	537		
Axonolaimus paraspinosus	483	1074	1191	525
Sabatieria punctata	3864	8595	893	1575
Odontophora setosa	966	3223	298	525
Paracanthonchus heterodontus	483			52
Camacolaimus tardus	483	537		
Cyatholaimus gracilis	483			
Desmolaimus zeelandicus	483			
Linhomoeus sp. 1	483		298	
Linhomoeus sp. 2	+			
Quadricoma sp. +				
Hypodontolaimus balticus	+			1050
Rhabdocoma riemani	+	+		
Eleutherlaimus sp.	+	+		
Neochromadora poecilosoma	+			+
Oncholaimus brachycercus	+	+		
Calyptronema maxweberi	+	537	+	
Anoplostoma viviparum	+	+	+	
Sphaerolaimus balticus	+		+	+
Tripyloides marinus	+		+	
Oxystomina asetosa	+			
Viscosia glabra	+			
Halalaimus isaitshikovi	+	537	596	525
Odontophora villoti	+	+	+	
Spirinia parasitifera	+			

continued ...

Station TW17 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Linhomoeid sp. 1		537		
Sigmophoranema rufum		4835		6300
Chromadora macrolaima		1612		5775
Pareudesmoscolex sp.		537		
Sphaerolaimus gracilis		537	596	
Metachromadora suecica		537		
Daptonema setosa		1074	298	4200
Parasphaerolaimus paradoxa		537		
Microlaimus conothelis		537		
Monhystera disjuncta		537	298	
Adoncholaimus thalassophygas		+		
Terschellingia longicaudata		+	+	
Stephanolaimus elegans		+		
Praeacanthonchus sp.		+	298	+
Spilophorella candida			2383	
Desmodora communis			298	
Viscosia viscosa			+	1050
Leptolaimus sp. 3			+	
Viscosia elegans			+	
Linhomoeid sp. 2			+	
Aegialoalaimid sp. 1				525
Cyatholaimid sp. 1				525
Belbolla teisseiri				+
Enoploides brunettii				+
Indet.	483	4835	0	1050
1B:2A	0.34	0.63	0.26	0.30
N	49750	58552	29782	53550
S	36	33	26	23
Copepoda				
Canuella perplexa	24	322		
Amphiascus angusticeps	120	11	108	
Schizopera clandestina	408			
Ectinosoma sp.	24			
Copepodites	120			
Stenhelia giesbrechti		522		
Tisbe sp.		100		
Stenhelia palustris			64	

continued ...

Station TW17 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Stenhelia sp.			36	25
Halophytophilus sp.				83
Amphiascella sp.				700
Ectinosoma melaniceps				33
Enhydrosoma propinquum				50
N	696	960	708	891
S	5	4	3	5
Acari				
Copidognathus rhodostigma	40			
N	40	0	0	0
S	1	0	0	0

Station TW18	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Theristus sp. 3	146			
Microlaimus marinus	878	138	67	
Xyalid sp. 3	2488			
Leptolaimus papilliger	146	104	270	
Sabatieria punctata	2635	450	911	157
Monhystera filicaudata	293			
Aegialoalaimid sp. 1	732			78
Setosabatieria hilarula	439		101	78
Spirinia parasitifera	146	1245	34	314
Daptonema sp. 1	585			
Linhomoeid sp. 2	293			
Monoposthia costata	293			+
Sabatieria longiseta	2781		67	
Linhomoeus sp. 1	293	35	101	78
Leptolaimid sp. 1	146	69		
Leptolaimus sp. 2	439			157
Oncholaimid sp. 2	1025			
Terschellingia longicaudata	146		34	
Spilophorella paradoxa	146			+
Oxystomina asetosa	146			
Halalaimus isaitshikovi	293			+
Daptonema normandica	439		67	4076
Sabatieria celtica	146		101	157
Anticoma acuminata	146			
Cyatholaimid sp. 2	146			
Campylaimus inaequalis	293			
Linhomoeid sp. 2	146	173	135	
Odontophora setosa	+	35	34	157
Paralongicyatholaimus sp.	+			
Quadricoma sp.	+			
Metachromadora remanei	+		34	314
Sphaerolaimus gracilis	+		135	
Thalassoalaimus tardus	+		+	+
Viscosia elegans	+		101	
Bathylaimus capocosus	+			
Calaomicrolaimus honestus		311		
Stephanolaimus elegans		69		

continued ...

Station TW18 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Camacolaimus barbatus		69		627
Monhystera disjuncta		104		
Cricolaimus sp.		415		
Viscosia cobbi		69		78
Sabatieria breviseta		35		78
Sabatieria longiseta		35		
Molgolaimus cuanensis		35		
Desmolaimus zeelandicus		35		78
Ascolaimus elongatus		+	67	235
Linhomoeid sp. 3		202		
Eleutherolaimus sp.			34	+
Leptolaimus sp. 3			202	
Trefusia longicaudata			135	157
Richterisa inaequalis			34	314
Xyalid sp. 1			169	+
Linhomoeus sp. 2			169	
Camacolaimus tardus			34	
Chromadorita sp.			34	
Oncholaimus oxyuris			34	
Monhystera disjuncta			34	
Theristus sp. 2			34	
Theristus acer			34	
Daptonema setosa				78
Calomicrolaimus honestus				235
Chromadora macrolaima				78
Bathylaimus capacosus				78
Daptonema furcata				78
Oncholaimus sp.				78
Axonolaimus paraspinosus				78
Oxystomina asetosa				+
Halanonchus sp.				+
Oncholaimus campylocercoides				+
Monoposthia mirabilis				+
Sphaerolaimus balticus				+
Pseudocella coecum				+
Prochromadorella ditlevseni				+
Linhystera sp.				+
Calyptronema maxweberi				+

continued ...

Station TW18 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Mescacanthion diplechma				+
Anoplostoma viviparum				+
Indet.	1171	243	641	392
1B:2A	6.18	1.47	11.67	3.82
N	16976	3669	4083	8228
S	35	20	31	42
Copepoda				
Tachidius sp.	183			
Schizopera clandestina	117			
Laophonte sp.	17			
Schizopera sp.		8		
Amphiascus angusticeps			42	
Stenhelia palustris				80
Copepodites				63
Stenhelia aemula				3
Bulbamphiascus sp.				3
Halectinosoma curticorne				53
Ectinosoma melaniceps				5
Enhydrosoma propinquum				3
Pseudobradyia brevicornis				5
Paramphiascella sp.				3
Amphiascus sp. 1				33
Canuella perplexa				15
Amphiascus sp. 2				18
Amphiascus sp. 3				20
N	317	8	42	304
S	3	1	1	13
Acari				
Oribatid sp.	8			3
Copidognathus dentatus	17	17		5
Copidognathus rhodostigma		8		
N	25	25	0	8
S	2	2	0	2

Station TW19s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Metachromadora suecica	81		81	+
Metachromadora sp.	81			
Chaetonema riemanni	27			
Richtersia inaequalis	27		27	199
Halalaimus longicaudatus	27			
Leptolaimus sp. 2	54			
Sabatieria punctata	27	49	108	
Dichromadora sp.	163			
Desmodorid sp. 1	163			
Aegialoalaimid sp. 1	54	343		199
Linhomoeus sp. 2	27			
Theristus sp. 3	54			
Desmodora sp. 1	190			
Calamicrolaimus honestus	27	98	54	
Prochromadorella ditlevseni	27	49		
Diplopeltid sp. 1	27	49		
Ptycholaimellus ponticus	27			
Halalaimus isaitshikovi	27	49	27	299
Cyatholaimus gracilis	27			
Spilophorella candida	27			299
Daptonema normandica	27			
Onyx perfectus	54	147	135	199
Hypodontolaimus balticus	27			
Paracanthonchus sp.	27			
Camacolaimus tardus	109			
Leptolaimus papilliger	27	49		
Spirinia parasitifera	27		27	+
Pseudonchus sp.	27			
Oncholaimus brachycercus	27			
Ascolaimus elongatus	+	49		
Mesacanthion diplechma	+	98		199
Spilophorella paradoxa		294	27	100
Cyatholaimid sp. 1		736		
Odontophora setosa		343	27	
Oncholaimellus calvadosus		49	+	
Xyalid sp. 2		98		
Trefusia longicaudata		49		
Ceramonematid sp. 1		49		

continued ...

Station TW19s continued QUARTER

Species	1989/2	1989/3	1989/4	1990/1
Microlaimus marinus		49	27	
Cricolaimus sp.		+		
Daptonema setosa		+		
Dichromadora cephalata			242	1396
Sigmophoranema rufum			81	
Xyalid sp. 1			323	
Viscosia viscosa			108	
Daptonema sp. 2			27	
Rhabditid sp. 2			27	
Paralongicyatholaimus sp.			189	
Cyatholaimid sp. 2			108	1995
Microlaimus conothelis			27	
Desmoscolex falcatus			27	+
Theristus sp. 3			27	
Enoplolaimus vulgaris			54	
Chromadorita tentabunda			27	
Odontophora villoti			27	299
Sabatieria longiseta			27	
Viscosia glabra				299
Oncholaimus skawensis				100
Paracanthonchus caecus				199
Eleutherolaimus sp.				100
Neochromadora trichophora				100
Leptolaimus sp. 3				100
Halichoanolaimus robustus				+
Indet.	326	343	215	499
1B:2A	1.49	1.36	1.44	0.69
N	3063	5247	2911	10471
S	32	22	29	22
Copepoda				
Ectinosoma melaniceps	80			
Halectinosoma sp.	16		245	
Copepodites	16		9	
Stenhelia giesbrechti		8		
Canuella perplexa		25	9	18
Cletodes longicaudatus			18	
N	112	33	281	18
S	3	2	3	1

continued ...

Station TW19s	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Acari				
Copidognathus dentatus				9
N	0	0	0	9
S	0	0	0	1

Station TW19i	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Odontophora villoti	1587			
Chromadora macrolaima	5555			15039
Ptycholaimellus ponticus	15078	10468	7821	7520
Tripyloides sp.	1587	13689	869	1504
Metachromadora riemani	794		1738	48125
Ascolaimus elongatus	2381	805		7520
Desmolaimus zeelandicus	6349			
Theristus sp. 3	794		869	
Microlaimus marinus	3968	24962		
Metachromadora sp.	14284	1610		
Monoposthia costata	2381	2416	2607	1504
Linhomoeid sp. 1	2381		2607	
Anoplostoma viviparum	1587	1610	7821	7520
Paracanthonchus heterodontus	2381	805		
Terschellingia longicaudatus	1587	805	869	1504
Calomicrolaimus honestus	794	805	4345	
Richtersia inaequalis	794	+	+	+
Axonolaimus paraspinosus	794	805		
Praeacanthonchus sp.	1587	1610	869	
Calyptronema maxweberi	794			+
Linhomoeus sp. 2	794			1504
Eleutherolaimus sp.	794	+	869	
Daptonema normandica	1587	6442	7821	
Daptonema tenuispiculum	1587	805	1738	
Sabatieria punctata	1587	8858	4345	4512
Oncholaimellus calvadosicus	1587			
Viscosia sp. 2	2381			
Spirinia parasitifera	794	1610	1738	6016
Daptonema sp. 2	794			+
Hypodontolaimus balticus	+		+	3008
Sphaerolaimus balticus	+		+	1504
Sabatieria longicaudatus	+			
Nemanema cylindraticaudatum	+		+	
Quadricoma sp.	+			
Desmoscolex falcatus	+			
Chromadorita tentabunda		2416	1738	1504
Viscosia glabra		805		
Diplopeltid sp. 1		805		

continued ...

Station TW19i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Oncholaimus skawensis		805	1738	1504
Daptonema setosa		805	1738	
Comesomatid sp. 1		+		
Euchromadora vulgaris		+		
Parasphaerolaimus paradoxa		+		
Dichromadora cephalata			11296	
Leptolaimus sp. 3			2607	
Aegialoalaimid sp. 1			3476	1504
Theristus acer			869	
Xyalid sp. 1			1738	
Microlaimus conothelis			18247	
Monoposthia mirabilis			869	
Anticoma acuminata			+	
Mesacanthion diplechma			+	
Halalaimus isaitshikovi			+	
Viscosia elegans			+	
Setosabatieria hilarula			+	
Sigmphoranema rufum				6016
Paracanthonchus caecus				7520
Odontophora setosa				4512
Microlaimus robustidens				12031
Oxystomina asetosa				1504
Viscosia cobbi				1504
Tripyloides marinus				4512
Praeacanthonchus opheliae				1502
Oxystomina elongata				+
Thalassoalaimus tardus				+
Indet.	6349	4026	4345	3008
1B:2A	0.40	0.34	0.54	0.26
N	85711	87767	101670	153403
S	35	27	36	30
Copepoda				
Bryocamptus sp.	709			
Pseudomesochra latifurea	205			
Schizopera clandestina	103			
Laophonte sp.	1829			
Copepodites	308	10	53	
Ectinosoma sp.		80		

continued ...

Station TW19i continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Stenhelia geisbrechti		760		
Paramphiascella sp.		10		
Longipedia sp.		70		
Longipedia coronata			441	
Cletodid sp.				83
Stenhelia palustris				100
Amphiascus sp. 1				75
N	3154	930	494	258
S	5	5	2	3
Acari				
Oribatid sp.	17		18	8
N	17	0	18	8
S	1	0	1	1

Station TW20	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Desmodora communis	288			
Daptonema tenuispiculum	8209	25		+
Oncholaimellus calvadosicus	1584			394
Desmolaimus zeelandicus	288			
Richtersia inaequalis	1152		353	1444
Metachromadora sp.	144			
Linhomoeus sp. 2	144			
Paracanthonchus sp.	144			
Metachromadora scotlandica	864			
Monoposthia mirabilis	720		50	
Ascolaimus elongatus	144	62		1313
Onyx perfectus	144			
Sabatieria punctata	144	895	3584	3545
Mesacanthion diplechma	144			263
Microlaimus robustidens	144			131
Chaetonema riemani	144			+
Eleutherolaimus sp.	+			131
Mononchus aquaticus	+			
Leptolaimus sp. 2	+			
Oncholaimus skawensis	+			
Xyalid sp. 3	+			263
Sphaerolaimus gracilis	+			
Metachromadora suecica		25	101	263
Cricolaimus sp.		12		
Microlaimus marinus		25		
Terschellingia longicaudatus		37	505	789
Chromadora macrolaima		75		131
Leptolaimus papilliger		12	+	
Theristus acer		12		
Daptonema normandica		12	50	1838
Calomicrolaimus honestus		37	50	
Paramonhystera sp.		12		
Sabatieria celtica			50	
Spirinia parasitifera			50	
Molgolaimus cuanensis			101	131
Trefusia longicaudatus			50	131
Dichromadora cephalata			50	
Setosabatieria hilarula			50	131

continued ...

Station TW20 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Viscosia elegans			+	
Xyalid sp. 1			+	
Leptolaimus sp. 3			+	
Viscosia viscosia				263
Desmodorid sp. 1				394
Sabatieria breviseta				263
Aegialoalaimid sp. 1				525
Microlaimus conothelis				131
Chromadorita tentabunda				131
Marylynnia sp.				131
Ptycholaimellus ponticus				131
Leptolaimus papilliger				131
Trefusia zostericola				131
Sphaerolaimus balticus				+
Odontophora setosa				+
Indet.	1008	37	202	1050
1B:2A	4.18	5.92	11.57	6.00
N	15409	1278	5246	14179
S	22	13	17	29
Copeopda				
Ectinosoma melaniceps	1905			
Copepodites	38	10		
Halectinosoma herdmani				73
Cletodid sp.				18
N	1943	10	0	73
S	2	1	0	2
Acari None observed				

Station TW21	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Daptonema normandica	1523	2959		+
Microlaimus robustidens	20556			
Desmodora communis	8374		360	
Aegialoalaimid sp. 1	761	592	+	2404
Ascolaimus elongatus	9874	592	+	2404
Viscosia cobbi	4568			
Dichromadora cephalata	761		360	
Richtersia inaequalis	2284	+	+	4808
Theristus sp. 3	1523		2882	
Metachromadora sp.	1523			
Xyalid sp. 3	1294			
Cyatholaimid sp. 2	761			2404
Microlaimus conothelis	761	2959	2162	3606
Odontophora villoti	3045			4808
Prochromadorella ditlevseni	761	592		
Calomicrolaimus honestus	1523	18346	3243	50488
Viscosia sp.	761			
Daptonema setosa	2284		+	+
Camacolaimus tardus	761			
Eleutherolaimus sp.	761			+
Sabatieria celtica	+			
Metachromadora scotlandica	+			
Stephanolaimus spartinae	+			
Nemanema cylindraticaudatum	+			
Oncholaimellus clavadosicus	+	592	3963	4808
Calyptronema maxweberi	+	+		
Oxystomina asetsoa	+			+
Enoploides brunettii	+	+	+	1202
Daptonema furcata	+	+		4808
Bathylaimus capacosus	+	1184	360	2404
Sphaerolaimus balticus	+		+	1202
Oncholaimus brachycercus	+			
Daptonema tenuispiculum	+			
Sphaerolaimus gracilis	+			
Coninckia sp.	+			
Axonolaimus paraspinosus	+	592		1202
Ptycholaimellus ponticus	+			1202

continued ...

Station TW21 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Paramonhystera sp.	+	15979		4808
Quadricoma sp.	+			
Thalassoalaimus tardus	+			
Microlaimus marinus		3551	10808	
Theristus acer		1184		
Trefusia longicaudata		592	360	1202
Xyalid sp. 2		592		
Chromadora macrolaima		1775		1202
Sabatieria punctata		592	360	+
Spilophorella paradoxa		592		
Desmodorid sp. 2		1175		1202
Metachromadora sp.		592		
Stephanolaimus jayassreei		592		1202
Cyatholaimid sp. 1		592		
Sigmophoranema rufum		592		1202
Odontophora setosa		592	721	
Viscosia glabra		1184		
Parasphaerolaimus paradoxa		+		
Adoncholaimus fuscus		+		+
Monoposthia costata		+		1202
Monoposthia mirabilis		+	360	
Chromadorita tentabunda			1441	2404
Metachromadora suecica			1801	
Chromadorita sp.			360	
Oncholaimus skawensis			3243	2404
Cermonematid sp. 1			721	
Trefusiid sp. 1			1081	
Xyalid sp. 1			1441	3606
Viscosia viscosa			360	1202
Spirinia parasitifera			+	
Pomponema sp.				1202
Metachromadora remanei				7212
Trefusia zostericola				4808
Mesacanthion diplechma				+
Terschellingia longicaudata				+
Indet.	2284	7694	721	2404
1B:2A	0.72	0.74	0.23	0.32
N	78391	66875	37108	125012
S	40	32	27	36

continued ...

Station TW21 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Copepoda				
Leptomesochra macintoshi	127			
Bryocamptus sp.	45			
Amphiascus angusticeps	18	8		
Pseudomesochra latifurea	55			
Schizopera clandestina	64			
Ectinosoma sp.	27			
Ectinosoma melaniceps	264			55
Laophonte sp.	482	25		
Stenhelia giesbrechti		167		
Cletodes limicola		342		
Longipedia sp.		50		
Canuella perplexa		8		27
Cletodes longicaudatus			345	
Pseudobradyia brevicornis			9	
Arenostella sp.			200	
Halectinosoma curticorne			18	
Halectinosoma herdmani				182
Cletodid sp.				327
N	1082	600	572	591
S	8	6	4	4
Acari				
Halacarid sp. indet.		8		
N	0	8	0	0
S	0	1	0	0

Station TW22	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Nematoda				
Richtersia inaequalis	2214	5811	3773	3738
Metachromadora scotlandica	939			
Onyx perfectus	134			
Neochromadora trichophora	201			
Paracanthonchus longus	67			
Molgolaimus cuanensis	67			
Calomicrolaimus honestus	67		290	
Desmodorid sp. 1	134	598	290	175
Theristus sp. 3	67			
Spilophorella paradoxa	201	256	73	643
Cyatholaimus gracilis	67			
Daptonema normandica	67			
Desmodora communis	335			
Leptolaimus papilliger	67	171		
Chromadorita tentabunda	67	171		
Microlaimus conothelis	67			
Ascolaimus elongatus	268			175
Prochromadorella ditlevseni	201			
Aegialoalaimid sp. 1	134	171	145	
Halalaimus isaitshikovi	201	513	+	234
Camacolaimus tardus	268			
Sabatieria breviseta	67			
Leptolaimus sp. 3	201			
Rhabdocoma riemani	67	+		
Gammanema rapax	67			
Dichromador cephalata	335		1596	
Viscosia elegans	67	+		
Microlaimus robustidens	67			58
Thalassoalaimus tardus	+			
Odontophora setosa	+	256	798	
Xyalid sp. 3	+			
Pomponema sp.	+			58
Comesomatid sp.	+			
Oncholaimellus calvadosicus	+			
Enoplolaimus vulgaris	+			
Monoposthia mirabilis	+			
Cyatholaimid sp. 1		427		

continued ...

Station TW22 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Dichromadora sp.		171		
Monhystera disjuncta		85	73	
Sabatieria punctata		85		
Monoposthia costata		+		58
Cermonematid sp. 1		+		
Microlaimus marinus			73	
Linhomoeid sp. 2			73	
Paracyatholaimus sp. 1			73	
Metachromadora suecica			+	
Halalaimus capitulatus			+	
Leptolaimid sp. 1			+	
Eleutherolaimus sp.				58
Spilophorella candida				117
Mesacanthion diplechma				58
Odontophora villoti				58
Cyatholaimid sp. 2				117
Daptonema furcata				117
Dichromadora cucullata				117
Oncholaimus sp. 1				58
Viscosia glabra				+
Indet.	201	1025	363	292
1B:2A	0.93	3.14	1.20	3.09
N	6905	9740	7620	6131
S	36	16	15	17
Copepoda				
Typhlamphiascus sp.	33			
Ectinosoma melaniceps	89			17
Halectinosoma curticorne	22	8		58
Laophonte sp.	156			
Copepodites			19	
Canuella perplexa				8
Pseudobradyia brevicornis				83
Halectinosoma herdmani				8
N	300	8	19	174
S	4	1	1	5

continued ...

Station TW22 continued	QUARTER			
Species	1989/2	1989/3	1989/4	1990/1
Acari				
Copidognathus rhodostigma	33		19	8
Copidognathus dentatus			9	
Halacarid sp. indet.			9	
N	33	0	37	8
S	1	0	3	1

Section 3

OTHER MEIOFAUNAL GROUPS

PRESENT IN THAMES SEDIMENT SAMPLES

APRIL 1989 - MARCH 1990

Section 3: Table 1. Key to Table of Other Meiofaunal Groups observed in Thames Sediment Samples, April - June 1989

1	Rhizopod Amoebae, tests of *Centropyxis* species
2	Foraminifera, planispiral and multilocular species (e.g. *Elphidium* and *Braziliana* species)
3	Turbellaria
4	Gnathostomulida
5	Gastrotricha, ?*Chaetonotus* species
6	Kinorhyncha, *Pycnophyes* species
7	Tardigrada, *Macrobiotus dispar* and *Batillipes mirus*
8	Ostracoda, juveniles of several species indet.

Section 3: Table 2. Other Meiofaunal Groups Observed in Thames Sediment Samples, April - June 1989

Stn.	GROUP							
	1	2	3	4	5	6	7	8
1	+		+				+	+
2	+		+				+	+
3	+						+	
4	+		+				+	
5		+	+				+	
6								
7	+	+					+	+
8s		+						
8i			+					
9		+						
10s								
10i			+					+
11s	+							
11i	+							
12s			+					
12i			+					
13s								+
13i		+	+					+
14	+	+						
15	+							+
16		+	+				+	+
17		+				+		+
18		+	+					+
19s	+	+				+		
19i	+	+					+	
20			+			+	+	+
21		+	+	+	+		+	
22		+	+		+		+	+
Stn.	1	2	3	4	5	6	7	8

Section 3: Table 3. Key to Table of Other Meiofaunal Groups observed in Thames Sediment Samples, July - September 1989

1	Ciliate Protozoa
2	Foraminifera, planispiral, uni- and multilocular species (e.g. *Elphidium*, *Braziliana* and *Lagena* species)
3	Turbellaria (several species)
4	Tardigrada, *Echiniscus* species and *Batillipes mirus*
5	Gastrotricha, *Chaetonotus* species
6	Ostracoda, juveniles of several species

Section 3: Table 4. Other Meiofaunal Groups Observed in Thames Sediment Samples, July - September 1989

Stn.	GROUP					
	1	2	3	4	5	6
1		+	+			+
2						+
3				+		
4			+			
5			+	+		
6			+			+
7s						
7i				+		
8s			+			
8i						
9		+				
10s						
10i			+			
11s			+			
11i		+				
12s		+				
12i			+			
13s		+				+
13i		+	+			
14		+				
15		+				+
16	+					
17	+	+				+
18			+			
19s		+	+			
19i	+	+	+			+
20		+			+	
21	+	+	+			+
22		+		+	+	
Stn.	1	2	3	4	5	6

Section 3: Table 5. Key to Table of Other Meiofaunal Groups observed in Thames Sediment Samples, October - December 1989

1	Ciliate Protozoa
2	Foraminifera, planispiral, uni- and multilocular species (e.g. *Elphidium*, *Braziliana* and *Lagena* species)
3	Turbellaria (several species)
4	Nemertea, juveniles indet.
5	Tardigrada, *Echiniscus* species and *Batillipes mirus*
6	Gastrotricha, *Chaetonotus* species
7	Kinorhyncha, *Pycnophyes* and *Echinoderes* species
8	Ostracoda, juveniles of several species

Section 3: Table 6. Other Meiofaunal Groups Observed in Thames Sediment Samples, October - December 1989

Stn.	GROUP							
	1	2	3	4	5	6	7	8
1			+		+	+		+
2								
3			+		+			+
4								
5			+					
6		+	+					
7s		+	+					+
7i								+
8s		+						
8i			+					
9		+						+
10s								
10i								
11s		+						+
11i		+						
12s		+			+			
12i		+	+					
13s								
13i		+						
14		+	+	+				+
15								+
16		+	+					+
17		+					+	
18			+					
19s		+	+		+			
19i		+	+					+
20		+						
21	+	+						
22	+	+						+
Stn.	1	2	3	4	5	6	7	8

Section 3: Table 7. Key to Table of Other Meiofaunal Groups observed in Thames Sediment Samples, January - March 1989

1	Ciliate Protozoa
2	Foraminifera, planispiral, uni- and multilocular species (e.g. *Elphidium*, *Braziliana* and *Lagena* species)
3	Turbellaria (several species)
4	Gnathostomulida
5	Gastrotricha, *Chaetonotus* species
6	Kinorhyncha, *Pycnophyes* and *Echinoderes* species
7	Tardigrada, species of *Echiniscus* and *Macrobiotus* and *Batillipes mirus*
8	Ostracoda, juveniles of several species

Section 3: Table 8. Other Meiofaunal Groups Observed in Thames Sediment Samples, January - March 1990

Stn.	GROUP							
	1	2	3	4	5	6	7	8
1	+		+				+	+
2			+				+	+
3	+		+					+
4		+	+				+	+
5			+					
6		+	+					+
7s		+						
7i								
8s								
8i								
9								
10s			+					+
10i			+					
11s			+					+
11i								
12s								
12i								
13s		+						+
13i		+						+
14		+	+					+
15		+	+					+
16		+	+					
17			+					+
18	+	+	+					
19s			+					
19i			+					+
20		+				+		+
21	+				+	+	+	+
22	+		+	+			+	+
Stn.	1	2	3	4	5	6	7	8

Section 4

NON-MEIOFAUNAL GROUPS

PRESENT IN THAMES SEDIMENT SAMPLES

APRIL 1989 - MARCH 1990

Section 4: Table 1. Key to Table of Non-meiofaunal Groups observed in Thames Sediment Samples, April - June 1989

1	Filamentous algae
2	Desmids
3	Diatoms, mostly centric species, some pennate
4	Ciliate Protozoa
5	Thecate hydroids, detached hydranths and sections of perisarc
6	Nemertea, juvenile
7	Rotifera, loricae of *Keratella* species (e.g. *K. quadrata* and *K. cochlearis*) and contracted remains of *Bracionus* species
8	Annelida: Oligochaeta, Tubificidae and Nadiidae
9	Annelida: Polychaeta, spionid and nereid neochaetes
10	Mollusca: Gastropoda, littorinid egg capsules
11	Mollusca: Bivalvia, newly settled spat, ?tellinid species
12	Crustacean nauplii
13	Cladocera, mostly *Bosmina* species, some *Daphnia* species
14	Amphipoda, eggs/embryoes of *Corophium* species
15	Copepoda: Calanoida, *Eurytemora affinis*
16	Hexapoda: Diptera: Nematocera: Chironomidae, larvae

Section 4: Table 2. Other Meiofaunal Groups Observed in Thames Sediment Samples, April - June 1989

Stn.	GROUP															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	+		+				+	+	+			+	+		+	+
2	+		+				+	+	+				+	+		+
3			+				+	+	+					+		
4			+				+	+	+							
5		+	+				+	+								
6			+				+									
7	+		+													
8s			+					+	+							
8i			+		+		+	+	+							
9	+		+				+									
10s			+					+	+							
10i	+		+				+	+	+					+		
11s			+													
11i			+									+				
12s			+						+			+		+		
12i			+					+	+			+		+		
13s	+		+					+	+					+		
13i	+		+		+			+	+		+	+		+		
14			+						+			+				
15					+				+		+	+		+		
16			+						+	+	+	+				
17			+		+				+	+	+	+				
18			+	+	+				+			+				
19s		+									+					
19i		+		+	+			+	+	+	+					
20			+	+												
21			+						+		+	+			+	
22			+	+					+			+				
Stn.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Section 4: Table 3. Key to Table of Non-meiofaunal Groups observed in Thames Sediment Samples, July - September 1989

1	Diatoms, mostly centric species, some pennate
2	Filamentous algae
3	Desmids
4	Thecate hydroids, detached hydranths and sections of perisarc
5	Rotifera, loricae of *Keratella* species (e.g. *K. quadrata* and *K. cochlearis*) and contracted remains of *Bracionus* species
6	Bryozoa: sessobalsts, probably of freshwater species
7	Annelida: Oligochaeta, Tubificidae and Nadiidae
8	Annelida: Polychaeta, spionid and nereid neochaetes (? *Manayunkia* species also present in upper reaches of estuary)
9	Mollusca: Bivalvia, newly settled spat, ?tellinid species
10	Mollusca: Gastropoda, littorinid egg capsules
11	Crustacean nauplii
12	Cladocera, mostly *Alona affinis* but also 2 species of *Pleuroxis*
13	Copepoda: Calanoida (*Eurytemora affinis*)
14	Copepoda: Cyclopoida (unidentified species)
15	Hexapoda: Diptera: Nematocera: Chironomidae, larvae

Section 4: Table 4. Other Meiofaunal Groups Observed in Thames Sediment Samples, July - September 1989

Stn.	GROUP														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	+	+			+	+	+				+			+	+
2	+	+	+		+	+	+				+	+			+
3					+	+	+								+
4	+				+		+								
5															
6	+						+	+							
7s	+						+								
7i	+						+								
8s	+			+											
8i	+										+				
9						+	+								
10s	+	+									+				
10i	+						+	+							
11s	+										+				
11i	+				+		+	+							
12s	+														
12i	+							+			+				
13s	+			+							+				
13i	+						+	+							
14	+			+			+	+							
15	+			+		+		+							
16	+				+		+	+	+	+	+				
17	+			+		+		+	+		+		+		
18	+			+					+						
19s	+						+	+	+						
19i	+							+		+					
20	+														
21	+							+		+	+				
22	+							+	+						
Stn.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Section 4: Table 5. Key to Table of Non-meiofaunal Groups observed in Thames Sediment Samples, October - December 1989

1	Diatoms, mostly centric species, some pennate
2	Filamentous algae
3	Desmids
4	Thecate hydroids, detached hydranths and sections of perisarc
5	Rotifera, loricae of *Keratella* species (e.g. *K. quadrata* and *K. cochlearis*) and contracted remains of *Brachionus* species
6	Bryozoa: detached zooids from colonies (possibly *Electra pilosa*)
7	Annelida: Oligochaeta, Tubificidae and Nadiidae
8	Annelida: Polychaeta, spionid and nereid neochaetes
9	Mollusca: Bivalvia, newly settled spat, ?tellinid species
10	Mollusca: Gastropoda, newly metamorphosed larvae
11	Crustacean nauplii
12	Cladocera, mostly *Alona affinis* but also 2 species of *Pleuroxis*
13	Amphipoda, juveniles possibly *Corophium* species
14	Hexapoda: Diptera: Nematocera: Chironomidae, larvae

Section 4: Table 6. Other Meiofaunal Groups Observed in Thames Sediment Samples, October - December 1989

Stn.	GROUP													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		+	+		+		+				+	+	+	+
2	+	+	+		+		+				+			
3	+		+	+	+		+							+
4	+						+				+			+
5	+						+			+	+			
6	+						+				+			
7s	+						+			+				
7i	+			+	+		+			+	+			
8s	+													
8i	+				+		+			+				
9	+			+	+									
10s	+													
10i	+			+	+		+				+			
11s				+			+		+		+			
11i	+						+							
12s	+													
12i	+			+			+				+		+	
13s	+			+			+	+	+					
13i	+						+		+					
14	+			+				+		+				
15	+			+					+				+	
16	+						+		+					
17	+						+		+					
18	+			+		+	+	+	+	+	+			
19s	+			+				+	+					
19i	+							+	+		+			
20	+								+					
21	+							+		+				
22	+			+				+	+					
Stn.	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Section 4: Table 7. Key to Table of Non-meiofaunal Groups observed in Thames Sediment Samples, January - March 1990

1	Filamentous algae
2	Diatoms, mostly centric species, some pennate
3	Desmids
4	Stalked, colonial Protozoa
5	Thecate hydroids, detached hydranths and sections of perisarc
6	Bryozoa: detached zooids from colonies (possibly *Electra pilosa*)
7	Rotifera, loricae of *Keratella* species (e.g. *K. quadrata* and *K. cochlearis*) and contracted remains of *Brachionus* species
8	Annelida: Oligochaeta, Tubificidae and Nadiidae
9	Annelida: Polychaeta, spionid and nereid neochaetes
10	Mollusca: Bivalvia, newly settled spat, ?tellinid species
11	Mollusca: Gastropoda, newly metamorphosed larvae
12	Crustacean nauplii
13	Cladocera, mostly *Alona affinis* but also 2 species of *Pleuroxis*
14	Amphipoda, juveniles possibly *Corophium* species
15	Calanoid Copepoda; *Eurytemora affinis*
16	Hexapoda: Diptera: Nematocera: Chironomidae, larvae

Section 4: Table 8. Other Meiofaunal Groups Observed in Thames Sediment Samples, January - March 1990

Stn.	GROUP															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	+	+	+			+	+	+	+							
2	+		+				+	+	+			+	+			
3			+			+	+	+	+					+		+
4	+		+				+	+	+			+	+			+
5	+		+													
6	+		+			+	+					+				+
7s			+			+	+	+				+				
7i			+		+		+	+		+						+
8s			+					+								
8i			+					+								
9								+		+						
10s			+					+			+					
10i			+					+								
11s			+					+				+				
11i			+					+				+				
12s			+									+				
12i			+					+		+		+				
13s			+													
13i		+	+					+			+					
14			+					+	+			+				
15			+			+										
16			+					+	+		+	+				
17			+					+	+			+				
18			+		+	+		+	+					+		
19s			+		+			+	+							
19i			+					+				+				
20			+		+	+		+	+			+				
21				+					+							
22			+						+		+					
Stn.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Section 5

NEMATODE FEEDING TYPES

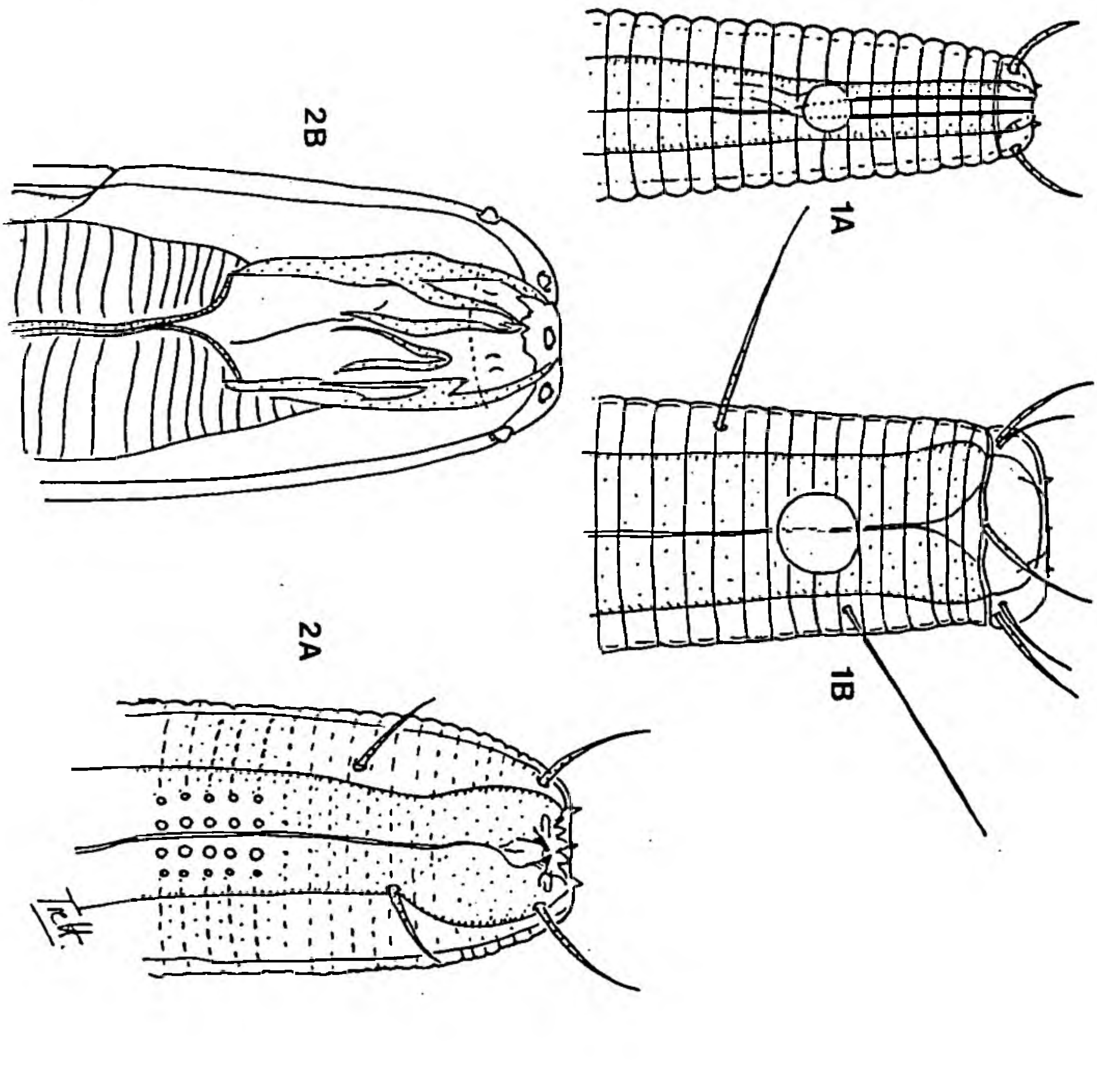
Nematode Feeding Types and the 1B:2A Ratio

Depending on the structure of the buccal capsule, nematodes can be classified into one of four different groups (see Figure 20). These groups appear to relate to their mode of feeding. Type 1 species lack cuticularised teeth whereas type 2 species have between 1 and 3 primary teeth that can be exceptionally large. Type 1 species are sub-divided into 1A species which have small or narrow buccal cavities and 1B species that have large unarmed buccal cavities. The type 1A species are believed to be microbivorous or selective deposit feeders and, in the present survey, include species such those belonging to the families Oxystominidae and the Leptolaimidae. Type 1B species are non-selective detritivores and, although they may ingest whole diatoms, they usually ingest 'plugs' of organically rich sediment. Examples found in the Thames Estuary include most of the xyalid nematodes and *Richtersia inaequalis*.

Type 2 species are also sub-divided on the basis of the size of their buccal cavities. 2A species have small cavities armed with teeth. These may be modified to split open frustules of sediment-dwelling diatoms or to rasp epigrowth from the surface of sand grains. Type 2A species attain their highest densities in coarse grained sediments and include most members of the Chromadoridae, Desmodoridae and Cyatholaimidae. Type 2B species have large armed buccal cavities, occasionally with moveable jaws and include predatory as well as omnivorous species. Oncholaimid species such as *Adoncholaimus thalassophygas* and enoplids such as *Enoplus brevis* belong to this group. These are often large nematode species with life-cycles of up to a year. Consequently, their populations are slow to re-establish following a catastrophic disturbance.

The ratio between 1B and 2A feeding types (1B:2A ratio) is a fundamental index used to describe the trophic composition of nematode populations. This has been used to detect changes in the composition of nematode assemblages with shifts to or from non-selective detritivore-dominated populations or selective epigrowth/diatomivorous species populations. The ratios for the stations at the mouth of the estuary and towards the western end of the Estuary are predominantly less than 5.00. Those for the muddier middle reach sediment communities are generally high. This reflects the low densities of selective epigrowth feeders combined with the elevated numbers of non-selective detritus feeding species in the middle reach. Used incombination with multivariate analyses of meiofaunal species complements, the 1B:2A nematode feeding type ratio is a powerful tool for the assessment of pollution status and in the detection of changes in prevailing environmental conditions in aquatic ecosystems.

Figure 20. The buccal structures of the four principal nematode feeding types used in the investigation of trophic structures of nematode assemblages. See text for descriptions.


1A
1B
2B
2A

Appendix II

PARTICLE SIZE DISTRIBUTIONS

(October - December 1989)

Site Code: TW1

Total dry weight: 471.00g

Decription: Mud and stones.

Particle Size	Percentage
< 63 μm	1.77
63 μm - 212 μm	5.99
212 μm - 600 μm	10.37
600 μm - 1 mm	2.52
1 mm - 2 mm	3.21
> 2 mm	76.14

Site Code: TW2

Total dry weight: 254.25g

Decription: Fine sand and gravel

Particle Size	Percentage
< 63 μm	1.77
63 μm - 212 μm	5.99
212 μm - 600 μm	10.37
600 μm - 1 mm	2.52
1 mm - 2 mm	3.21
> 2 mm	76.14

Site Code: TW3

Total dry weight: 430.20g

Decription: Sand with some organic matter.

Particle Size	Percentage
< 63 μm	7.35
63 μm - 212 μm	16.45
212 μm - 600 μm	74.74
600 μm - 1 mm	0.66
1 mm - 2 mm	0.32
> 2 mm	0.48

Site Code: TW4

Total dry weight: 204.54

Decription: Fine sand and stones.

Particle Size	Percentage
< 63 μm	25.59
63 μm - 212 μm	11.21
212 μm - 600 μm	47.35
600 μm - 1 mm	2.21
1 mm - 2 mm	0.39
> 2 mm	13.25

Site Code: TW5

Total dry weight: 312.50g

Decription: Sand.

Particle Size	Percentage
< 63 μm	2.27
63 μm - 212 μm	9.89
212 μm - 600 μm	85.20
600 μm - 1 mm	1.80
1 mm - 2 mm	0.61
> 2 mm	0.24

Site Code: TW6

Total dry weight: 172.57g

Decription: Silty mud with some stones.

Particle Size	Percentage
< 63 μm	24.78
63 μm - 212 μm	20.26
212 μm - 600 μm	22.59
600 μm - 1 mm	2.38
1 mm - 2 mm	5.83
> 2 mm	24.15

Site Code: TW7s

Total dry weight: 271.54g

Decription: Sand.

Particle Size	Percentage
< 63 μm	9.14
63 μm - 212 μm	32.62
212 μm - 600 μm	51.75
600 μm - 1 mm	2.63
1 mm - 2 mm	1.84
> 2 mm	2.02

Site Code: TW7i

Total dry weight: 214.64g

Decription: Silt and mud.

Particle Size	Percentage
< 63 μm	22.54
63 μm - 212 μm	52.34
212 μm - 600 μm	22.05
600 μm - 1 mm	1.05
1 mm - 2 mm	2.02
> 2 mm	0.00

Site Code: TW8s

Total dry weight: 155.28g

Decription: Silt and mud.

Particle Size	Percentage
< 63 μm	35.06
63 μm - 212 μm	54.32
212 μm - 600 μm	10.35
600 μm - 1 mm	0.15
1 mm - 2 mm	0.12
> 2 mm	0.00

Site Code: TW8i

Total dry weight: 301.22g

Decription: Mud and stones.

Particle Size	Percentage
< 63 μm	13.82
63 μm - 212 μm	14.75
212 μm - 600 μm	12.62
600 μm - 1 mm	1.61
1 mm - 2 mm	1.97
> 2 mm	55.23

Site Code: TW9

Total dry weight: 177.58g

Decription: Mud.

Particle Size	Percentage
< 63 μm	50.65
63 μm - 212 μm	39.61
212 μm - 600 μm	9.24
600 μm - 1 mm	0.09
1 mm - 2 mm	0.20
> 2 mm	0.21

Site Code: TW10s

Total dry weight: 205.36g

Decription: Fine mud.

Particle Size	Percentage
< 63 μm	40.03
63 μm - 212 μm	50.76
212 μm - 600 μm	8.46
600 μm - 1 mm	0.11
1 mm - 2 mm	0.20
> 2 mm	0.42

Site Code: TW10i

Total dry weight: 175.08g

Decription: Fine mud.

Particle Size	Percentage
< 63 μm	34.76
63 μm - 212 μm	48.32
212 μm - 600 μm	16.25
600 μm - 1 mm	0.25
1 mm - 2 mm	0.42
> 2 mm	0.00

Site Code: TW11s

Total dry weight: 145.04g

Decription: Fine mud.

Particle Size	Percentage
< 63 μm	41.19
63 μm - 212 μm	36.54
212 μm - 600 μm	22.12
600 μm - 1 mm	0.15
1 mm - 2 mm	0.00
> 2 mm	0.00

Site Code: TW11i

Total dry weight: 114.35g

Decription: Fine mud.

Particle Size	Percentage
< 63 μm	67.41
63 μm - 212 μm	16.35
212 μm - 600 μm	16.13
600 μm - 1 mm	0.02
1 mm - 2 mm	0.00
> 2 mm	0.07

Site Code: TW12s

Total dry weight: 180.10g

Decription: Coarse mud.

Particle Size	Percentage
< 63 µm	36.10
63 µm - 212 µm	44.99
212 µm - 600 µm	12.07
600 µm - 1 mm	0.27
1 mm - 2 mm	2.03
> 2 mm	4.54

Site Code: TW12i

Total dry weight: 167.29g

Decription: Coarse mud.

Particle Size	Percentage
< 63 µm	44.47
63 µm - 212 µm	45.03
212 µm - 600 µm	9.21
600 µm - 1 mm	0.30
1 mm - 2 mm	0.45
> 2 mm	0.51

Site Code: TW13s

Total dry weight: 296.07g

Decription: Coarse mud.

Particle Size	Percentage
< 63 µm	38.36
63 µm - 212 µm	52.54
212 µm - 600 µm	8.57
600 µm - 1 mm	0.53
1 mm - 2 mm	0.00
> 2 mm	0.00

Site Code: TW13i

Total dry weight: 434.55g

Decription: Mud.

Particle Size	Percentage
< 63 µm	22.54
63 µm - 212 µm	51.21
212 µm - 600 µm	26.19
600 µm - 1 mm	0.06
1 mm - 2 mm	0.00
> 2 mm	0.00

Site Code: TW14

Total dry weight: 265.10g

Decription: Mud.

Particle Size	Percentage
< 63 µm	29.49
63 µm - 212 µm	46.50
212 µm - 600 µm	23.56
600 µm - 1 mm	0.21
1 mm - 2 mm	0.23
> 2 mm	0.00

Site Code: TW15

Total dry weight: 316.54g

Decription: Mud and shell (bivalve).

Particle Size	Percentage
< 63 µm	23.80
63 µm - 212 µm	65.26
212 µm - 600 µm	8.72
600 µm - 1 mm	0.45
1 mm - 2 mm	0.60
> 2 mm	1.17

Site Code: TW16

Total dry weight: 365.62g

Decription: Mud.

Particle Size	Percentage
< 63 μm	35.85
63 μm - 212 μm	54.58
212 μm - 600 μm	9.54
600 μm - 1 mm	0.01
1 mm - 2 mm	0.01
> 2 mm	0.02

Site Code: TW17

Total dry weight: 295.46g

Decription: Mud and shells (bivalve).

Particle Size	Percentage
< 63 μm	37.83
63 μm - 212 μm	35.15
212 μm - 600 μm	20.51
600 μm - 1 mm	0.57
1 mm - 2 mm	0.94
> 2 mm	5.01

Site Code: TW18

Total dry weight: 186.81g

Decription: Mud with shells (bivalve) and bored wood.

Particle Size	Percentage
< 63 μm	20.70
63 μm - 212 μm	18.96
212 μm - 600 μm	13.63
600 μm - 1 mm	2.08
1 mm - 2 mm	2.63
> 2 mm	42.01

Site Code: TW19s

Total dry weight: 289.73g

Decription: Sand with stones and shells (bivalve).

Particle Size	Percentage
< 63 μm	5.83
63 μm - 212 μm	29.42
212 μm - 600 μm	52.34
600 μm - 1 mm	0.39
1 mm - 2 mm	0.48
> 2 mm	11.54

Site Code: TW19i

Total dry weight: 319.16g

Decription: Fine sand and shells (bivalve).

Particle Size	Percentage
< 63 μm	14.44
63 μm - 212 μm	65.82
212 μm - 600 μm	12.92
600 μm - 1 mm	0.75
1 mm - 2 mm	0.51
> 2 mm	5.53

Site Code: TW20

Total dry weight: 241.02g

Decription: Fine sand.

Particle Size	Percentage
< 63 μm	20.79
63 μm - 212 μm	47.03
212 μm - 600 μm	32.15
600 μm - 1 mm	0.02
1 mm - 2 mm	0.02
> 2 mm	0.00

Site Code: TW21

Total dry weight: 564.25g

Decription: Fine sand and shells (bivalve).

Particle Size	Percentage
< 63 μm	7.81
63 μm - 212 μm	31.48
212 μm - 600 μm	57.06
600 μm - 1 mm	0.56
1 mm - 2 mm	0.51
> 2 mm	2.58

Site Code: TW22

Total dry weight: 245.90g

Decription: Fine sand.

Particle Size	Percentage
< 63 μm	5.71
63 μm - 212 μm	50.50
212 μm - 600 μm	43.28
600 μm - 1 mm	0.29
1 mm - 2 mm	0.07
> 2 mm	0.15
